Callous-Unemotional Trait Modulation of the Neurological Processing of Empathy and Emotion

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ABSTRACT

Callous-Unemotional (CU) traits are personality attributes which include a deficit of affective valence and reduced empathetic responding (Guay et al., 2007). Conditions that exhibit high levels of CU traits demonstrate a disassociation within empathic processing; typically, emotional empathy is evidenced to be dysfunctional, while cognitive empathy is reported intact (e.g. psychopathy - Blair, 2008, 2005). This profile of empathetic processing, in relation to CU traits, was investigated in the general population. 124 participants completed the Inventory of Callous-Unemotional Traits (Frick, 2004), the Interpersonal Reactivity Index (Davis, 1983), the Empathy Quotient (Baron-Cohen & Wheelwright, 2004), an expression recognition task, and a measure of affective response.

Negative correlations with CU trait score were observed for both cognitive empathy and emotional empathy. Accuracy in the identification of fearful expressions presented a negative association with CU trait score. Self-rating of affective valence, when viewing both positive and negative images, indicates a universal reduction in emotional response associated with increased CU trait manifestation. The dual reduction in empathy contrasts clinical research (Richell et al., 2003; Blair et al., 1996); however, the findings regarding expression recognition and emotional valence mirror previous clinical findings (Hastings et al., 2008; Herpertz et al., 2001).

High, low and control CU trait experimental groups were selected using the Inventory of Callous-Unemotional Traits from the research sample described above. These groups were used to explore the neural responses of participants with defined levels of CU trait manifestation to stimuli associated with empathy and affective valence. Electroencephalographic recording and event-related potential analysis were used to investigate the group's neural responses to 3 types of stimuli: facial expressions, painful and non-painful situations and emotional stimuli (both attended and unattended). Differences in the ERP responses of the CU trait groups were observed across the research, furthermore an interacting effect of attention was observed in the exploration of affective valence.

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Key Research Questions

There are six pivotal questions that will be addressed through this thesis:

1. What is the distribution of empathic processing ability and callous-unemotional (CU) traits? The proposed research aims to examine these constructs within a general population using a constellation of established self-report measures.

2. The second objective is to examine the relationship between empathy and CU traits. Do measures of CU trait severity correlate negatively with measures of empathy-processing, emotion recognition and affective valences as would be predicted from clinically-diagnosed populations?

3. Are cognitive empathy and emotional empathy dissociable within CU traits? The self-report data will simultaneously investigate the possible fractionation of empathic abilities in CU traits.

4. How are the neurological correlates of emotional empathic ability, measured by expression recognition, as identified using topographic electroencephalographic (EEG) recording and event related potential (ERP) analyses modulated by CU traits?

5. How are the ERP waveforms of cognitive empathy, measured by reactions to abstract painful and non-painful scenarios, modulated by CU traits?

6. How are the electroneurological correlates of affective valence modulated by CU traits and attention?

The Structure of the Thesis

The following report is split into two sections. Section one explores the manifestation of CU traits using psychometric measures to investigate the relationship between CU traits, empathy-processing abilities and emotion. The inclusion of measures of both cognitive and emotional empathy allows for the analysis of potential disassociation of these distinct forms of empathy within high CU trait manifestation. Prevalence and distribution of CU traits in the sample population are also analysed. Crucially, this primary research underpins and informs investigation into the electrophysiological correlates of empathy processing with regards to CU traits. This electrophysiological research forms section two of this thesis.

There is a paucity of electrophysiological research into empathy processing and whether empathy processing is modulated with regards to CU traits. Section two focuses on research which applies EEG technology and ERP analysis techniques to expand on previous publications, by considering empathy processing with regards to CU traits in a general population. Event related potential (ERP) analysis allowed the unique exploration of empathic responses with regards to CU traits; the ERP waveform components of empathy processing in high, normal and low CU trait individuals are examined in three studies titled:

1. The Electro-Neurological Correlates of Facial Affect Processing in Relation to Callous-Unemotional Traits.
2. The Modulating Effect of Callous and Unemotional Traits on Responses to Painful Stimuli Imagined in the Self and Other Perspective.
3. The Mediating Effect of Attention on Emotional Valence Processing in those with High and Low Levels of Callous and Unemotional Traits.

This research aimed to advance previous understand of the neural responses underlying empathy by exploring the mediating effect of CU trait manifestation on empathy processes in a general population demographic.

Section 1:

Empathising Processes in Relation to Callous and Unemotional Traits within a General Population

CHAPTER 1:

EMPATHISING PROCESSES IN THE NEUROTYPICAL INDIVIDUAL

Empathy is the attribute of the human mind which governs our ability to interact with one another in a social environment, when deficient one enters disorders of atypical empathy, such as antisocial personality disorder (ASPD), conduct disorder (CD) and psychopathy, and the deficits in empathy, emotion and prosocial behaviour there witnessed (Decety, 2011). CU traits are a cluster of psychological attributes which can manifest in one's personality: these traits include factors such as; a lack of emotion, decreased empathy and a diminished capacity to feel guilt (Guay et al., 2007). Callous and unemotional (CU) traits comprise a significant proportion of the symptoms of personality disorder presented in ASPD, CD and psychopathy (Richell et al., 2003). Disrupted empathy processing is a key CU trait, strongly correlated with clinical psychopathic populations (Richell et al., 2003). Empathy is an established psychological process, it is, however, not a simplistic construct and, therefore, will be considered in depth before considering the relation to CU traits.

1.1 Defining Empathy

Empathy is a complex, multifaceted cognitive process. Heterogeneous in nature, it is thus not consistently defined within the literature. The etymology of the word 'empathy' (the English version) dates to 1903 when it was transformed from a German word 'einfühlung' (ein meaning "in" and Fühlung translating as "feeling", Aragno, 2008). The German word 'einfühlung' was coined by the German philosopher Rudolf Lotze in approximately 1858 as a translation of Greek empatheia (em meaning "in" and pathos translating as "feeling", Aragno, 2008). Therefore, the word empathy is a relatively recent addition to the English language in etymological terms. Since the addition of the word to the English language researchers and philosophers have adapted the meaning of the term empathy in line with the current scientific evidence and postulations. In Batson's (2009) meta-analytical review of empathy literature, 8 distinct definitions or concepts of the term empathy were found. These 8 are:

1. Knowing another person's internal state, including his or her thoughts and feelings.
2. Adopting the posture or matching the neural responses of an observed other.
3. Coming to feel as another person feels.
4. Intuiting or projecting oneself into another's situation.
5. Imagining how another is thinking and feeling.
6. Imagining how one would think and feel in the other's place.
7. Feeling distress at witnessing another person's suffering.
8. Feeling for another person who is suffering.

It is, therefore, necessary to look beyond a simple definition and in doing so the literature reveals that there are two dissociable components of empathy processing which occur within the range of human empathy; Numenmaa et al (2008) and Shamay-Tsoory et al (2009) suggest that human empathy is a psychological construct regulated by both *cognitive* and *affective* components, thereby producing emotional understanding of others. Nummenmaa et al (2008) and Shamay-Tsoory et al (2009) have published evidence that these two components of empathy, the emotional and the cognitive, are neurologically distinct vectors of emphatic processing. Divergent neurological pathways are observable in the cortex for the emotional and cognitive components of empathetic processing (Shamay-Tsoory et al., 2009; Nummenmaa et al., 2008); the complexities of the neurological processing of empathy will be reviewed in detail in the second section of the thesis. Empathy, therefore, consists of the two fractionated but associated abilities of cognitive empathy (CE) and emotional empathy(EE), relying on both the congruent communication of affective signals between individuals and higher cognitive inference using contextual cues (Shamay-Tsoory et al., 2009; Blair, 2008; Nummenmaa et al., 2008).

Cognitive empathy (CE) has been likened to theory of mind (Blair, 2008). Theory of mind is the ability to attribute mental states to another given their environment and individual characteristics, whilst acknowledging that the individuals mental processing may not be similar to one's own. Emotional (or affective) empathy (EE) processes both emotional recognition and contagion (Blair, 2008). Emotional recognition refers to our ability to recognise expressions of emotion accurately in others, while emotional contagion is the ability to autonomically mimic the expression of others both in our physical output and by synchronisation of internal emotion (Blair, 2008).

1.2 Emotional (Affective) Empathy and its Integral Elements

Emotional empathy is essential to both the ability to recognise expressions of emotion accurately in others and to the autonomic mimicry of expressions (Blair, 2008). Emotional empathy allows the perceived emotions of others to be simulated internally; Preston and De Waal (2002) developed the perception-action hypothesis which states that the observation of behaviour by another individual will automatically result in the activation of one's own schema of said behaviour. Furthermore, extension simulation theory postulates that the neural processing of social cues of emotion operates in a similar manner, in that the observation of an emotion in another autonomically actives one's own neural representations of that emotion through the activation of mirror neurons (neurons which produce action potentials in response to the observation of movement and to the production of that movement) (Gallese, 2003). Such congruency between one's own feelings of emotion and the response to perceived symmetrical emotional in others allows for empathy to occur and serves to underpin our ability to understand another's mental state.

The motor mirror neuron system within the inferior frontal gyrus has been revealed to be active when undertaking tasks requiring emotion recognition or evaluation (Seitz et al., 2008; Carr et al., 2003) and emotional empathy (Jabbi et al., 2007; Schulte-Ruther et al., 2007). Carr et al (2003) observed that components of the inferior frontal cortex's mirror neuron system where active during both the observation and imitation of facial expressions of emotion. Simulation of the emotional state of another within oneself is associated with the inferior frontal gyrus in emotional empathy research (Schulte-Ruther et al., 2007). Furthermore, fMRI neuroimaging data measuring cortical activation during the imitation and passive observation of emotional facial expressions showed an increased BOLD signal of the inferior frontal gyrus in both conditions, indicating that this cortical area and the contained mirror neurons are associated with emotion recognition and mimicry (Dapretto et al., 2006).

A lesion study by Shamay-Tsoory et al (2009) explored emotional and cognitive empathy in thirty neurological patients with localised lesion damage specific to either the ventromedial prefrontal cortex (n = 11), the inferior frontal gyrus (n = 8) or posterior lesions (n = 11), and 34 healthy controls. Aetiologies of the lesions included stroke, meningioma and head injury, the proportion of each was matched between groups. Results revealed that lesions to the inferior frontal gyrus were associated with reduced emotional empathy capacity, but intact cognitive empathy, as measured by the patients responses to the empathic concern scale and perspective taking scale of the Interpersonal Reactivity Index (Davis, 1983); whereas the ventromedial prefrontal cortex was associated with the reverse profile of empathy. Inferior frontal gyrus lesions, particularly those to BA 44, were associated with significant impairment in both emotional empathy and emotion recognition. BA 44 is cytoarchitectonically homologous to F5, a central part of the mirror neuron system, therefore the authors conclude that the findings present further empirical evidence that the mirror neuron system is essential for emotional empathy (Shamay-Tsoory et al., 2009) (*see Figure 1*).

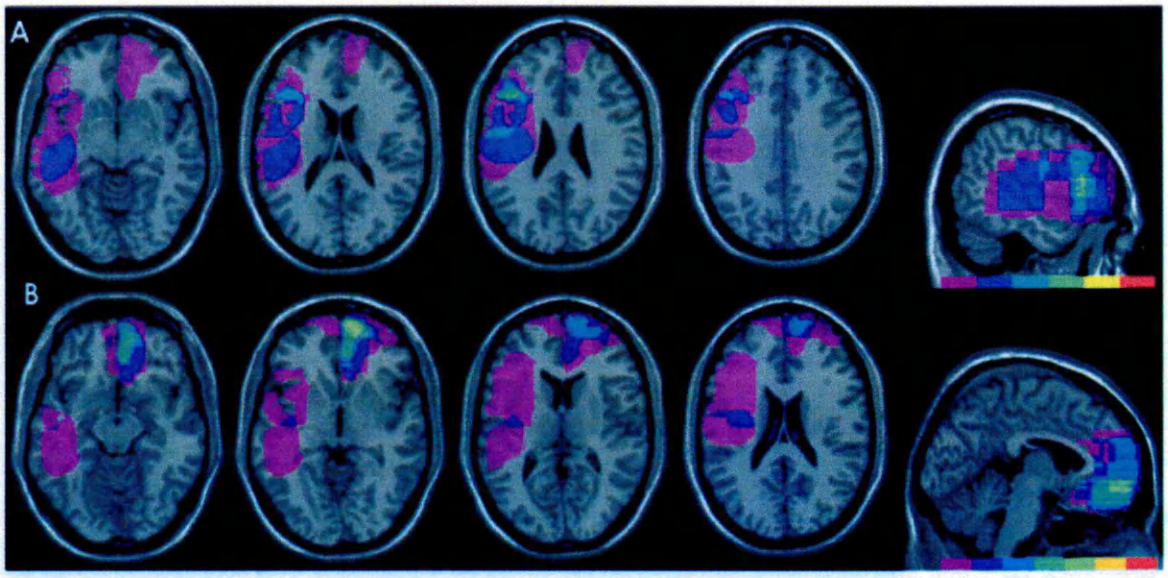

Figure 1 : Location and overlap of brain lesions according to emotional versus cognitive empathy impairment-groups. (A) Lesions of the emotional-empathy-impaired group (n = 6). Four patients had an inferior frontal gyrus damage involving area BA 44, one had ventromedial damage and one had prefrontal cortex damage. (B) Lesions of the cognitive-empathy-impaired group (n = 7): five had ventromedial damage involving ***area BA*** *10 and 11, one had inferior frontal gyrus damage and one had prefrontal cortex damage (Shamay – Tsoory et al., 2009).*

The activation of the inferior frontal gyrus appears to modulate with regards to individual differences in emotion empathy capacity; it has been demonstrated that there is a positive association between scores on an emotional empathy measure (the empathic concern scale of the Interpersonal Reactivity Index) and the strength of activity in the inferior frontal gyrus when observing emotional empathy eliciting stimuli (Kaplan & Iacoboni, 2006). Therefore, it could be concluded that the inferior frontal gyrus is an essential structure for the processing of emotional empathy. However, it is necessary to note that another study reported that individuals who score higher on the cognitive empathy scale of the same self-report empathy measure – the Interpersonal Reactivity Index (the perspective taking subscale) were associated more strongly with mirror neuron activation in the inferior frontal gyrus (Gazzola et al., 2006). Therefore, there is some debate within the literature regarding the neural areas associated with the emotional and cognitive components of empathy.

Further to this evidence of the mirror neuron system and associated cortical structures being a core component of the neural response to emotional empathy stimuli, there are studies implicating other areas of the cortex as being vital for a functional neural emotional empathy response (Nummenmaa et al., 2008; Singer et al., 2004). In a review of research from areas of affective neuroscience, social neuroscience and neuroeconomics, Singer et al (2004) suggest that the insular cortex, particularly the anterior portion, functions to integrate sensory and affective information, and is required for learning about emotion states, predicting emotion and generating prediction errors.

Nummenmaa et al (2008) explored the potential of emotional empathy to recruit the neural networks involved in motor representation and imitation in 10 healthy, neurologically-intact females. To evoke emotional empathy in their participants, blocks of photographs depicting people in neutral everyday situations (cognitive empathy) or suffering serious threat of harm (emotional empathy) were shown to the participants; when viewing the stimuli participants were requested to empathise with the people in the stimuli photographs (Nummenmaa et al., 2008). Emotional empathy was correlated significantly with an increased activity in the mirror networks, thalamus and cortical areas, specifically the fusiform gyrus which is associated with face and body perception. Their interpretation of the findings was that stimuli evoking emotional empathy were associated with increased BOLD signal in the neural regions that process emotional cues through the perception of information in both facial expression and body posture, in addition to understanding and allowing internal simulation of the possible mental state of the individual observed (*see Figure 2*). These areas were distinct from those recruited for cognitive empathy condition stimuli which were the left parahippocampal gyri and fusiform gyrus, cuneus and right middle frontal sulcus. This study suggests that emotional contagion may indeed occur through the internal simulation of our representation of another's emotional experience via a state matching neurological ability.

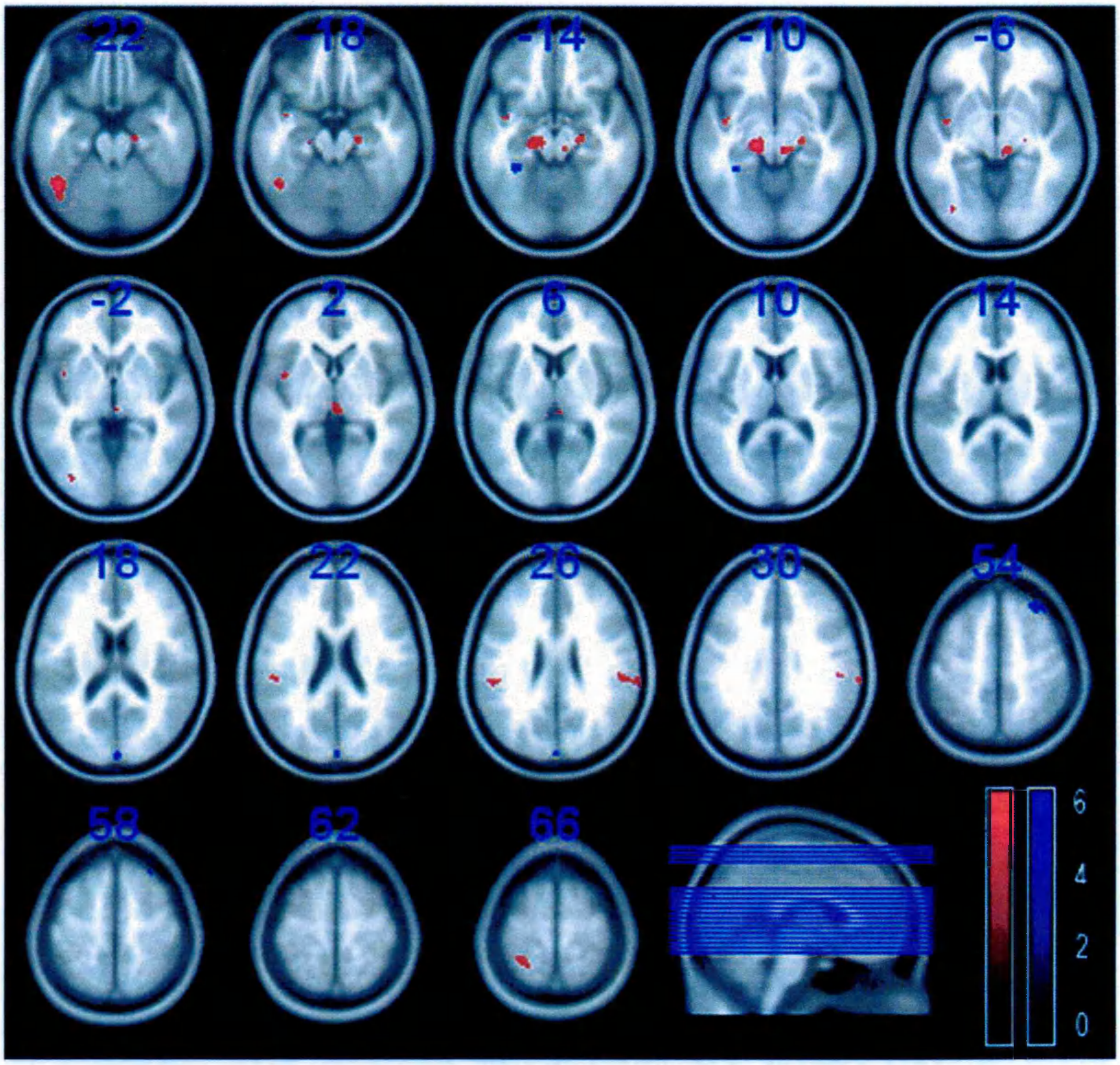

Figure 2: Axial sections with regions of brain showing greater BOLD responses to emotional versus cognitive empathy (red) and to cognitive versus emotional empathy (blue) (Nummenmaa et al., 2008).

1.3 Electrophysiological Correlates of Emotional Empathy

Recognition of emotional expression is a key component of emotional empathy (Blair, 2007; 2005); correct recognition of emotion in peers facilitates appropriate empathy responses and thus contributes to the regulation of social behaviour. The consideration of responses to facial expressions of emotion will form the key focus of the electrophysiological research into emotional empathy. Research into attendance to emotional stimuli shows attentional bias towards cues of emotional content, indicating that these cues are typically prioritised (Eastwood et al., 2003; Öhman et al., 2001; Vuilleumier et al 2001). A neurological dissociation has been observed between the neural patterns which code for the recognition of the structure of a face as an object within the environment and those which infer semantic meaning from expressions of affect (Eimer et al., 2003; Holmes et al., 2003; Bentin & Deouell, 2000). Furthermore, electrophysiological research has shown that the brain generates specific ERP component patterns and EEG waveform activity in response to facial expression stimuli, which will be discussed henceforth (Utama et al., 2009; Eimer & Holmes, 2007; Batty & Taylor, 2003; Eimer et al., 2003).

Event Related Potential (ERP) analysis is suitable to study responses to facial affect because it is a uniquely temporally accurate method of inquiry allowing investigation of the neural response to stimuli at millisecond resolution (Luck, 2005); therefore, despite ERP neural recording being spatially less accurate that other neural activity recording technologies, ERP can provide insight into the electrophysiological response of the brain to facial affect stimuli.

The electrophysiological correlates of facial affect recognition will be considered in temporally ascending order from the presentation of the facial affect stimuli. Correlates specific to facial affect stimuli have been observed from 100ms (Eimer & Holmes, 2007; Batty & Taylor, 2003; Pizzagalli et al., 1999). For example, an increase in the P100 (P1) component has been observed in response to fearful expressions of affect when compared with equivalently presented neutral faces at a latency of 120ms at prefrontally positioned electrodes (Eimer & Holmes, 2007). These early P100 effects are considered to reflect activation of the neural mechanisms which encode responses to stimuli with emotional content and, thus, would be predicted to be observed within ERP experimental paradigms using affect based stimuli arrays (Sato et al., 2001; Pizzagalli et al., 1999).

The anterior N100 (N1) has also been observed to increase in amplitude when elicited by fearful faces rather than happy or neutral faces; attention was also observed to modify this amplitude increase over the anterior N100 in response to fearful expressions (Luo et al., 2010). Other research reports that N100 amplitudes were reduced in response to fearful when compared to sad faces (Dennis et al., 2009).

Particularly well-researched is the modulation of the N170 component of the neural response. An effect at N170 is well-evidenced as a component of the electrophysiological response to the presence of a structure that resembles a face; however, there is some evidence that the emotional expression of the facial stimuli can also modulate the N170 component (Blau et al., 2007; Balconi & Pozzoli, 2003; Krolak-Salmon et al., 2001; Streit et al., 2000). Batty and Taylor (2003) had 26 participants observe unfamiliar faces expressing the six basic emotions (anger, disgust, fear, happiness, surprise and sadness), as well as neutral faces, during ERP recording. As well as an increased P100 effect at 90ms latency, emotional expressions mediated the N170 component response at 140ms, with positive emotions evoking the component with less latency than negative ones. Furthermore, Batty and Taylor (2003) observed that the amplitude of the N170 component was larger in response to expressions depicting fear, than in response to expressions of neutrality or surprise.

The N170 component has also been shown to be sensitive to the intensity of emotion represented in the visual stimuli; for example, Sprengelmeyer and Jentzsch (2006), in a study of 16 participants utilising stimuli arrays containing angry, disgusted and fearful facial expressions (varying in intensity at levels of 50%, 100%, 150%), found a significant increase in amplitude of the N170 by intensity; though it is worth noting that the N170 component was not found to be mediated by the specific emotion portrayed (Sprengelmeyer & Jentzsch, 2006). More recently, Utama et al (2009) investigated the effect of expression and intensity on the cerebral, electrophysiological response to facial stimuli. Images of seven facial emotions (neutral, anger, happiness, disgust, sadness, surprise and fear) were collated into presentation blocks for the experiment and, in addition, ten intensity graduated levels of expression were included to parametrically research the interaction between expression and intensity. The results showed that, in addition to P100 being correlated with the correct detection of facial emotion, the N170ms was modulated in response in association with intensity level. Both the P100 and N170 components were consistently found to originate in the right occipito-parietal region indicating that this cortical region is integral to affective response (Utama et al., 2009).

By contrast, some earlier described studies into the N170 ERP responses to facial expressions of emotion, shows no adaptation of the N170 component in response to facial affect stimuli (Eimer & Holmes, 2002; Bentin & Allison, 1996). Research that investigated the same range of facial expressions as Batty and Taylor (2003), showed no modulation of the N170 component in response to expressions of emotion; Eimer et al (2003) employed an experimental paradigm that presented the same basic six facial expressions with neutral, angry, disgusted, fearful, happy, sad, and surprised affective content. Eimer et al (2003) concluded that the N170 component of the ERP response may simply reflect the detection of a facial structure and be distinct from emotional processing. However, there were differences in the presentation of stimuli, whereas Eimer et al used modified facial images cropped to remove hair and clothing, thus the expression was abstracted from natural presentation, Batty & Taylor presented the expressions without cropping. Furthermore, Eimer et al (2003) required the participants to discern the emotional content of the photos, whereas Batty & Taylor's task required only that the participants attend to the stimuli. These factors may influence whether the N170 modulates with regards to the emotion of facial expression stimuli.

Spatial presentation and attending to the affective stimuli may modulate the P110 and N170 ERP components; research by Holmes et al (2003) presented stimulus blocks containing two faces and two non-face stimuli, the participant's attention was focused on one or other. Within the facial stimuli presented were depictions of fearful or neutral affect (Holmes et al., 2003). Attended fearful stimuli were associated with an increase in frontal positive amplitude of the P100 component; however, by contrast this influence of emotional expression was eradicated when the facial affect stimuli were presented outside of the attended area. The N170 component, conversely, showed no adaption in response to facial affect, however, a general effect was observed in the N170 component in response to attention; N170 amplitudes were enhanced when stimuli were attended by the participant (Holmes et al., 2003). It is concluded that the processing of facial affect is dependent upon, and modulated by, spatial presentation and participant attention, attention thus gates the neural mechanisms responsible for affective processing of facial expressions. It is, therefore, perhaps unclear whether the N170 component of the facial affect ERP is responsive to facial affect or if, in fact, N170 modulation is a correlate of the presence of a facial structure or attention to stimuli.

Despite much research on the N170 component and its association with emotional facial expressions, there is a paucity of literature evidencing changes in the P170.

Electrophysiological research exploring response to facial expressions of emotion has also evidenced presence of later ERP components (Balconi & Pozzoli, 2003; Sato et al., 2001; Eimer, 2000). In the previously described research by Eimer et al (2003), emotional facial stimuli were associated with a broadly distributed sustained positivity beyond P250ms post-stimulus. Furthermore, Batty and Taylor's (2003) research evidenced a late positive potential (LPP) modulation of amplitude at later latencies (330–420ms) across the frontal and central electrodes; the exact pattern of response was differentiated between the 6 presented emotions. The researchers discovered that the mean amplitude of these later latencies was highest for neutral faces and significant smaller responses were observed for stimuli portraying anger, fear and disgust. Interestingly, these results reflect previously reported ERP responses to visual affective stimuli which commonly evidence the presences of an increased positive amplitude slow wave at 300ms latency (Cuthbert et al., 2000; Diedrich et al., 1997).

Greater negative amplitude in response to fearful faces relative to neutral faces has been found to be elicited at lateral posterior electrodes between N220 and N320 post stimulus (Eimer et al., 2003). The results demonstrated that emotional expressions elicited a negative peak at 230 ms (N200/N2) over the posterior electrodes (Balconi & Pozzoli, 2003). Elevated N230 amplitudes were observed for expressions of anger, fear and surprise (Balconi & Pozzoli, 2003).

In conclusion, there are 3 ERP components identified as being potentially necessary to facilitate responses to facial expressions of emotion in others, these are; an increase in the amplitude at 100ms, potential modulation at 170ms with regards to amplitude and/or latency of response, and adaptation at 200-300ms (although the exact manifestation of this adaptation is not consistently reported). As facial affect recognition is a key factor in empathy processing and empathy well-evidenced as being disrupted and/or reduced in high CU trait individuals, it is suggested that CU traits may be associated with variation in the manifestation of these ERP components (Wilson et al., 2011; Hastings et al., 2008; Blair, 2006). This will be considered in chapter 3.

1.4 Cognitive Empathy

As previously explained, cognitive empathy is a second pathway of the empathy construct; it is theoretically and demonstrably dissociable from the emotional empathy counterpart. It is the role of cognitive empathy to allow a person to abstractly put themselves in the mind of another and, thereby, determine the other's mental state by using social and environmental cues, as well as the knowledge that another's point of view may be different from one's own, a process akin to Theory of Mind (Premack & Woodruff, 1978) (Preston et al., 2007).

Research has identified neural areas recruited for theory of mind capacity; the prefrontal cortex, paracingulate gyrus, superior temporal sulcus, the temporal poles, and the temporoparietal junction (Amodio & Frith, 2006; Gallagher & Frith, 2003; Saxe & Kanwisher, 2003). In addition, the medial frontal lobes have been implicated in Theory of Mind processing (Gallagher & Frith, 2003). These brain areas are responsible for higher cognitive functions and operate at a more voluntary and conscious level; they differ from the areas active during affective empathy. When asked to consider the psychological characteristics of another individual, human or non-human, regions of the brain associated with Theory of Mind are activated (Mitchell et al., 2005).

Using PET (Positron Emission Tomography) Fletcher et al (1995) imaged participants whilst they engaged in reading and answering questions about stories involving complex mental states in the characters (Theory of Mind (ToM) stories) verses stories involving inferences of physical cause and effect (named "physical" stories). Fletcher et al compared the activation of cortical areas during the ToM and physical story conditions; analysis of the neural scans revealed increased activation in the medial frontal gyrus on the left (BA 8/9), the posterior cingulate cortex and the right inferior parietal cortex (BA 40) at the temporoparietal junction in response to the stories requiring Theory of Mind.

In a partial replication of Fletcher et al (1995), but employing the greater spatial resolution of fMRI, Gallagher et al (2000) recruited the same Theory of Mind and physical stories, as well as written stories; furthermore participants were shown humorous cartoons expected to prompt the cognitive attribution of mental states to the characters. Gallagher et al (2000) observed increased BOLD signal to Theory of Mind stimuli, specifically in the Brodmann areas 8/9 and the border of 10 and 32 relating to the paracingulate sulcus. In a subsequent study, when participants were tasked with playing a computerised version of the game 'stone, paper, scissors', the medial prefrontal cortex showed increased activation when the participants were under the impression they are playing against the experimenter; however, a condition in which the participant believed that they were playing against a computer failed to evoked similar activation suggesting the medial prefrontal cortex is associated with inferring the mental state of peers (Gallagher et al., 2003).

Castelli et al (2000) built on work by Heider and Simmel (1944) who demonstrated that geometric shapes could, when animated, provoke the attribution of an internal state, despite the impossibility of an internal state existing. Castelli et al predicted that Theory of Mind animations, but not the Random animations, would elicit the activation of mental state attribution neurological pathways in the brain. In line with previous research, the results presented increased activation in the medial prefrontal cortex, temporoparietal junction (superior temporal sulcus), basal temporal region (fusiform gyrus and temporal poles adjacent to the amygdala), and occipital cortex. These results are replicated by Klin et al (2000).

Research looking specifically at cognitive empathy with regards to the deliberate effort to imagine the emotional situation of another person as if it is happening to you is limited; However, Preston et al (2007) explored the responses of individuals when imagining an emotional experience from another's perspective using positron emission tomography (PET) combined with psychophysiology in a study during which participants imagined: a personal experience of fear or anger from their own past; an equivalent experience from another person as if it were happening to them; and a nonemotional experience from their own past. Their results suggest that when participants imagined a scenario to which they could relate, there were no differences between the cortical areas recruited for personal and non-personal imagery. The authors suggest that this finding is reflective of the recruitment of mirror neurons when individuals activate their own emotion-producing substrates to facilitate understanding of a peer's emotional state of another, a finding reminiscent of previous research (Singer et al., 2004; Carr et al., 2003; Preston & de Waal, 2002; Gallese, 2001). However, when participants choose a scenario with which they could not relate, there were differences between the personal and non-personal scenario conditions including decreased psychophysiological responses and recruitment of a region between the inferior temporal and fusiform gyri. These observations serve as an extension of other research that suggests that participants do not activate their own feeling substrates to the same extent when imagining an event from another's perspective (Jackson et al., 2006, 2005; Ruby & Decety, 2004). Therefore, personal experience and the ability to relate to another's situation may mediate cognitive empathy.

These neurological areas associated with inferring the mental state of others through cognitive empathy are, importantly, distinct from those associated with emotional empathy (Shamay-Tsoory et al., 2009). This delineation of the neural pathways associated with emotional and cognitive empathy further supports the theory that empathy is not a single ability, but one that can be differentiated into cognitive and affective component parts. Research has explored empathy for pain in others in individuals who have a congenital insensitivity to pain and thus have little experience of pain themselves (Danziger et al., 2006). 12 patients were recruited from 7 families known to be afflicted with pain insensitivity (5 males, 7 females) and were thoroughly tested for pain insensitivity showing a complete absence of distress, grimacing or withdrawal reaction to prolonged pinpricks, strong pressure, soft tissue pinching and noxious thermal stimuli (0 and 50°C) applied to both the proximal and distal parts of the four limbs and to the face (Danziger et al., 2006). Participants were requested to rate imaginary painful situations, facial expressions of pain and observation of pain-inducing video events which were played without any visible or audible pain-related behaviour. Counter intuitively, ratings of the verbally presented imaginary painful situations, exploring the participants' semantic knowledge of others' experience of painful stimuli, and the successful recognition of pain expression stimuli were not significantly different from healthy controls (Danziger et al., 2006). However, ratings of recorded painful events were significantly lower than controls, as were aversive emotional responses to the videos (Danziger et al., 2006). Inferred pain in others from facial pain expressions and from pain-inducing events, were correlated with differences in emotional empathy in the pain insensitivity group but not in controls. This research suggests that cognitive empathy is possible even without personal experience of an emotion. However, social information, such as expressions of pain, relevant to the event needs to be available for correct inference and, thereby, empathy. Without this social information, one might struggle to empathise through environmental information only; this suggests that cognitive empathy may not be sufficient for empathy when isolated from complimentary affective components.

An fMRI study by Völlm et al (2006), which recruited a non-verbal cartoon task to compare brain activations during theory of mind and empathetic responding, observed congruent results to Danzinger et al (2006). Völlm et al (2006) report mutual cortical regions of activation for ToM and empathy responses including: the medial prefrontal cortex, temporoparietal junction and temporal poles. However, ToM stimuli was associated with increased activations in lateral orbitofrontal cortex, middle frontal gyrus, cuneus and superior temporal gyrus, whereas empathetic responding revealed activations of the paracingulate, anterior and posterior cingulate and amygdala. These findings again suggest that, for an empathic response to occur, the brain requires the affective, as well as the cognitive, neurological processing abilities associated with the empathy construct to be active.

Empathy for others' pain is a commonly used as a test of the more cognitive aspect of human empathy, featuring the aptitude to correctly assess and appropriately respond to the painful experiences of others often with only situational rather than social (expression) information available in the stimuli (Decety & Jackson, 2006). Empathy for others' situational pain will be the focus of the cognitive area of this research programme. Several neurological correlates of empathy for pain have been observed in various painful empathy scenarios (Lamm et al., 2011). Empathy for pain is a complex psychological process theorised to have discrete sensory and affective components represented in the neural network known as the 'pain matrix' (Rainville, 2002; Peyron et al., 2000). The neural components of the network governing pain empathy are well documented. fMRI research has shown that several brain areas are active both when one experiences an affective state and when one observes a symmetrical emotional state in another; for example Botvinick et al (2005) presented participants with short videos of faces depicting either moderate pain or no pain, the participants also underwent painful and non-painful thermal stimulation, it was observed that the others facial expressions of pain were associated with BOLD signals in cortical areas which were also activated by the painful thermal stimulus. These cortical areas included the anterior cingulate cortex (ACC) an area responsible for the integration of consciousness and emotional responses, and the insula functionally associated with the integration of sensory, emotional and social stimuli from the limbic system and sensory cortices (Botvinick et al., 2005). Similar observations are reported by Singer et al (2004).

Duel activation of areas to one's own pain and that of other is possibly facilitated by the presence of mirror neurons (Saarela et al., 2007). Saarela et al (2007) have further observed that the magnitude of the activation in these regions is governed by one's cognitive estimate of the pain levels experienced by their peer. Both the activity of the insula and ACC in response to the presentation of painful expressions was correlated with the estimates of intensity of pain being experienced in the picture; in addition, the insula and left inferior frontal area's scale of activation correlated with the self-reported empathy levels (Saarela et al., 2007). Facial expressions of pain are not the only painful stimuli with which activity magnitude in the insula and ACC activation have correlated; subjective estimation of pain intensity with regards to painful stimuli applied to hands and feet also illicit this neural empathy response (Jackson et al., 2006; Jackson et al., 2006). The semantic information contained within painful stimuli administered to either oneself or a peer is, therefore, processed primarily within these high cognitive processing areas, an assertion evidenced by a meta-analysis conducted by Lamm et al (2011) who observe that the neural network associated with empathy processing typically activates the bilateral anterior insular cortex and medial/anterior cingulated cortex. Furthermore, Lamm et al (2011) found that variation in brain responses outside of the insular/ACC pathway constant was due to variation in the experimental paradigm used.

Although the above findings concentrate predominately on functional imaging research, other neural imaging technologies have revealed a role for further neural networks in the empathy response to pain experienced by others (Avenanti et al., 2006; Avenanti et al., 2005). Though the insula and ACC are the most commonly evidenced areas of the brain governing empathy for pain, and thus it is posited by

Lamm et al (2011) that it is the affective and cognitive components of empathy for pain that is contagious and not the somatosensory experience, there is, however, some sporadic evidence that the sensorimotor cortex can be also involved in empathic responses to painful stimuli (Avenanti et al., 2006; Avenanti et al., 2005). Avenanti et al (2005) used transcranial magnetic stimulation (TMS) and electromyography (EMG) recording to observe motor representations of hand muscles during participants' presentation with stimuli depicting needles pricking hands or feet of a human peer or non-sentient objects. A decrease in amplitude of motor-evoked potentials positioned symmetrically to the specific muscle penetrated by the needle in the other person, in comparison to the non-sentient objects, was observed; the reported inhibition also correlated with the participant's subjective ratings of the peer's pain (Avenanti et al., 2005). This involvement of somatosensory networks in the empathic response to painful stimuli is further evidenced in a review paper by Avenanti and Aglioti (2006) in which they argue that the sensorimotor node of the pain response matrix, including the primary and secondary somatosensory cortices, the cerebellum and motor areas, as well as the affective node comprised of the ACC and the insula, are required for a function empathy response to pain in others.

1.5 Evoked Potentials Associated with Cognitive Empathy to Pain

Somatosensory-evoked potentials (SEPs) have been recruited to explore the response of the somatic network to the observation of painful and tactile stimuli in a peer. Bufalari et al (2007) presented participants with short video stimuli portraying pain and tactile stimuli being experienced by others. The research revealed that variations in the amplitude of the P450 SEP correlated with the intensity of the stimuli but not the unpleasantness; the P450 component is associated with the primary somatosensory cortex (Bufalari et al., 2007). Thus, the shared experience component of empathy for pain may be facilitated not only by neural networks processing the affective, semantic information but also by the somatosensory and motor networks. A finding supported in part by the employment of laser-evoked potential (LEP) paradigms to investigate the modulation of empathetic response to pain observed in others by pain experienced by the participant, as induced by the laser stimuli (Valeriani et al., 2008). It was observed that when participants viewed stimuli depicting needles penetrating a peer's hand, the amplitude of the N100/P100 LEP component decreased at the somatic nodes of the pain matrix (Valeriani et al., 2008). Furthermore, the modulations of the P110/N100 component reductions were correlated with participant's ratings of their own pain as higher than the discomfort experienced by their peer (Valeriani et al., 2008); thus, the participant's own level of pain modulated their empathy response.

In addition to the somatosensory research use of SEPs and LEPs, there is further research which looks more broadly at event related potential (ERP) components associated with research into empathy for pain in others. Fan and Han (2008) recruited 31 neurotypical participants (16 males and 15 females, although artefacts excluded 5 participants from the data) to investigate the ERP component responses associated with participant empathic response to pain in others. The visual stimuli depicting pain in another included 40 digital colour photographic stimuli portraying one hand or two hands in both potentially painful real-life accidents (the examples given are a hand trapped in a door or cut by scissors) and environmentally symmetrical but neutral situations (Fan & Han, 2008). These stimuli were transformed into cartoons using software and presented for 200ms (Fan & Han, 2008). Analysis of main effects revealed that empathy for pain reported frontal-central lobe differential activation between painful and neutral stimuli at 140ms, as well as over the central–parietal cortex after 380 ms; this response was more pronounced in the left hemispheres (Fan & Han, 2008). It is also concluded by Fan and Han (2008) that responses at 140–180ms could be correlated with participant reports of personal distress and the intensity of the painful stimulus. A positive shift in the latency at 100ms-280ms was reported when the participants were asked to make a judgement as to the pain experienced by the other, by comparison to a task which required the participant to count the number of hands; furthermore, the P300 component was larger in amplitude during this pain judgment task (Fan & Han, 2008). When this study is considered with other similar research, empathy for pain seems to evoke an early frontal N120 processing component and central–parietal late-positive potentials (LPPs) which may be reflective of semantic, top-down processing (Fan & Han, 2008; Han et al., 2008; Decety et al., 2010).

In an extension of the above research, Li and Han (2010) investigated the interaction of self-other perspective when viewing pain stimuli. Using a smaller sample of 24 neurotypical adults (12 males and 12 females) and stimuli similar to those used in Fan and Han's (2008) research (40 photographs showing hands in painful accident situations and environmentally similar but non-painful situations), Li and Han (2010) explored the effect of self and other perspective on the ERP components related to painful stimuli. Ratings of pain were higher in the self-perspective condition than in the imagined other perspective condition; however, there was no observed difference in the scores of unpleasantness between the conditions (Li & Han, 2010). With regards to the ERP components the paper reports that all stimuli across both conditions evoked a negative component between 80 and 120ms (N110) at the fronto-central electrodes, followed by a positive component (P160) and a negative deflection later at 220–270ms (N240) latency; at the longer latencies a negative component at 310–350ms (N320) and a positivity deflection at 340–740ms (P300) maximal in amplitude at the same recording site were reported (Li & Han, 2010) (*see Figure 3*).

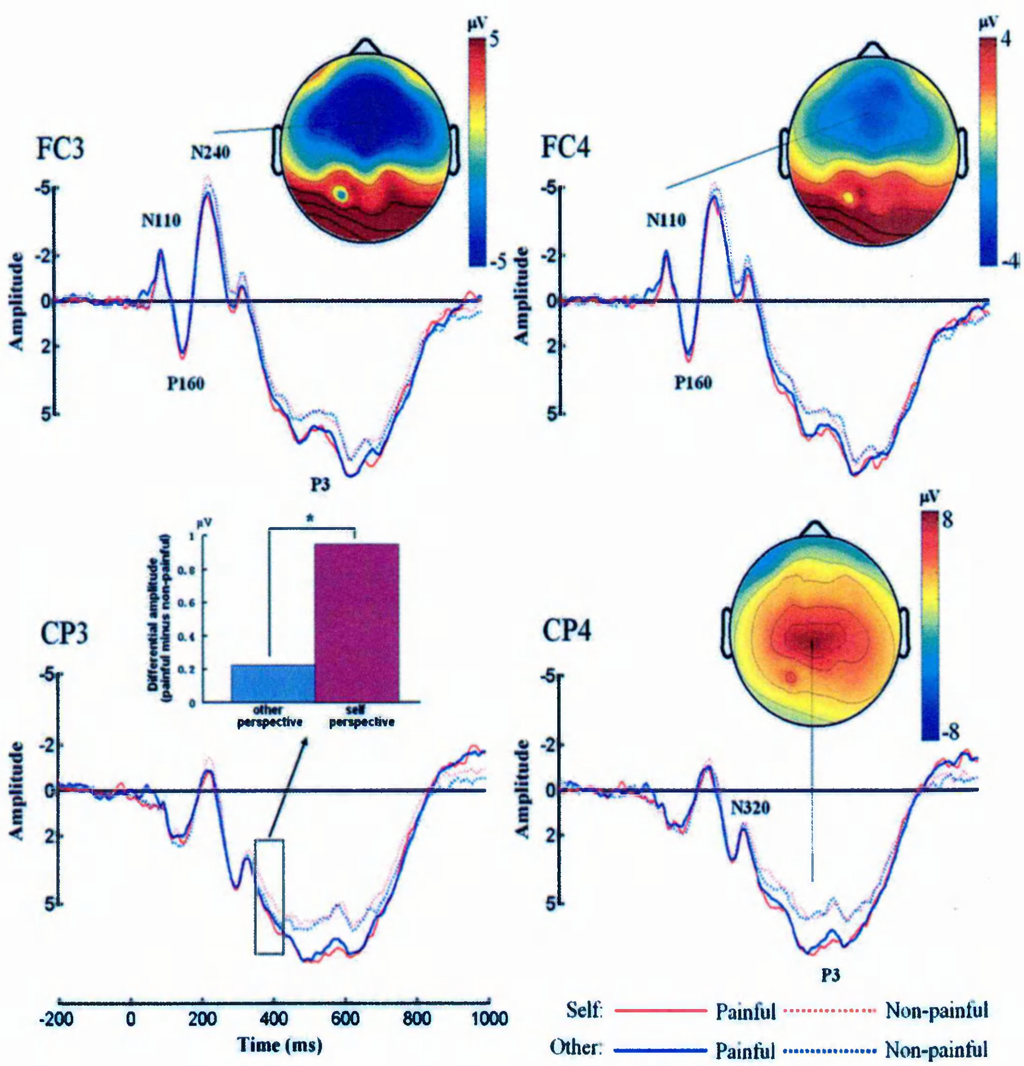

Figure 3: ERPs recorded at the frontal-central electrodes FC3 and FC4 and central-parietal electrodes CP3 and CP4 plotted respectively to painful and non-painful stimuli in the self- and other-perspective conditions (Li & Han, 2010).

The pain condition was associated with ERPs with maximal amplitudes at 160–180ms (parietal electrodes), 230–250ms (frontal electrodes; central electrodes), 290–360ms (frontal electrodes), 370–420ms (frontal electrodes; central electrodes; parietal electrodes), 420–500ms (frontal electrodes; central electrodes; parietal electrodes), 500–580ms (frontal electrodes; central electrodes; parietal electrodes) and 630–700ms (frontal electrodes; central electrodes; parietal electrodes) (Li & Han, 2010). These components were associated with a positive shift in latency by comparison to the control, matched stimuli (Li & Han, 2010). Li and Han (2010) also observed that increased ERP component amplitude at 370–420ms at the central–parietal electrode sites was associated with the self-perspective when compared to the other perspective. Therefore, not only does empathy for pain evoke differential and observable ERP components, but one's imagined perspective (self or other) modulates the response.

The discussed research leads to the consideration that a social response to pain in others is a key component of the empathy construct. Furthermore, the neurological response to stimuli presenting depictions of pain in others creates measurable electrophysiological components as evidenced through ERP research paradigms (Li & Han, 2010; Fan & Han, 2008; Goubert et al., 2005). This review of relevant literature considering empathy for pain suggests that this could be a productive area of study by using an ERP research paradigm to explore potential differential electrophysiological response to pain in others in those with varying manifestation of callous and unemotional traits (CU traits).

1.6 Empathy Processing in Callous and Unemotional Individuals

Antisocial personality disorder (ASPD) has been well established as being characterised by a dysfunction in empathy processing and consequently a disregard for the emotions of others (Blair, 2005). ASPD is considered to represent a heterogeneous population in which sub- groups can be distinguished by the manifestation of personality traits known as callous and unemotional traits; although not all individuals with ASPD will have higher than average callous and unemotional traits, there is a sub-group who are characterised by their presentation of extremely high levels of this trait and a congruent extreme lack of empathy, this group are known as psychopaths (Soderstrom, 2003). Conduct disorder has been similarly established to represent a dichotomous population of those with extreme levels of callous and unemotional traits (Frick & Ellis, 1999).

Callous and Unemotional traits are exhibited by those individuals who have a lack of remorse or guilt, a callous-lack of empathy, a decreased concern about performance and shallow or deficient affect (Frick & Moffitt, 2010). The empathy deficit which forms a core factor in callous and unemotional traits will be the focus of the following thesis. The empathy deficits associated with callous and unemotional traits are, however, not mono-dimensional in nature but instead are, similarly to the construct of empathy itself, complex. Callous and unemotional traits are more strongly associated with deficits in affective empathy than in cognitive empathy. Individuals who present with high levels of callous and unemotional traits, typically report intact cognitive empathy and disrupted emotional empathy as displayed in psychopaths

(Blair, 2008, 2005; Richell et al., 2003); however, some research reports global reductions in empathy processing ability across the emotional and cognitive components in those with high CU traits (Dadds et al., 2009). The disparate nature of these components of empathy and their relation with callous and unemotional traits is to be explored in detail in chapter 3.

As empathy dysfunction is a core factor in CU traits it may seem redundant to consider both empathy and CU traits within the research. However, as empathy consists of the two fractionated abilities of CE and EE, providing both the congruency of affective signals between individuals and the higher cognitive inference required to produce the complete ability of empathy, it is necessary to consider these facets of empathy with regards to CU traits. Such an in depth consideration of empathy processing in relation to CU traits within a general sample could not be achieved through currently available measures of CU trait alone, which do not seek to consider the EE and CE facets of empathy and, instead, often portray empathy as a uni-dimensional construct (eg. The Inventory of Callous-Unemotional Traits (Frick, 2004)). Furthermore, the dysfunction of empathy within high CU traits manifests differently when considering CE and EE as individual neural processes.

Chapter 3 will consider in detail the effects of callous and unemotional traits. In addition, the state of our current knowledge regarding these traits will be discussed, as well as how the current thesis will contribute unique information to this knowledge base, furthering the understanding of these traits.

CHAPTER 2:

EMOTION PROCESSING IN THE NEUROTYPICAL INDIVIDUAL

Emotions are thought to arise from a combination of interoceptive awareness of the body and the neurological triggers of affective state generation and awareness (Pollatos et al., 2007; Heims et al., 2004). Areas of the brain that process emotion were first considered in pioneering research by Broca (1878) who postulated that emotion is generated by a group of structures in the midbrain called the limbic system; these structures included the amygdala, hypothalamus, hippocampus and the cingulate gyrus.

2.1 The Neurotypical Emotional Response

There have been several meta-analyses exploring the neural response to affective stimuli. One of the earliest, Phan et al (2002), assimilated 55 fMRI and PET neuroimaging studies to explore the brain responses to emotions of fear, sadness, disgust, anger, and happiness; the included research targeted specifically higher neural processing of emotion rather than reflexive or motor responses. Phan et al (2002) measured peak activation coordinates which were standardised through conversion into a standard space and plotted onto canonical 3-D brain renderings; they divided the brain into 20 discrete regions, categorising each region's responsiveness to the emotions. Furthermore, various emotion evocation modalities were explored including visual, auditory and recall. Statistical chi-squared analysis investigated, through tabulation, whether the studies recorded neurological responses during an emotion in a particular neural area. 66% of studies prompting fear found increased activity in amygdala; furthermore, it is observed that 20% of studies inducing happiness and 15% of studies inducing sadness also report increased activity in the amygdala. The cingulate cortex was more active in studies aiming to invoke sadness, happiness and anger (46%, 20% and 20% respectively). Distinct emotional responses were also observed in the basal ganglia for emotions of happiness and disgust and, more broadly, in the medial prefrontal cortex (happiness 60%, anger 55%, sadness 40%, disgust 40%, and fear 30%). Phan et al's analysis also indicates that affective evocation through visual stimuli activated more strongly the occipital cortex and the amygdala, whereas, if the emotion was induced through recall or mental imagery, the anterior cingulate and insula where active. Finally, tasks which required emotional consideration and had greater cognitive demand recruited the anterior cingulate and insula regions.

Murphy et al (2003) built on the work of Phan et al using a larger sample of 106 research papers employing $H_2{}^{15}O$ PET or fMRI neuroimaging techniques, published between January 1994 and December 2001. Again, the data set was standardised to a consistent anatomical space and used only healthy, neurotypical participants. Fear, disgust, anger, happiness and sadness were included in the meta-analysis which looked for increases in measured activity in the brain. 3-D Kolmogorov-Smirnov (KS1 and KS3) statistics were recruited to compare spatial patterns of neural activation for the emotional stimuli categories. Murphy et al (2003) observe that the amygdala activity was associated with fear induction in 62.5%, but less than 12.5% for the other affective states, suggesting that fear is most commonly associated with activity in amygdala.

Furthermore, it is reported that the insula/operculum and globus pallidus were active most consistently in research considering processing of disgust. Anger, by comparison, was seen to activate the lateral orbital frontal cortex in all of the included research investigating anger specifically; 62.5% of fear research also showed activation in the lateral orbital frontal cortex. The anterior cingulate cortex was associated with both happiness and sadness. Therefore, similarly to Phan et al (2002), Murphy et al (2003) show that specific cortical areas are associated with response to discrete affective induction in healthy individuals. Barrett et al's (2006) consideration of 161 papers also observed neurological patterns of responses to discrete valence states mostly consistent with Phan et al and Murphy et al.

Further work by Vytal and Hamann (2010) considering 83 PET and fMRI neuroimaging studies built on these findings. Activation likelihood estimation was recruited to perform statistical comparisons of voxel activation across studies for discrete emotional experiences. Again, distinguishable patterns of activity were found of each emotion. Findings for invocation of happiness were associated with activity in 9 neural regions; happiness in this meta-analysis was differentiated more strongly from the other emotional categories, with activation situated in the right superior temporal gyrus and left rostral anterior cingulate cortex when compared with other emotional states. Furthermore, sadness, an emotion previously not associated with strong distinctive activation, was consistently associated with 35 regional activations; including greatest activation of the left medial frontal gyrus, as well as activity in right middle temporal gyrus, and right inferior frontal gyrus. Anger was distinguished from other valence states in the activation of the bilateral inferior frontal gyrus and in the right parahippocampal gyrus. Disgust recruited greater activity in the right putamen and the left insula, mirroring Murphy et al's findings. Again, fear was primarily associated with the activation in the amygdala. Despite different statistical techniques, a pattern of discrete neural responses is emerging for different affective state processing (*see Figure 4*). Indeed, it is the conclusion of Vytal and Hamann (2010) that basic emotional states can be distinguished by their brain activation correlates, as measured by the modalities of PET and fMRI.

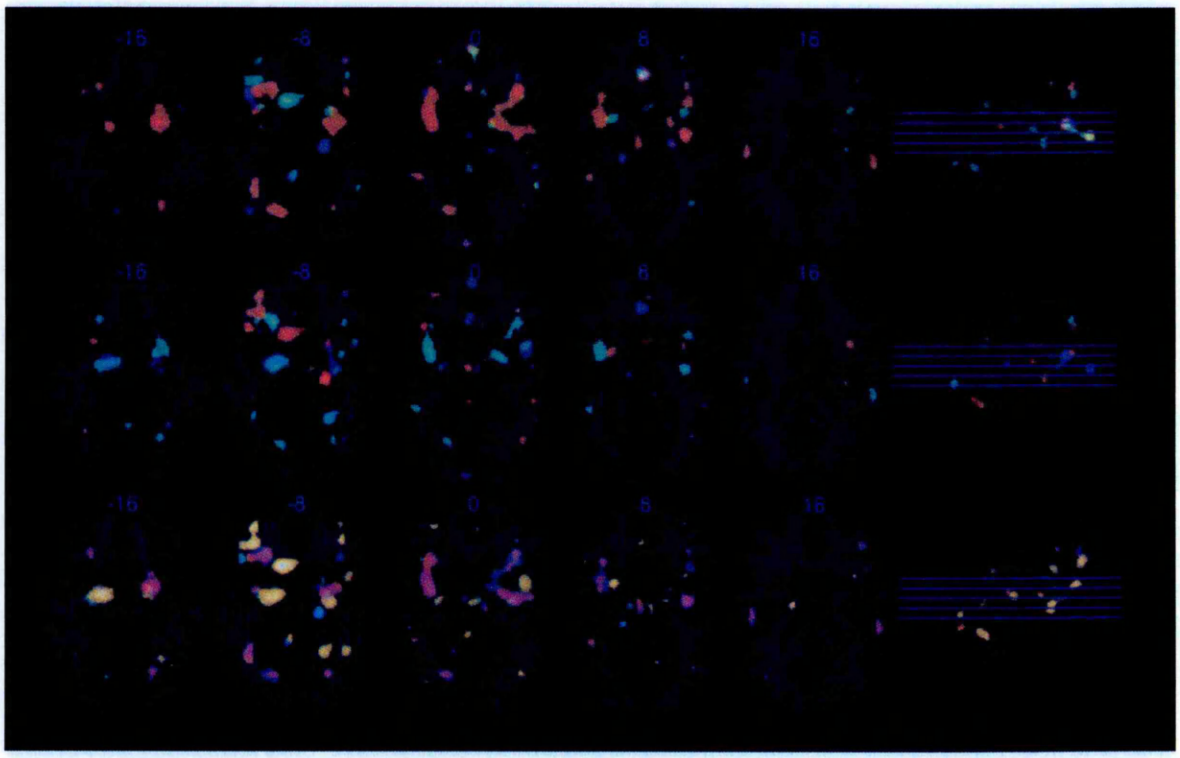

Figure 4: Brain regions whose activity discriminated between each pair of basic emotion . Blue numbers indicate inferior-superior level: Red: happiness vs. disgust; Green: happiness vs. sadness; Blue: happiness vs. anger. Middle panel: Red: sadness vs. anger; Green: fear vs. disgust; Blue: fear vs. happiness. Lower panel: Red: sadness vs. disgust; Green: fear vs. anger; Blue: anger vs. disgust; Gold: fear vs. sadness (Vytal & Hamann, 2010).

There are two prominent theories of emotion genesis in the brain; the locationist theory and the constructionist theory. The locationist approach, first postulated by Panksepp (1998) considers that emotions exist as discrete valence categories and are represented as such in the brain by their genesis being specifically localised to separate brain regions or networks. Whereas, the constructionist approach to the neural generation of emotional sensations proposes that, rather than being represented discretely in the brain, emotions arise from the amalgamation of areas and networks common to affective response and cognitive processing, forming lesser or greater constituents of difference affective valence states (Lindquist et al., 2012; Kober et al., 2008) (*see Figure 5).* So far the considered analysis provides partial support for both theories; the data suggest that, although there are areas of the brain which are strongly associated with discrete emotional states, activity is not mutually exclusive within the area and multiple, often overlapping regions, and networks can be observed to be active during emotion induction.

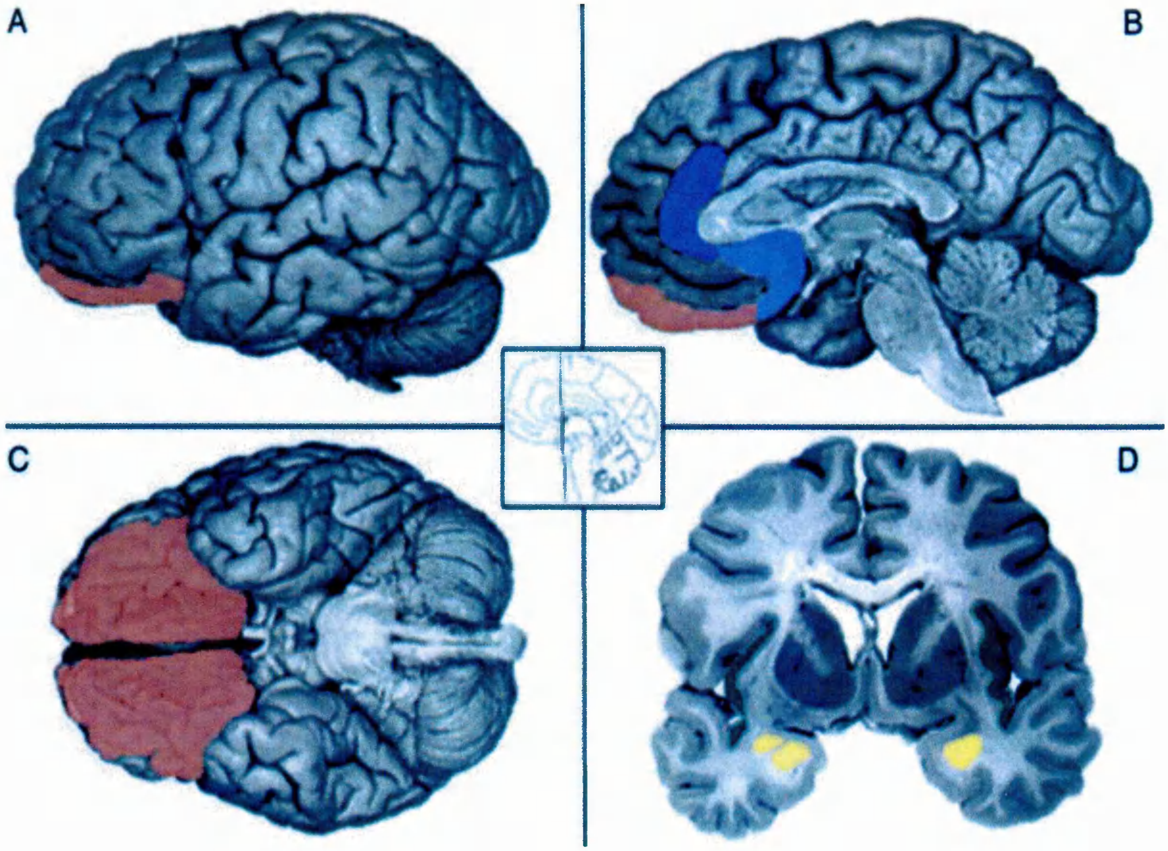

Figure 5: Brain regions hypothesised to be associated with emotion categories are depicted. Fear: amygdala (yellow); Disgust: insula (green); Anger: OFC (red); Sadness: ACC (blue). (Lindquist et al., 2012).

More recent meta-analytical work by Kober et al (2008) analysed 162 PET and fMRI neuroimaging studies and observed six constructionist networks that generate emotion, instead of previously considered discrete neural locales:

1. The Occipital/ Visual Association group (areas V8 and V4 of the primary visual cortex, the medial temporal lobe, and the lateral occipital cortex) which respond primarily to visual affective stimuli.
2. The Medial Posterior group (posterior cingulate cortex and the V1) again modulating visual response.

3. The Cognitive/ Motor Network group (right frontal operculum, the right interior frontal gyrus, and pre-supplementray motor area) integrate affect with high cognitive functions and motor control.
4. The Lateral Paralimbic group (insula, frontal operculum, posterior orbitofrontal cortex, anterior/mid insula, temporal cortex, dorsal putamen and left hippocampus) assesses the value of affective stimuli with regards to motivating behaviour.
5. The Medial Prefrontal Cortex group (dorsal medial prefrontal cortex, pregenual anterior cingulate cortex, and rostral dorsal anterior cingulate cortex) are considered to be important for the regulation of affect.
6. The Core Limbic group (amygdala, hypothalamus, periaqueductal gray, thalamus regions, striatum, globus pallidus and thalamus) which generates valence and assesses affective significance.

The findings suggest a constructionist view of emotion genesis and affective response may be a more accurate reflection of neurological responses to emotional states (*see Figure 6*).

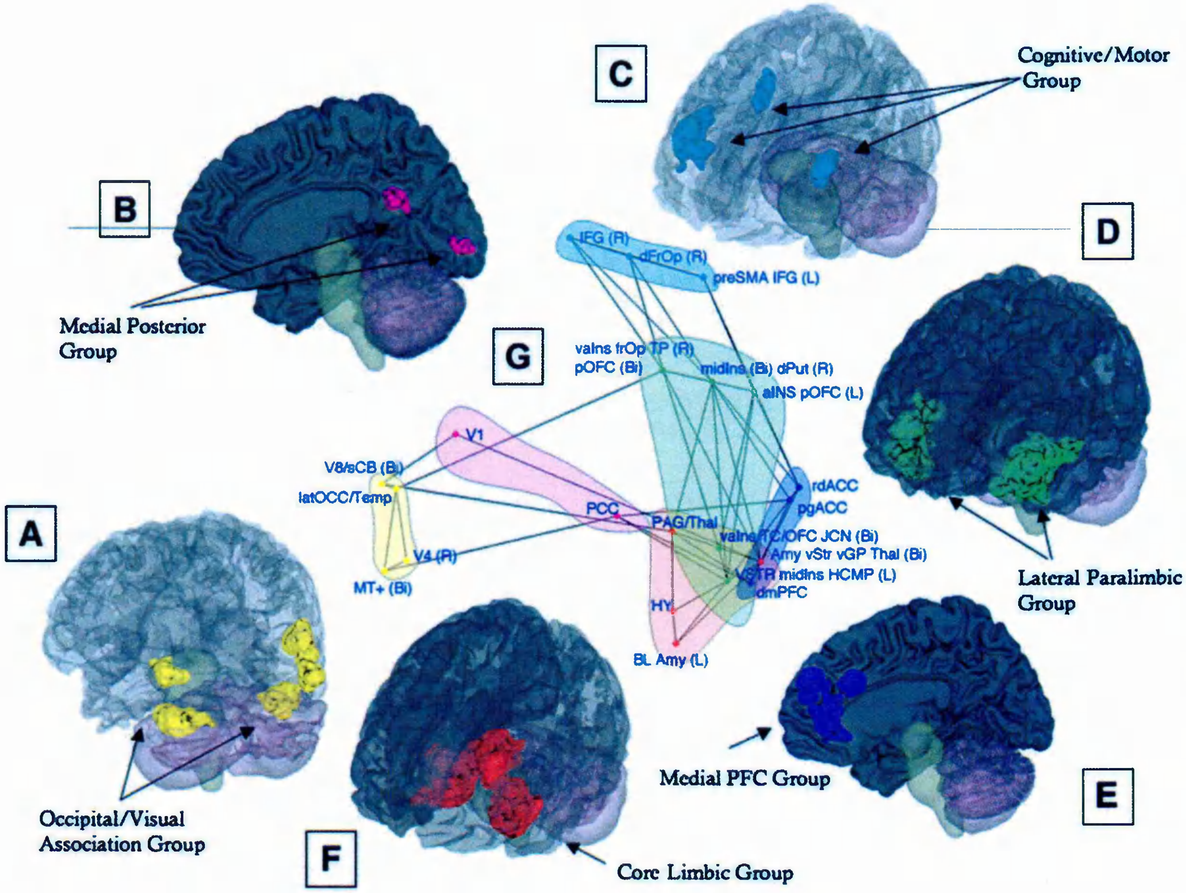

Figure 6: (A–F) The six functional groups; regions in each group are rendered in a unique color. (G) Both regions and co-activation lines are displayed on a "flattened" map of the connectivity space." (Kober et al., 2008).

In a meta-analysis by Lindquist et al (2012), 91 PET and fMRI research papers were considered in order to compare the locationist and constructionist theories of affect generation. Multilevel Peak Kernel Density Analysis was recruited to convert the individual responses into a standardised neural reference space, evaluating emotion experience or perception for discrete emotions (anger, fear, happiness, sadness, and disgust). Chi-squared analysis indicated whether neural regions presented increases in activity for the experience or perception of an emotion, by comparison to other affective categories. Logistic regression considered the selectivity of a neural region to an exclusive emotion category through presenting increased activations for only one emotional category. Brain regions were observed to be associated with discrete neural correlates of activation in a similar manner to previous meta-analysis; however, no neural region revealed functional exclusivity for the analysed emotions of fear, disgust, happiness, sadness or anger. The amygdala, anterior insula and orbitofrontal cortex were considered to provide a base level of pleasant or unpleasant affective sensation which was then integrated with wider neural networks. For example, the insula may process affective awareness, the orbitofrontal cortex assimilating internal and external somatosensory stimuli with emotional response and decision making processes, the anterior cingulate and dorsolateral prefrontal cortex regulate attention and provide appropriate processing of motor responses, and, finally, the dorsolateral prefrontal cortex integrating affective responses with higher cognitive functions and executive attention. Lindquist et al concluded that the neural correlate regions associated with the emotion states are not exclusive to that emotion and, instead, form networks integrating affect with cognitive and perceptual processing in the neurotypical individual. Thus, the findings from this meta-analysis fail to support the key locationist assumption and lend increased support for the constructionist approach to emotion genesis.

2.2 ERP Components Associated with Affective Valence

Increased P100 components are well cited in research which considers ERPs to affective picture stimuli (Carretie et al.,2006; Carretie et al., 2004; Delplanque et al., 2004). Research which specifically investigated the role of the P100 was conducted by Smith et al (2003). 34 undergraduates were recruited for the research, these participants were presented with 20 positive and 20 negative pictures which were selected from the International Affective Picture System (IAPS) and matched for affective impact based on the self-reported arousal scores included with the IAPS (Smith et al., 2003). Principal components analysis revealed that the P100 amplitude in response to the negative stimuli were larger than for positive stimuli at an average latency of 117ms over the occipital electrodes. Smith et al (2003) concluded that the modulation of the P100 component in response to different emotional stimuli is evidence of a neural differentiation of positive and negative stimuli in emotional valence and a negativity bias in attention allocation. This affective valence modification of the P100 ERP component and negative stimuli response bias was replicated by Carretie et al (2006; 2004). Delplanque et al (2004) also observed modulation of the P100 during an oddball task, though at the parietal–occipital sites at 150-165ms latency; however, this study was more limited with regards to the number of picture stimuli used (25 in each condition, positive, neutral and negative) which reduces the power of the average response. An enlargement of the P100 amplitude across the occipital and parietal, electrode sites was seen in response to the presence of stimuli with emotionally stimulating content. This response is biased towards larger responses to negative stimuli. Further to the P100 effects found by Delplanque et al (2004) and Carretie et al (2004), a N100 component (176ms) has been found to be resistant to habituation to continued presentation of unpleasant affective stimuli in the general population (Carretie et al., 2003), implicating the N100 component as a constituent of response to negative emotional stimuli.

In addition to the P100 adaptation to affective stimuli, there are other ERP components associated with affect response in the 200-300ms range. ERP components of 200–300ms latency are postulated to be associated with discrimination and response selection (Di Russo et al., 2006). Delplanque et al (2004) also observed effects at the following latencies; P200 from 180 to 213ms, N200 from 233 to 323ms, P300a from 343 to 390ms and P300b from 406 to 603ms. Amplitudes of the P300b and P200 revealed a significant effect. The P200 related to the unpleasant stimuli was found to be more positive in amplitude than the P200 to pleasant stimuli at parieto-occipital sites, though the P200 was larger to pleasant than to neutral stimuli over most electrode sites (Delplanque et al., 2004). The P300b component was observed to be higher in amplitude to negative stimuli than positive ones at the fronto-central sites (Delplanque et al., 2004). This research evidences specific ERP waveform responses to positive and negative affective stimuli.

Carretie et al (2004) also observed adaptation of the N200 and P200 components in response to presented emotional stimuli. 37 students partook in a passive oddball paradigm during which 378 stimuli were presented; 303 of an emotionally neutral picture (a wristwatch) and 3 types of affective stimuli (though only 25 presentations for each condition), positive stimuli (opposite-gender nude), negative stimuli (snarling wolf) and another neutral stimulus (a wheel) (Carretie et al., 2004). Each presentation lasted only 200ms. It was observed that the P200 ERP component exhibited greater amplitudes in response to emotional stimuli, both negative and positive, than to neutral stimuli with a latency of 180ms (Carretie et al., 2004). The

N200 (Peak at 240ms) was observed to record higher amplitudes in response to positive and neutral stimuli (Carretie et al., 2004).

In conclusion, as well as strong evidence for an increased amplitude for negative stimuli at the 100-300ms latency, P200 ERP components and N200 components show smaller but consistent amplitude increases to affectively positive stimuli (Olofsson & Polich, 2007; Amrhein et al., 2004; Carretie et al., 2004; 2001). Furthermore, it has been observed that latency and amplitude modulations at 200-300ms during affective stimuli presentation can occur, even when cognitive facilities are limited by swift presentation (Schupp et al., 2003). These ERP component effects have been shown to exhibit modulation in research paradigms which use both passive and active viewing (Delplanque et al., 2004; Keil et al., 2002; Schupp et al., 2000), although some P300 ERP component research employing a passive viewing condition do not report viewing effects (Codispoti et al., 2006; Amrhein et al., 2004). In addition, when positive and negative affective stimuli are included as distractors irrelevant to the core task, P300 amplitudes are increased across the frontal and central electrode sites when compared to neutral affective images (Delplanque et al., 2005).

There are some methodological differences in the research paradigms employed in ERP research into affective valence processing which can potentially influence component adaptation outcomes. A key difference is that some studies use only one stimulus presented multiple times for each experimental condition, whereas others use novel stimuli for each presentation (Polich & Kok, 1995); this could affect the neural responses to the stimuli (Luck, 2005). Furthermore, ERP components have been found to be sensitive to the complexity of the scene presented (Bradley et al., 2007). For example, Sadeh and Verona (2012) observed that picture complexity can moderate response to affective stimuli. Colour has also been shown to modulate ERP component outcomes in response to affective stimuli (Cano et al., 2009); pictures from the IAPS depicting unpleasant, neutral and pleasant affective scenes presented in an oddball paradigm, were placed in experimental conditions containing colour, black/white and scrambled conditions. The P300 component was larger in amplitude over the frontal electrode sites for pleasant stimuli verses the unpleasant or neutral IAPS images for the colour condition; however, no significant affective valence effects were observed in the black/white or scrambled conditions (Cano et al., 2009).

In the next chapter the modulating effects of callous and unemotional traits on the psychological and neurological processing of empathy and affect will be considered.

CHAPTER 3:

CALLOUS AND UNEMOTIONAL TRAIT MANIFESTATION IN CLINICAL AND GENERAL POPULATIONS

3.1 Callous and Unemotional Traits and their Psychological Attributions

Callous and unemotional (CU) traits were identified in an effort to delineate the heterogeneity of the population diagnosed with conduct disorder (CD) in patients under 18, and antisocial personality disorder (ASPD) in patients over 18 who are currently diagnosed on purely behavioural criteria (The Diagnostic and Statistical Manual of Mental Disorders - 5th ed, DSM-V, APA, 2013); These criteria, which focus on antisocial behaviour, are portrayed as ignoring key patient sub-groups by using one, all-encompassing designation (Frick and Ellis, 1999). CU traits have been found to identify key sub-groups within the CD and ASPD populations which are psychologically different in their symptomatic profiles, neurologically dissociable, have less favourable prognoses and respond differently to available treatments (Guay et al., 2007; Frick and Ellis, 1999). ASPD patients who also present with high CU traits are commonly defined as being psychopaths, furthermore, high CU trait individuals within both clinical patient groups and general populations are often described as psychopathic or as having psychopathic traits (Barry et al., 2000; Frick, 1998; Hare, 1998; Cleckley, 1976). Thus the terms 'CU traits' and 'psychopathic traits' are so similar as to create a functional equivalency.

CU traits are a cluster of psychological attributes which can manifest in one's personality; these traits include factors such as: a lack of emotion, decreased empathy and a diminished capacity to feel guilt (Guay et al., 2007). CU traits are broadly defined as a dysfunction in empathy, lack of guilt and shallow affect (Viding & McCrory, 2012). Blair (2007) goes as far as to postulate that high CU trait disorders are such as psychopathy are prototypical disorders associated primarily with empathic dysfunction.

CU traits have been demonstrated to manifest in both children and adults, though research suggests that the traits first present in childhood and proliferate into adulthood (Moran et al., 2009; Lynam et al., 2008). CU traits in children and adolescents have been shown to be prognostic indicators of future psychiatric difficulties (Moran et al., 2009). Longitudinal research conducted into the predictive nature of callousness and CD has found that when measured annually in individuals from age 7-19 both callousness and CD are prognostic indicators of the development of psychopathic traits (Burke et al., 2007). In addition, the social conduct problems and psychosocial impairment indicative of psychopathy are strongly correlated with the presence of CU traits in adolescents (Essau et al., 2006). Children with CU traits exhibit such a predisposition towards the emotional dysfunction and antisocial behaviour associated with psychopathy, that psychopathy is considered to be a developmental disorder that continues into adulthood (Lynam et al., 2008).

A more recent review of the literature concerning CU traits in children and adolescents by Frick et al (2014) comprehensively considers the nature of CU trait. The review hypothesises that CU traits manifest due to a psychopathological development of conscience, which incorporates deficiencies in empathy and emotion. Frick et al (2014) also note, that when assimilated in one paper, the available research exploring the prognostic and longitudinal nature of CU traits suggests that CU traits are relatively stable within ones personality across developmental stages and into adulthood.

The protracted nature of CU trait presentation, its stability and its unfavourable prognosis require that CU trait presentation is also considered in the adult population. ASPD is the common diagnosis for adults with elevated CU traits, however, similarly to the CD population, the ASPD population is heterogeneous in nature and, whereas most psychopaths would qualify as suffering from ASPD, not all ASPD patients are psychopathic and thus they do not present with extreme high CU trait personalities; ASPD is thus a composite of both high CU trait psychopathic and non-psychopathic ASPD individuals (Hare et al., 1998).

3.2. Empathy and Affect within the High Callous and Unemotional Trait Individual

Research has identified that a dysfunction of empathy processing and a shallow emotional affect are substantial components within the psychological profile of a high callous and unemotional individual (Viding & McCrory, 2012; Guay et al., 2007). Previously, the processing of empathy in the neurotypical brain was discussed. Empathy is a complex cognitive ability, which draws on many neural facilities. This multifaceted nature of empathetic processing can, however, be fractionated into two dissociable components of empathy processing, cognitive empathy (CE) and emotional (or affective) empathy (EE).

Individuals identified as presenting with high levels of CU traits consistently display a reduced empathy response to others, however, this disruption of the empathy processing ability in high CU trait individuals does not manifest equally across the different components of empathy. The deficit is disparately present in emotional empathy and cognitive empathy processing; high CU trait individuals, such as psychopaths, most often report intact cognitive empathy with the disruption in empathy processing limited to the emotional empathy components (Blair 2005; Richell et al., 2003). However, some limited research observes a duel deficit in empathy reduction over both the emotional and cognitive empathy components (Dadds et al., 2009).

3.2.1 Emotional Empathy and Callous and Unemotional Traits

Emotional empathy processing is typically tested using facial recognition, emotional valence to emotion in others and autonomic physiological reaction to distress in others. This thesis focus' on facial recognition, as this area of emotional empathy is most evidenced as being dysfunctional within high CU trait individuals; Hastings et al (2008) explored the facial affect recognition ability in criminal psychopaths. Male prisoners (n=145) were recruited and subsequently screened using Hare's Psychopathy Checklist: Screening Version (Hare, 1991). The sample was presented with facial stimuli depicting five emotions (happiness, sadness, fear, anger, or shame). Intensity of expression was split into a high-low dichotomy of 100% or 60%

for each expression. Hastings et al (2008) reported that psychopathic participants were significantly less accurate at identifying fearful and sad facial affect; in addition, the accuracy of recognition for less intense affect stimuli was deficient in psychopathic inmates across all emotions. More recent papers have also shown particular deficits in ability to recognise fear and sadness facial affect stimuli associated with psychopathic traits and related disorders (Fairchild et al., 2010; Fairchild et al., 2009; Woodworth & Waschbusch, 2008); whereas, deficits in fear recognition seem particularly prevalent when the research uses measures of CU traits specifically (Leist & Dadds, 2009; Muñoz, 2009; Dadds et al., 2008).

Hastings et al (2008) present findings that recognition of happy facial stimuli was also negatively correlated with the level of psychopathy in the inmate population, which led the authors to postulate that psychopathy, may be associated with a general deficit in affect recognition. Hastings et al's (2008) conclusion that psychopathic traits are associated with a pervasive reduction in affect recognition ability is supported by Wilson et al's (2011) meta-analysis that included papers and theses published up to 2009 (though this analysis used a less stringent alpha level of $p = .10$). However, these deficits in affect recognition associated with psychopathic traits and CU traits are not consistently reported within the literature; for example, performance in recognising facial expressions of fear was not reduced in several papers (Book et al., 2007; Glass & Newman, 2006). Reduced ability to correctly identify sadness was also not reported in association with higher CU traits in several cases (Leist & Dadds, 2009; Muñoz, 2009; Glass & Newman, 2006). Furthermore, psychopathic traits were associated with an increase in ability to recognise fear in facial expression stimuli in two papers (Del Gaizo

& Falkenbach, 2008; Woodworth & Waschbusch, 2008). By contrast, in a meta-analysis of 20 papers Marsh et al (2008) identified a robust link between antisocial behaviour and specific deficits in recognizing fearful expressions, which was not moderated by whether the sample was psychopathic. Finally, in convergence with facial expression ERP research, it is the attendance to stimuli and activation of the neural mechanics governing attention regulates emotion recognition deficits (Dadds et al., 2008; 2006).

Hastings et al's (2008) finding regarding deficient recognition of happy expressions in those screened as psychopathic, is not reliably replicated in the published literature (Marsh and Blair, 2008). Expressions of happiness are often not degraded in the cognitive ability of high CU participants of research (Blair, 2005). Furthermore, a meta-analysis published in 2012, Dawel and colleagues also found that psychopathy was associated with impaired recognition of several emotions including: anger, fear, happiness, sadness, and surprise, using random effects and fixed-effects models; however, only 5 studies of 19 report reduced recognition ability with regards to stimuli depicting happiness (Dawel et al., 2012). It maybe that happiness recognition processing is preserved within the high CU trait individual.

Limited research has also identified a reduced accuracy in the interpretation of disgusted facial stimuli and psychopathy (Blair, 2005); however, when IQ was considered as co-variable, this result was no longer significant. This suggests that IQ can potentially act as a confounding variable in facial recognition research and should be controlled for within research paradigms.

Deficits in emotion recognition capacity have also been observed in children who present with high CU traits. Blair et al (2001) used the Psychopathy Screening Device (Frick et al., 2000) to recruit children with 'psychopathic tendencies' and a control group. The sample population were asked to attempt to recognise facial expression stimuli depicting; sadness, happiness, anger, disgust, fear, and surprise. Intensity was included as a co-variable of the facial recognition deficit in high CU trait individuals; this was achieved through the intensity of the facial expressions increased progressively over 20 frames in 5% increments. Results concluded that children identified with psychopathic tendencies required stimuli to display significantly greater intensity before they could correctly distinguish sad expressions; furthermore, children with psychopathic tendencies often failed to recognise fearful expressions even at full intensity.

Further research found that, relative to controls, recognition of anger, disgust, and happiness in facial expressions was disproportionately impaired in participants with early-onset conduct disorder, whereas recognition of fear was impaired in participants with adolescence-onset conduct disorder (Fairchild et al., 2009). Participants with CD who were high in psychopathic traits showed more impaired fear, sadness, and surprise recognition relative to those low in psychopathic traits. There were no group differences in facial identity recognition (Fairchild et al., 2009). Though it is not clear why this finding occurs, the authors suggest that if CU traits are present in one's personality to a high enough intensity coupled with an early onset, representations of both negative and positive facial affect can be misidentified.

Facial expression research has reported that certain expressions are processed primarily through the amygdala, these expressions often indicate the presence of a threat, either in the environment or from the expresser, such expressions thus include fear, anger, sadness and pain (Adolphs et al., 1999). Lesions on the amygdala can result in deficits in fearful facial expression recognition (Cristinzio et al., 2007); Bilateral lesions of the amygdala presented larger deficits in processing fearful facial expressions than other expressions (Adolphs et al., 1999). However, presenting fearful expressions in a manner that controls for attention to features often mitigates differences in amygdala responsiveness (Etkin et al., 2004; Williams et al., 2005). Additional research has described an extensive role of the amygdala in response to facial expressions, including anger (Fitzgerald et al., 2006; Yang et al., 2002), surprise (Kim et al., 2003), disgust (Fitzgerald et al., 2006), sadness (Fitzgerald et al., 2006; Yang et al., 2002), and happiness (Fitzgerald et al., 2006; Yang et al., 2002). Individuals with high CU trait personalities are associated with atypical amygdala response to facial expressions depicting negative emotion and, in turn, a reduced recognition of such expressions (Marsh & Blair, 2008; Blair, 2005).

Other cortical areas are also affected by high CU trait manifestation, such as: the malfunctioning of the amygdala-ventromedial prefrontal cortical circuitry in high CU trait and psychopathic participants identified by a review of available literature by Dolan (2008). As discussed in chapter 1, a lesion study by Shamay-Tsoory et al (2009) observed that the ventromedial prefrontal cortex is necessary for emotional empathy; those patients with lesions on the ventromedial prefrontal cortex had dysfunctions in their processing of emotional empathy. Therefore, a combination of dysfunction in the amygdala, ventromedial and connecting cortical circuitry might be central to the disturbances in empathy and emotion observed in high CU trait (Dolan, 2009; Marsh & Blair, 2008; Blair, 2005).

The limited research which does exist, exploring the neural correlates of CU traits amongst the general population, reports emerging findings which suggest that CU traits are associated with different neurological responses to facial affect stimuli; for example, Gordon et al (2004) employed fMRI to investigate the neurological function of those who were shown to manifest 'high' and 'low' psychopathic traits. The study reports that there were no significant behavioural differences in the ability of the groups in identity recognition conditions. However, significant differences were observed in a task designed to measure affect recognition; several sub-regions of the frontal cortex and the amygdala were less active in the high psychopathic trait group. It is Gordon et al's (2004) conclusion that the participants, who scored highly on the PPI, although not behaviourally distinct from the controls, demonstrated significantly altered pattern of neural activity to stimuli requiring affective processing. This allows the postulation that a unique neural signature is associated with psychopathic traits in a general population. This signature seems to reflect the deficiency in amygdala and frontal cortex region function observed in psychopathy (Blair, 2003) and is consistent with the notion that psychopathic individuals may indeed be extremes of a continuous distribution across the general population (*see Figure 7*).

Although this study employs fMRI and not ERP research techniques, the results indicate that there is the potential for the adaptation of neural response to facial affect stimuli with regards to CU traits in a non-psychiatric population, which could potentially manifest in modulation of the ERP components of facial affect response discussed earlier (see chapter 1). Certainly there is a dearth of research in this area which could potentially yield interesting and unique results regarding the effect of the manifestation of CU traits on empathy processing. Given that particular profiles of intact and deficient emotion processing skills have been demonstrated in those with psychopathy, further research is needed to determine whether a corresponding profile is present at general levels of CU traits.

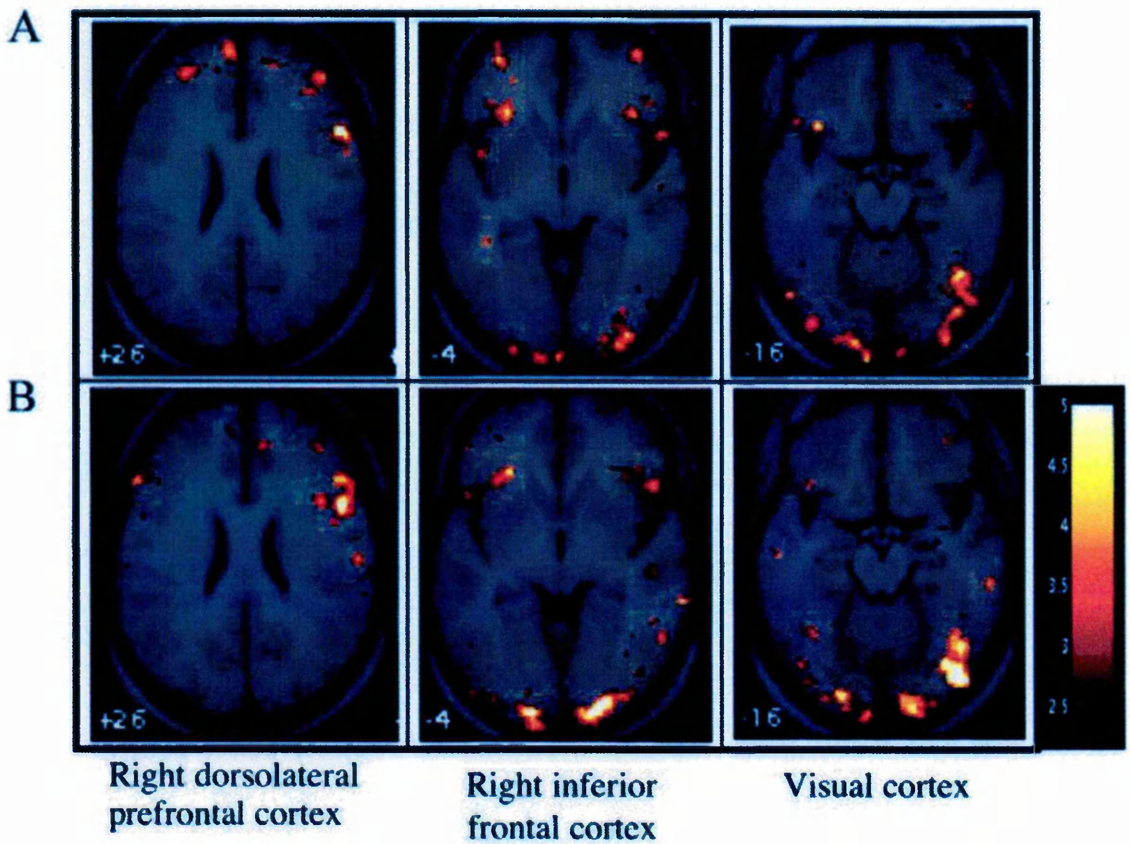

Figure 7: Blood oxygen level–dependent activity during the emotion recognition condition relative to baseline. (A) Participants who scored below the mean on the Psychopathic Personality Inventory (PPI-Revised). (B) Participants who scored above the mean on the PPI (Gordon et al.,2004).

3.2.2 Cognitive Empathy and Callous and Unemotional Traits

Despite the substantial evidence of a dysfunction in the neural circuitry processing emotional empathy in high CU trait individuals, there is a paucity of evidence showing a deficit in cognitive empathic ability or theory of mind ability. For example, Blair et al (1996) applied Happé's (1994) advanced test of Theory of Mind to the exploration of cognition in a sample population of psychopathic (n=25) inmates and non-psychopathic incarcerated controls (n=25); the analysis revealed that the psychopathic inmates did not have a Theory of Mind deficit (Blair et al., 1996). Such findings have been consistently replicated by other researchers exploring the theory of mind phenomenon in psychopaths with regards to their ability to assign mental states to other people (e.g.Jones et al., 2010; Richell et al., 2003).

There is, however, limited research which observes a reduction in cognitive empathy processing ability. Dadds et al (2009) investigated cognitive empathy in children aged 3-13 years (n = 2760). Participants' parents were asked to rate their children on measures of empathy, CU traits and antisocial behaviour. Psychopathic traits, derived from the participants scores on the applied measures, were found to negatively correlate with both cognitive empathy and emotional empathy; it is suggested by the authors that cognitive empathy has a developmental component and, thus, as the child becomes an adult they are able to overcome these deficiencies in cognitive empathy processing by learning to 'talk the talk' of human emotions (Dadds et al., 2009).

However, contrastingly in a young population, Jones et al (2010) observed that boys with psychopathic tendencies had cognitive perspective-taking abilities equivalent to control boys, only their affective empathy profiles were significantly different. Jones et al note that Autism, a disorder sometimes associated with callousness, was associated with cognitive difficulties with regards to the cognitive elements of empathy. Little is known about CU traits in girls and the empathy profiles associated with CU traits there within.

Patients within high CU trait clinical groups often present with an impairment of emotional empathy but not cognitive empathy (Hastings et al., 2008; Marsh & Blair, 2008; Blair, 2005); since empathy is thought to be a primary facilitator in promoting prosocial behaviour and inhibiting aggression and, contrariwise, a lack of empathy is associated with antisocial behaviour (Decety & Meyer, 2008; Blair, 2005; Decety & Jackson, 2004). Behavioural findings into CU traits suggest that in neurotypical individuals pain in others is an aversive experience that causes pain or distress in the individual, however, those with high CU traits may not experience this aversion (Wolf & Centifanti , 2014). Neurological research is scarce, however, fMRI research by Lockwood et al (2013) observed that CU traits were associated negatively with activity in the anterior insula cortex and the ACC response. There is a paucity of papers investigating empathy for pain using ERP methodology; although, one paper exploring ERP components for empathy for pain and the interaction of CU traits in juvenile offenders was recently published (Cheng et al., 2012).

Cheng et al (2012) recruited 15 low CU trait offenders with a score of less than

25 on the Psychopath Checklist Youth Version (PCL:YV), 13 high CU offenders with a score of over 30 on the YCL:YV and 15 matched, neurotypical, non-criminal male adolescents. 124 colour photographs depicting painful and non-painful situations, validated for pain intensity and perceived agency by previous research (Akitsuki & Decety, 2009), were used in the study. Painful stimuli were shown to evoke a negative component between 100 and 140ms (N120), a positive deflection between 160 and 200ms (P180), then a negative amplitude maximal between 210 and 250ms (N230), a positive peak at 300ms (P300), a negative deflection at 360ms (N360), and an LPP, peaking at 600ms over the frontal and central areas in the controls (Cheng et al., 2012). A parietal-occipital positive wave maximal in amplitude at 120ms and a LPP at 400 and 800ms were also observed, suggesting both early affective processing and later semantic processing of the stimuli. The presence of CU trait manifestation was found to modulate these ERP components. The frontal N120 was more negative for painful stimuli in the low CU trait group; furthermore, central recording sites observed that painful stimuli elicited larger central P300 amplitudes in both the control and low CU trait groups, but not the high CU trait group (Cheng et al., 2012). The authors postulate that high CU trait individuals may be deficient in the frontal N120 and central P300 components when responding to empathetic pain stimuli.

Stimuli depicting painful events also evoked a larger central LPP component in the control, but not in the low or high CU trait experimental groups; later frontal N360 amplitudes were larger for painful stimuli in the control and low CU trait experimental groups, though not the high CU trait groups (Cheng et al., 2012). Parietal, frontal and central electrodes recorded differential LPP amplitudes in the control and high CU trait groups in response to stimuli portraying painful events, but not in the low CU trait group (Cheng et al., 2012). It is concluded that preserving a LPP response to painful stimuli may allow cognitive semantic processing of the stimuli to compensate for the lack of earlier affective response (Cheng et al., 2012) (*see Figure 8*). This research suggests that the N120, P300 and LPP empathetic response ERP components would be most likely to be differentiated with regards to CU traits in the general sample.

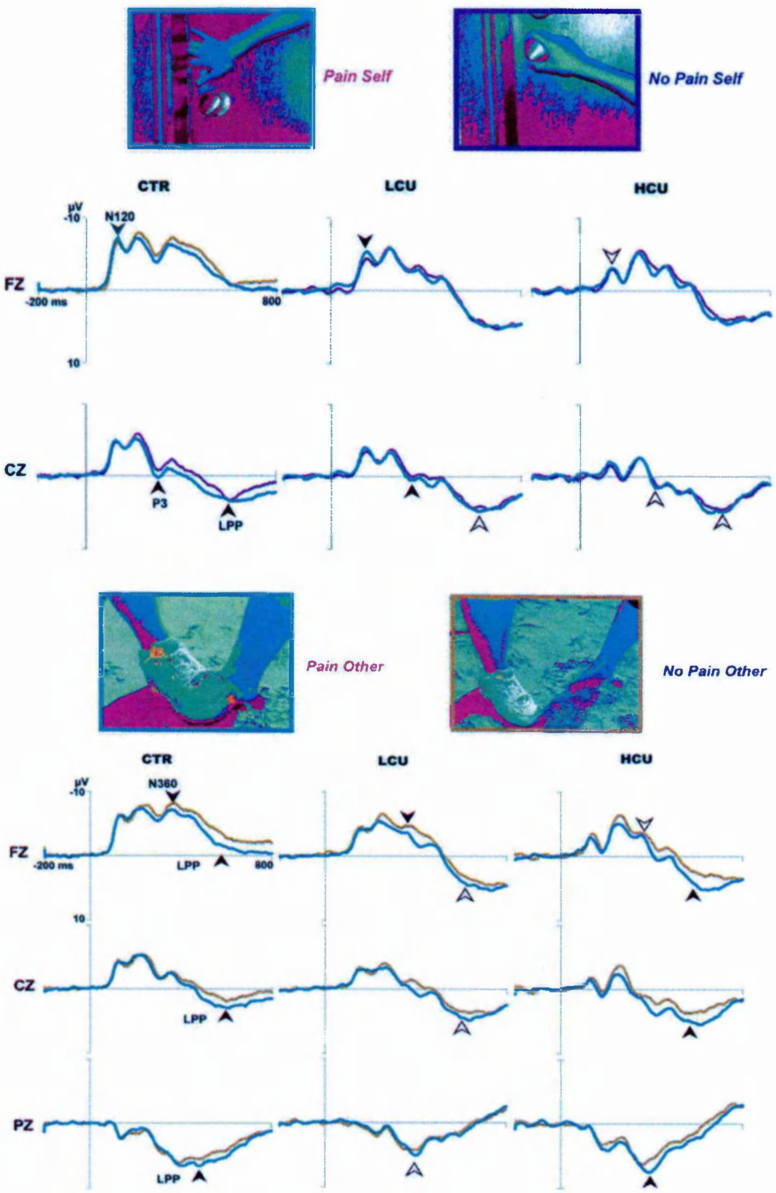

Figure 8: ERPs to perceiving individuals intentionally hurt by their self and another versus no pain in the interaction (pain-other, red, vs. no pain-other, blue) in the controls versus the group with low callous–unemotional traits versus the group with high callous–unemotional traits (Cheng et al., 2012).

The current programme of research would expand on these previous publications by looking at empathy for pain with regards to CU traits in a general population, an area lacking in published literature. Those with varying levels of CU traits may have different responses to the presentation of painful situational stimuli requiring cognitive empathy.

3.2.3 Shallow or Deficient Affect

High CU traits in individuals within both CD and psychopathic populations are correlated with reduced emotional valence (Loney et al., 2003). Individuals with psychological disorders indicative of extremely high CU traits reliably present with a reduced intensity of reaction to negative emotive stimuli (Loney et al., 2003). For example, a study of psychopaths (n=25) and controls (n=24) employed electrodermal galvanic response as an indicator of emotional arousal, startle reflex as a measure of valence, and electromyography recordings of the corrugator muscle as a predictor of emotional expression during the presentation of positive and negative emotional stimuli (Herpertz et al., 2001). Results observed that, in response to both positive and negative stimuli, the psychopaths presented with reduced galvanic skin responses, decreased emotional expression, and a lack of or, often, a complete absence of a startle reflex (Herpertz et al., 2001).

This deficient startle reflex, signifying a reduced emotional valence, has been found in other studies of psychopath characteristics. Startle reflexes were found to be inhibited in psychopathic individuals when they were exposed to photographic stimuli containing scenes of victims (Levenston et al., 2000). Furthermore, it is extolled that the startle reflex was only weakly potentiated during stimuli showing threats (Levenston et al., 2000). These findings evidence a heightened aversion threshold in psychopaths and suggest a weakness in initial stimulus evaluation among psychopaths, portentous of a pervasive paucity of emotive response (Levenston et al., 2000).

In addition to reduced physiological responses, the use of the lexical decision task designed to test reaction speeds to words, has identified key differences in the emotional processing characteristics of the psychopathic individual. Seminally, Williamson et al (1991) observed that, unlike previous research recruiting general samples which reported that participants identify emotional words more quickly than neutral words, psychopaths did not demonstrate this increased speed of recognition for emotional stimuli. Those in the psychopathic condition supplied comparable valence ratings of the stimuli words used in the task. These finding have been replicated by Lorenz and Newman (2002); during a modified lexical decision task the psychopathic individuals exhibited reduced affective facilitation. However, research comparing Caucasian and African American psychopaths has observed that these results do not generalise across cultures within the psychopathic population (Lorenz & Newman, 2002). Although research concluding the affective deficiencies is substantial, not all evidence within this remit is in agreement with regards to the role of emotional deficits in high CU trait individuals. A dot-probe research paradigm, used by Kimonis et al (2008) to study 88 incarcerated youths, revealed that the emotional processing of distressing stimuli was not correlated to CU traits.

Thus, there is considerable evidence that there are deficits in emotional responses to affective stimuli associated with high CU trait disorders and incarcerated high CU trait individuals. In limited research these behavioural findings have been seen to translate into electrophysiological outcomes, which will be discussed subsequently.

Callous and unemotional traits are strongly correlated with a reduced emotional valence; individuals with psychological disorders indicative of extremely high callous and unemotional traits reliably present with a reduced intensity of reaction, particularly to emotive stimuli which are negative in nature such as anger, fear and pain (Loney et al., 2003). There is a dearth of research exploring the relationship of affect stimuli on the ERP response of those with different manifestations of CU traits. However, a study by Anderson and Stanford (2012) presented psychopathic and control participants with affective stimuli in two conditions; a first where the emotional information is presented but is not relevant to the performance of the task and a second condition in which the participants' attention is directed towards processing the affective content through categorisation of the emotional content. The researchers report that the controls present with a robust, persistent ERP positivity (200–900ms) to the affective stimuli when compared to neutral stimuli in both conditions. However, importantly, the psychopathic participants only exhibited this electrophysiological differentiation when their attention was specifically directed towards the emotional content of the stimuli through the behavioural task of identifying and categorising affective content, though the responses were still smaller than the amplitude of response observed in the control sample (Anderson and Stanford, 2012). Thus, attention to affective informational content of stimuli could be an important distinguishing feature of the design paradigm in research into emotional valence and CU traits.

In conclusion, there is evidence to postulate that those high in CU traits may be deficient in their emotional valence response to affective stimuli. Furthermore, there are well recorded ERP component moderations associated with the observation of affective stimuli (see chapter 2). Therefore, investigating the electrophysiological manifestation of the CU trait deficit in emotional valence is not only a logical area of research, but also one with the potential to generate novel results.

3.3 Callous and Unemotional Trait Manifestation in the General population

A paucity of research exists exploring CU traits in the general population. Key investigations of psychopathic and CU traits in this developing research area have supported the hypothesis that such traits are not limited to clinical populations, but can be observed at varying levels and with various affects in the general population (Prado et al., 2015; Ali & Chamorro-Premuzic, 2010; Ali et al., 2009). The traditional view of psychopathy and conduct disorder is that these conditions exist as discrete disorders within the population; however, this long established categorical view has been challenged with evidence suggesting a dimensional manifestation of high CU traits and psychopathic traits where psychopathic personality traits are pervasive at a normal distribution of prevalence within society (Hare & Neumann, 2008; Marcus et al., 2004; Skeem et al., 2003). That the core personality traits of these disorders, exist on a normal distribution continuum within the population, and those patients of psychopathy and conduct disorder lie at the extreme high end of this distribution (Edens et al., 2006; Lynam, 2002; Lilienfeld, 1994). Therefore, Psychopathy may instead be a configuration of extreme levels of continuously distributed CU personality traits (Edens et al., 2006). However, currently the evidence does not exist to explore the merits of these views rigorously. Associated correlates of components of CU traits, for example neurological correlates, and reliable measures of CU trait manifestation would need to be compared between those at different points in the distribution and individuals suffering from high CU trait disorders, in order that such hypotheses could be tested efficiently.

Recent research by Prado et al (2015) using a non-clinical sample examined the relationship between sub-clinical psychopathic traits, self-control and the identification of facial emotion using the Levenson self-report psychopathy scale (LSRPS; Levenson et al., 1995), the Brief self-control scale (BSCS; Tangney et al., 2004) and the Montreal set of facial displays of emotion (MSFDE; Beaupré & Hess, 2005). The authors observed that both primary and secondary psychopathic traits were associated with reduced accuracy in identifying facial affect (although impairments for primary psychopathy were found to be larger) and deficits in self-control. Secondary psychopaths have less deficiency in their ability to experience negative emotions than primary psychopaths; furthermore, secondary psychopaths are more impulsive, reactive and aggressive. Primary psychopaths are argued to be innately deficient in emotion and conscience, whereas secondary psychopaths acquire these dysfunctions through their environment (Prado et al., 2015). The largest effect sizes were associated with recognition of disgust, sad and shame expressions, although deficiencies in the recognition of fear expression were observed the effect size was smaller than expected in Prado et al's research given previous findings showing that fear was the most commonly and strongly misrecognised emotion (e.g. Hastings et al, 2008; Montagne et al., 2005). However, Del Gaizo and Falkenbach (2008) observed that primary psychopathic-traits were positively correlated with accuracy of perception of fearful faces and positive affect and negatively associated with negative affect, whereas secondary psychopathic traits were not related to exactitude in emotional recognition but positively correlated with negative emotion. Therefore, the relationship between CU traits and the recognition of expressions may be more complicated in subclinical samples.

These findings are supported by previous research by Ali et al (2009) who found that psychopathic traits and Machiavellianism were correlated within a general population, as well as being associated with the experience of positive emotional valence when observing negative images. That is, unlike controls, their experience of negative stimuli is not rated as unpleasant. Unfortunately, the distribution of the traits examined was not reported. Further research in 2010 by Ali and Chamorro-Premuzic revealed that psychopathic traits and Machiavellianism were both correlated with disruption in empathy processing; this, the authors note, serves as a replication of previous findings (Dadds et al., 2009; Mahmut et al., 2008). Specifically, it was reported that psychopathic traits correlated negatively with accuracy on mental state inference tests which used facial cues (Ali & Chamorro-Premuzic, 2010). This research suggests that the affective deficits observed in clinical samples may also be associated with sub-clinical trait manifestation.

The research reported in this thesis will afford a unique contribution to the fields of psychology and neuroscience in three distinct ways. Firstly, the majority of research in this area has focussed on clinical populations; most notably conduct disorder in children, or psychopathy in adult populations. There is a dearth of research investigating the manifestation of CU traits with regards to empathy disruption in an early adulthood sample and particularly lacking is research in the general population. Both of these will be the focus of the subsequently described research.

Secondly, the following research will explore the distribution of these CU traits in a general sample, as well as the poorly understood empathy and affective processing profiles of CU trait manifestation in the general population. Finally, there is a dearth of electro-neurological research into empathy with regards to CU traits. Thus, by using event related potential (ERP) analysis and a range of empathy processing tasks to investigate empathic responses with regards to CU traits, unique results will be generated. The EEG-based neurological element of the research will be discussed at length in section 2 of the thesis.

The primary study aimed to increase comprehension of the empathy and emotional aetiology of CU traits in the general population; it would allow insight into whether clinical patients are similar to high CU trait, general individuals, or whether clinical disorders present with unique deficits in psychological processing and neurological function. Understanding the psychological and neurological profiles of empathy and affective processing associated with CU trait levels in a general sample will inform our understanding of how empathic ability manifests with regards to these traits; specifically, whether the emotional and cognitive components of empathy are dysfunctional and fractionated in general high CU trait distributions can be explored. Recruiting research paradigms assessing affective processing will discern whether changes in emotional affect occur with regards to the prevalence of CU traits in a general sample.

CHAPTER 4:

CALLOUS AND UNEMOTIONAL TRAIT MANIFESTATION AND THE RELATIONSHIP WITH EMPATHY AND AFFECTIVE VALENCE

4.1 Aim and Hypotheses

Of the six key research questions that were addressed through this thesis, this first study was concerned with the primary three. To recap these questions include:

1. What is the distribution of empathic processing ability and callous/unemotional (CU) traits? The proposed research aims to examine these constructs within a general population using a constellation of established self-report measures.

2. The second objective is to examine the relationship between empathy and CU traits. Do self-report measures of CU trait severity and empathy-processing correlate negatively as would be predicted from clinically-diagnosed populations?

3. Are cognitive empathy and emotional empathy dissociable within CU traits? The self-report data will simultaneously investigate the possible fractionation of empathic abilities in CU traits.

Hypotheses included:

H_1: Callous and unemotional traits will manifest in a normal distribution in the general sample.

H_2: A negative relationship will be observed between measures of emotional empathy and callous and unemotional traits.

H_3: No correlation will be observed between the constellation of cognitive empathy measures and callous and unemotional traits.

H_4: A difference between the cognitive and emotional facets of empathy will be observed in relation to callous and unemotional traits, evidencing fractionation of empathic abilities in these traits.

H_5: Self-report measures of CU traits negatively correlate with participant's accuracy in the recognition of facial expressions of emotion.

H_6: There will be a positive correlation between the participants' scores on measures of empathy when related to the accuracy in the recognition of facial expressions of emotion.

H_7: An associate will be observed between self-reported scores of emotional valence and stimuli with emotional content with high CU traits or low empathy scores correlating with reduced emotional valence.

4.2. Methodology

4.2.1 Participants

A self-selected sample was recruited for the research via a university based advertisement. 124 participants completed the research tasks. The age of the included participants ranged from 18 to 45 (X= 21.16, SD= 5.08). 84 of the participants were female, 40 were male. Power analysis with G-Power reveals that the total of 124 participants is able to detect associations with a moderate effect size of $r > .3$ at a .05 alpha level and, thus, provides appropriate power. A combination of undergraduate students, mature students, post-graduate students and graduates were included in the sample demographic. All participants were screened for a history of diagnosed disorders through self-report; specifically Conduct Disorder and Antisocial Personality Disorder. None of the participants revealed history of either disorder.

4.2.2 Design

A correlational design was employed in order to examine the relationship of CU traits with questionnaire measures of cognitive and emotional empathy, and direct and indirect measures of emotion recognition and emotional valence.

4.2.3 Materials

To investigate the influence of Callous and Unemotional traits on empathy and emotional processing the Inventory of Callous–Unemotional Traits (Frick, 2004) and

[1] Sections of this chapter have been submitted for publication and are currently under review (Lethbridge, Richardson, Reidy & Taroyan).

The Antisocial Process Screening Device (Frick & Hare, 2001) were recruited (see table 1). Two self-report measures of empathy, the Interpersonal Reactivity Index (Davis, 1983) and the Empathy Quotient (Baron-Cohen & Wheelwright, 2004) examined both the cognitive and emotional empathy of the participant. Two measures of the empathy constructs and CU traits were included in order to negate the effect of subjective definition of the empathy construct (Reniers et al., 2011). In addition, two measures of each construct were included to look for consistency of response in the participants and to increase the validity of the responses for each psychological construct examined and to thus improve validity. The inclusion of measures of both cognitive and emotional empathy allowed the analysis of the potential disassociations between these distinct forms of empathy (*see Table 1*). Furthermore, a direct measure of facial emotion recognition and indirect measures of affective valence were included to explore empathetic response. The prevalence and distribution of CU traits in the sample general population could also be investigated.

Table 1:

The constellation of tasks included in study 1.

A – Questionnaire Measures of CU traits	**B – Questionnaire Measures of Empathy**	**C - Empathy and Emotional Valence Tasks**
A1 Inventory of Callous and Unemotional Traits (Frick, 2004; Kimonis et al., 2008)	**B1** Empathy Quotient (EQ) (Baron-Cohen & Wheelwright, 2004)	**C1** Emotion Recognition Task
A2 Antisocial Process Screening Device (APSD) (Frick and Hare, 2001)	**B2** Interpersonal Reactivity Index (Davis, 1980)	**C2** Emotional Valence Task

A: Measures of Callous and Unemotional Traits

A1: Inventory of Callous-Unemotional Traits

The Inventory of Callous–Unemotional Traits (ICU) (Frick, 2004) is a 24-item scale designed to be rated on a four-point Likert scale from 0 (Not at all true) to 3 (Definitely true), scores range from 0 to 72. Three sub-scales are present within the ICU measure of CU traits, these are the Uncaring, Callousness and Unemotional sub-scales (Frick, 2004). The Uncaring sub-scale includes items such as 'I always try my best at everything I do', whilst the Callousness scale is characterised by statements such as 'I do not care if I get into trouble', and finally, items such as 'I do not show my emotions to others' are representative of the Unemotional sub-factor.

Bifactor confirmatory analysis conducted by Kimonis et al (2008) confirms a general factor present across the ICU items. Kimonis et al (2008) also evidenced that a total score from the ICU moderately correlates with the six-item CU scale from the Antisocial Personality Screening Device (APSD) showing convergent validity. Furthermore, the ICU has demonstrated validity in cross-cultural populations, including German samples (Essau et al., 2006) and an ethnically diverse sample of detained adolescents from the United States (Kimonis et al., 2008). Within these two diverse, independent populations the 3 factor solution of sub-scales described earlier (Uncaring, Callousness and Unemotional), confirms the measurement of 'independent dimensions of behaviour' (Kimonis et al., 2008). An internal reliability of $\alpha = .73$ has been demonstrated in a sample of incarcerated adolescents (Kimonis et al., 2008).

A2: The Antisocial Process Screening Device

The Antisocial Process Screening Device (APSD) was designed to assess antisocial personality traits, including a CU trait subscale (Frick & Hare, 2001). The APSD includes 20 items to be scored on a three-point scale from 0 (Not at all true) to 2 (Definitely true). Factor analysis performed in range of research consistently reports a 3 factor solution to the APSD; this structure entails a Narcissism dimension of 7 items (example 'You can act charming and nice to get what you want'), an Impulsivity dimension of 5 items (example 'You do not plan ahead or leave things until the last minute'), and finally, a CU dimension of 6 items ('You feel bad or guilty when you do something wrong') (Vitacco et al., 2003; Frick et al., 2000). The CU sub-factor of the APSD formed the basis for the development of the ICU item content and is used within this study to investigate CU trait manifestation in the participants (Frick, 2004).

Exploration of the internal consistency of the APSD factors been found to be only moderate when examined with Cronbach's standardized alphas: CU = .59, Narcissism = .74, Impulsivity = .53, and total APSD = .62 (Vitacco et al., 2003). However, longitudinal research has shown APSD scores to be reasonably reliable and stable over 3 years (Munoz & Frick, 2007).

B: Self-Report Measures of Empathy

B1: The Empathy Quotient

The Empathy Quotient (EQ) (Baron-Cohen & Wheelwright, 2004) was developed as a measure of empathy which would be appropriate for scrutinising differential levels of empathy in respondents' from clinical, general and general populations. The short-version of the EQ used for the purposes of this research consists of 40 items which the respondent rates on a 4-point scale from 'strongly agree' to 'strongly disagree', potential scores range from 0 to 80. Examples of statements presented for rating in the EQ include 'I really enjoy caring for other people' and 'Other people tell me I am good at understanding how they are feeling and what they are thinking'. Principal Components Analysis has suggested a three factor solution for the EQ which resulted in sub-scales of cognitive empathy, emotional reactivity and social skills being revealed (Lawrence et al., 2004). Confirmatory Factor Analysis agreed with this 3 factor outcome (Berthoz et al., 2008). The cognitive empathy and emotional reactivity scales are of particular interest to the current research as they allow discrimination between the cognitive and affect processes of empathy and their interaction with the measures of CU traits.

Cronbach's alphas have been observed for the EQ varying from .85 (Muncer & Ling, 2006) to .88 (Wakabayashi et al., 2006). Additionally, the EQ has been demonstrated to have test–retest reliability (Lawrence et al., 2004). Furthermore, the EQ has established convergent validity with several measures of empathy; correlations have been evidenced with the 'Reading the Mind in the Eyes' Test (Baron-Cohen et al., 2001) and with the IRI, the other self-report measure recruited for the described research (Lawrence et al., 2004).

It should be acknowledged that the EQ reliably reports sex differences in empathy in respondents from the general population; this difference manifests in females reporting higher levels of empathy than males and was reliable across cultures (Berthoz et al., 2008; Wakabayashi et al., 2007; Baron-Cohen & Wheelwright, 2004).

B2: The Interpersonal Reactivity Index

The Interpersonal Reactivity Index (IRI) (Davis, 1983) consists of a 28 item self-report questionnaire constructed to measure empathy. Each item was rated by the participant on a scale from A-E where A denotes 'does not describe me well' and E 'describes me very well', scores range from 0-112. Within the IRI, 4 sub factors of distinct but related concepts are assessed; these include the perspective-taking scale, the fantasy scale, the empathic concern scale and, finally, the personal distress scale (Davis, 1983). Each of these scales was gauged through 7 items on the IRI measure.

The Empathic Concern scale of the IRI was formulated to examine participant's ability to 'experience feelings of warmth, compassion and concern for others undergoing negative experiences' (Davis, 1983). Examples of the Empathic Concern scale of the IRI include 'I often have tender, concerned feelings for people less fortunate than me' and 'I would describe myself as a pretty soft-hearted person'. The Perspective Taking scale of the IRI 'reflected a tendency or ability of the respondent to adopt the perspective, or point of view, of other people' (Davis, 1983). Statements such as 'I sometimes find it difficult to see things from the "other guy's" point of view' and 'I try to look at everybody's side of a disagreement before I make a decision' form the content of this sub factor. The IRI Fantasy scale 'denoted a tendency of the respondent to identify strongly with fictitious characters in books, movies, or plays' (Davis, 1983). Examples of this scale include 'I really get involved with the feelings of the characters in a novel' and 'I daydream and fantasize, with some regularity, about things that might happen to me'. Finally, the Personal Distress sub factor of the IRI 'indicated that the respondent experienced feelings of discomfort and anxiety when witnessing the negative experiences of others' (Davis, 1983). Examples of statements included in the IRI for the purpose of measuring personal distress include 'in emergency situations, I feel apprehensive and ill-at-ease' and 'I tend to lose control during emergencies'. The perspective taking and empathic sub-scales are of particular interest to this study as they are analogous to cognitive and emotional empathy respectively and, therefore, can be recruited to look at the relationship between CU traits and the differential elements of empathy (Davis, 1983).

Evaluation of the IRI in two independent samples has revealed stability in this four sub factor structure to assess an individual's empathy (Davis, 1983). Outcomes of statistical analysis conclude internal reliability as tested via Cronbach's alpha (subscales range from $\alpha = .70$ to $\alpha = .78$); furthermore, the IRI measure demonstrated good test–retest reliability (subscales range in reliability from .62 to .81) and convergent validity (Davis, 1983). In addition, investigation of a Dutch version of the IRI concluded that similar structure solutions were appropriate and further demonstrated the reliability and validity of the measure (De Corte et al., 2007).

C: Materials for the Measurement of Emotion Recognition and Emotional Valence

C1: Materials used for the Emotion Recognition Task

This first task measured participants' ability to recognise facial expressions of emotionality in others and indirectly measures their emotional response to said expressions. 48 photographic stimuli depicted 6 emotions: happiness, fear, disgust, sadness, anger and pain. Unique facial expression stimuli have been amalgamated to create this facial recognition task, specific in its design to test the hypotheses. These stimuli were selected from online sources and then tested for reliability through pilot research. In order to ensure that all the stimuli were valid representations of the expressions they were chosen to depict, pilot studies were conducted. This was achieved by collating responses from specifically created open surveys. Multiple samples of 50 – 100 people were recruited for the surveys, these participants were self-selected through advertisements for the survey; these individuals were not screened for confounding variables and no personal information was collected, to ensure anonymity for participants. The stimuli were placed in a random sequence and below each were 6 options for the included expressions, of which the participant could choose one of; happiness, pain, fear, sadness disgust and anger. Once over 50 responses had been collected those stimuli that had obtained an agreement level of 70% were included, those that failed to reach this level of agreement were replaced with other examples of the required expression and retested in the exact same manner. 70% was chosen as an appropriate level of agreement as this level has been previously employed by other facial stimuli research (e.g. Ebner et al., 2009; Tottenham et al., 2009). The result of this pilot testing was that all of the expression stimuli used had over a 70% agreement that they are a consistently recognisable depiction of the required facial expressions of emotion.

Facial expression recognition tasks require the consideration of co-variables which may interact with the main effect of expression recognition and empathetic response. Research investigating facial expression recall, recognition and response has reliably documented the 'own-group' bias (Van Bavel et al.,2013); meaning that participants have been evidenced to perform better when the stimuli contain human subjects with whom they identify in some manner (Van Bavel et al., 2013). In order to ensure that 'own-group' bias does not skew or create artefacts in the collected data, it was necessary to consider information perceivable in the photographic stimuli which could result in 'own-group' bias effects as co-variables. For the purposes of the described task these were considered to be age, sex and race. The demographic was compiled so that each emotion condition had a broad and equal range of ethnicities and that both male and female stimuli were included in equal numbers.

The jewellery, neckline, clothing and hair style of the stimuli, although not extravagant, were not removed from the photo as this process may have distorted the expression, and impact the accuracy of recognition more than the social information provided by these features (e.g. Saegusa et al, 2015, Smith et al., 2013; Batty & Taylor, 2003). The photo stimuli were presented with a plain light coloured background. In order to control for potential counter variables which could be introduced by allowing different orientations of the photograph subject, all subjects were square enough to the camera such that both eyes could be observed.

The Self-Assessment Manikin (SAM) was recruited for the purpose of recording the participant's emotional response to photographic stimuli during the emotion recognition and affective valence tasks (Bradley & Lang, 1994). The participants were asked to rate each picture in terms of how it made them feel while viewing it using 2 scales. These scales were labelled such that the design would test: whether the participants felt negative or positive during their viewing of the stimuli and how intensely participants felt regarding the stimuli. The participant was informed that there are no right or wrong answers and thus to respond as honestly as possible.

The SAM is comprised of 2 sets of 5 simple figures (*see Figure 9*). These SAM figures allow the rating of the photographic stimuli on the 2 scales previously described. Arranged in three rows the SAM figures depict the 2 different scales through the 5 figures. The first row reflected the positivity, neutrality or negativity of the participant during stimuli observation by presenting a scale of simplified homunculi from smiling, through neutral, to frowning; the second scale of 5 figures depicted a representation of emotional intensity providing a method to rate the intensity of the participants' response. Each scale was also labelled appropriately (*see Figure 9*). Below each row of figures there is a row of nine dots indicating the scale from the lowest figure of the scale to the highest. Participants designate their reaction to the stimuli using this 9 point scale by placing an "X" in the circle which best describes where on the scale they lie.

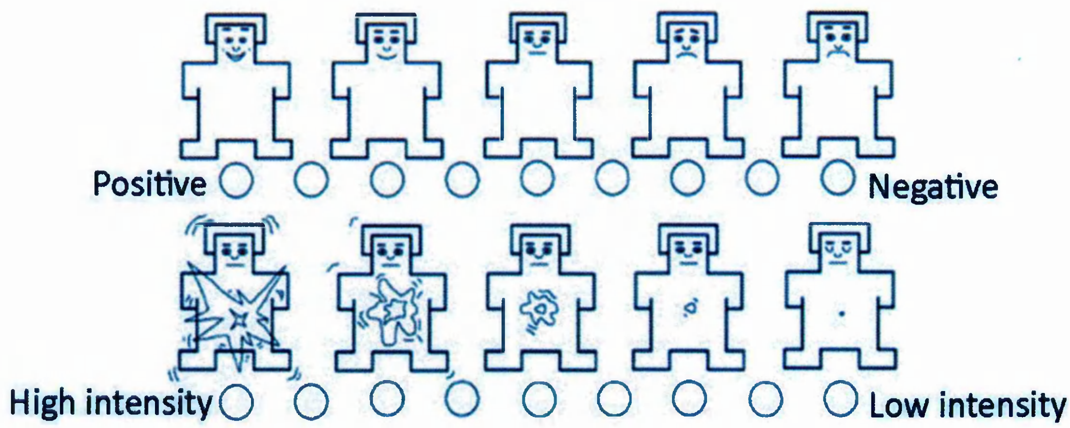

Figure 9: The SAM manikin adapted for the purposes of this research to measure valence and intensity (Bradley and Lang, 1994).

C2: Material used for the Emotional Valence Task

29 photographic stimuli were selected for this task, each photograph depicting a scene which contains emotional subject matter. These stimuli were selected from online sources because of their suitability for this research and restrictions with existing stimuli sets (e.g. the IAPS). The chosen stimuli include a total of 10 positive emotive stimuli (6 depicting humans showing care and 4 showing contentment in non-human animals). Human based positive portrayal stimuli have been standardised to a happy embrace. Positive stimuli in the case of animals were homogenised to the portrayal of contentment. Negative stimuli include a total of 17 photographic stimuli; 9 representing negative emotions in humans and 8 in animals. Specifically, the stimuli depicting negative emotions in humans were divided into stimuli showing conflict and those showing pain. The conflict stimulus was prescribed as one human hitting another without a weapon, as to affect fear in a victim. The photographic stimuli showing a subject in pain have been standardised to the subject receiving an injection from a

health professional. These photographic stimuli selected for this second task maintain their context through both their background and the actions of the subject(s).

4.2.4 Procedure

A and B: Procedure for the Self-Report Measures of Callous and Unemotional Traits and Empathy

The described self-report measures were presented to all participants alongside clear instructions on how to successfully complete the questionnaires using a computer in a quiet laboratory. No time limit was defined for completing the self-report psychometrics.

C: Procedures for the Experimental Tasks Measuring Emotion Recognition and Emotional Valence

For both task images and instructions on how to successfully complete the tasks, as well as the stimuli, were presented using a computer in a quiet laboratory.

C1: Procedure for the Emotion Recognition Task

During the emotion recognition task the participant was required to note their interpretation of the emotion depicted by the previously described facial expression stimuli below each photograph, using a drop down menu facility. The presentation program randomised the order of the photo stimuli were presented to control for order effects. The described Self-Assessment Manikin (SAM) was recruited for the purpose of recording the participant's emotional response to the stimuli during this research (Bradley & Lang, 1994). Whilst observing photographic stimuli the participant was required to accurately report how they felt, using the two, 9-point scales described earlier. Therefore, whether the participants felt negatively or positively during their viewing of the stimuli and how intensely participants felt regarding the stimuli would be indirectly measured, as well as the participant's recognition of the facial expression stimuli.

C2: Emotional Valence Task

The empathetic response task was designed to investigate participants' reactions to emotive stimuli. Using the SAM, the participant was required to rate each emotive photograph with regards to how they felt whilst observing the stimuli. The participant was only required to rate the emotive photographic stimuli on the two scales of the SAM in a manner that accurately reflects their own experience when observing the stimuli. As such, it was the emotional valence of the participants in relation to the sample population which was indirectly recorded. Differences in response were observed across the population. The photographic stimuli were randomly presented and counterbalanced. None of the tasks were timed. Participants were allowed as long as required to complete the measures. Though none required more than 45 minutes

4.2.5 Ethical Considerations

Participants were briefed regarding the content of the research tasks (with examples of included questions), details of the research area, the aims of the study, their rights and the ethics of the study, using an information sheet before any data collection was undertaken (*for the participant information sheet see appendix A*). After being given as long as required to absorb the material contained in the information sheet, the participant was given the opportunity to ask questions regarding the study's procedure and protocol. Once the participant indicated that they had asked any questions they may have and were happy to continue with the study, the participants' consent was obtained using a standard consent form (*see appendix B*).

Immediately subsequent to the data collection tasks being completed by the candidate they were debriefed (*see appendix C*). There was no deception within the research process using this ethics proforma, therefore the purpose of the debrief was to thank the participant for their participation, explain to the participant the purpose of the included measures without reference to the term callous and unemotional traits, remind them of their rights regarding the withdrawal of their participation and, finally, to remind them of the intended purpose of the research.

The final briefing complexity, which required addressing in order that this study maintained high ethical standards, was the issue of anonymity. As this preliminary research was used to identify experimental participants for future neurological research, the contact details of the participants needed to be associated with the self-report data. In order to ensure that the highest standards of confidentiality were maintained the contact information and collected data was coded. These codes were possessed by the key researcher and kept separate and secure from the data in order to maintain anonymity. The procedures in place for ensuring participant confidentiality were explained in the information sheet given to the participants (see appendix A).

Should the participant have wished to withdraw from the study sometime after the debriefing, they were given a 7 day period from the completion of the debriefing in order to do so; this was stated in the briefing, on the consent form and, again, in the debriefing. Should the participant wish to withdraw their data from the research, the coding system was used to locate the participant's data which would then have been destroyed. After the 7 day period the participant was not permitted to withdraw their data.

These procedures were approved by the university's ethics committee.

4.3. Results of the Callous and Unemotional Trait and Empathy Psychometrics in a General Population

4.3.1 A1: Inventory of Callous and Unemotional Traits

To investigate the distribution of psychometric scores within the general sample, a skewedness and kurtosis tolerance of +/-1 was used to indicate normality; outside of these values it is considered that the parameters for normality have been violated and that the distribution is not normal (e.g. Dancey & Reidy, 2008). This measure was used in preference to the Shapiro-wilk test as Shapiro- Wilk proved too strict to provide useful data on the normality of the data. When analysed for distribution and reliability, the ICU total shows skewedness and kurtosis within the parameters appropriate for a distribution to be considered normal. This is also true for 2 of the 3 ICU sub scales; the uncaring and the unemotional sub factors. However, the callous sub factor revealed a positively skewed distribution with higher than normal kurtosis, suggesting that the population is tending towards a pattern of low scoring on the measure of callousness (see table 2).

Internal reliability analysis with Cronbach's Alpha across the ICU total and sub factors show good internal reliability for the ICU total scores (24 items: $\alpha = .78$); appropriate values are those above .7 (e.g. Dancey & Reidy, 2008). Similarly, the unemotional sub scale (5 items: $\alpha = .80$) shows good internal reliability, as does the uncaring sub factor (8 items: $\alpha = .73$). However, the callous sub factor of the ICU shows less internal reliability (9 items: $\alpha = .62$), though the split-half reliability is just over the .4 cut off for appropriate reliability (r=.41) (e.g. Dancey & Reidy, 2008).

Outliers exist at the higher end of the scale for the ICU total (n=1) and the callous sub factor (n= 3). These outliers do not seem erroneous and are not numerous enough to artificially skew the data. The mean scores obtained for the ICUT total and the uncaring and unemotional sub factors were consummate with previous research on similar demographics (Byrd et al., 2013; Essau et al., 2006); however, the callous sub factor mean was a lower than previously obtained mean scores.

Table 2:

Descriptive statistics exploring the ICU total and the 3 sub factor results.

ICU Total and Sub Factors		Result
ICU Total (Range of scores = 0 – 72)	Mean	18.03
	Std. Deviation	6.38
	Minimum	5.00
	Maximum	38.00
	Skewness	.55
	Kurtosis	.33
ICUT Callous Sub Factor (Range of scores = 0 – 27)	Mean	2.33
	Std. Deviation	2.41
	Minimum	.00
	Maximum	10.00
	Skewness	1.43
	Kurtosis	1.67
ICUT Uncaring Sub Factor (Range of scores = 0 – 24)	Mean	7.78
	Std. Deviation	3.46
	Minimum	1.00
	Maximum	17.00
	Skewness	.45
	Kurtosis	-.33
ICUT Unemotional Sub Factor (Range of scores = 0 – 15)	Mean	7.92
	Std. Deviation	2.79
	Minimum	1.00
	Maximum	15.00
	Skewness	.18
	Kurtosis	.48

4.3.2 A2: Antisocial Process Screening device

Unlike the other measures recruited to form the psychometric underpinning of this research, the APSD measures callous and unemotional traits as one of 3 sub factors within the overall measure. The mean total of this scale across participants is low ($\bar{X}$ = 2.75, *SD* = 1.25) even though there are 6 items each with a potential score between 0-2, thus the potential top score is 12. The mean was also lower than previously obtained means in similar research (Frick et al., 2007; Vitacco et al., 2003). Furthermore, the range of this subscale is limited to the bottom scores between 0 and 7 and the standard deviation is small. The APSD was analysed for internal reliability using Cronbach's Alpha, the Alpha value was found to be below that considered acceptable ($\alpha = .15$); as was the split half reliability (r=.09).

The APSD is reported a normal distribution in the data, though when the individual items of the scale are examined a consistent positive skew is observed across all items, however this is only outside normal parameters for item 3, 4 and 6 (*see Table 3*). The mean for all items is between 0 and 1, apart from item 2 which has a mean of 1.17, in addition these standard deviations are low (between 0 and 1) for all items. When examining other measures of central tendencies, the median and mode reveal that for items 3-6 the central and most common response was 0. This suggests that the items may not be eliciting a range of responses from the participants, perhaps due to the small scoring range of the response scale.

Table 3:

Consideration of the APSD callous unemotional sub factor scale items.

Items on the APSD Callous Unemotional Scale	1. You keep the same friends.	2. You hide your feelings or emotions from others.	3. You are concerned about the feelings of others.	4. You feel bad or guilty when you do something wrong.	5. You are good at keeping promises.	6. You care about how well you do at school work.
Mean	.63	1.17	.16	.21	.41	.17
Median	1.00	1.00	.00	.00	.00	.00
Mode	1.00	1.00	.00	.00	.00	.00
Std. Deviation	.56	.52	.37	.43	.53	.42
Skewness	.17	.20	1.86	1.76	.70	2.44
Kurtosis	-.78	.26	1.50	1.96	-.78	5.53
Range	2.00	2.00	1.00	2.00	2.00	2.00

4.3.3 B1: Empathy Quotient.

The distribution of empathy in a general sample will now be considered via the Empathy Quotient for comparison. The results for the EQ suggest that the EQ total and the scores for the subscales, although very slightly negatively skewed, lie within the necessary parameters to be considered a normal distribution (*see Table 4*). Furthermore, the range and standard deviation scores across the EQ total and the 3 sub factors suggest that the measure has appropriate variance and has elicited a variety of responses from the demographic.

The internal reliability for the EQ total was found to be above the .7 level limit for appropriate reliability (items 40: α = .88), this was also true for the cognitive empathy sub scale (items 11: α = .85) and the emotional reactivity scale (items 11: α = .82). However, the social skills sub factor showed a much lower internal reliability (items 6: α =.50), as such this factor will not be used in further analysis.

Means obtained from the research sample for the EQ total and the sub-factors were similar to those acquired in previous research into subclinical samples (Berthoz et al., 2007; Baron-Cohen & Wheelwright, 2004).

Table 4:

Descriptive statistics exploring the EQ total and sub factor results.

EQ Total and Sub Factors		Result
EQ Total (range of scores = 0 – 80)	Mean	42.50
	Median	42.00
	Std. Deviation	12.21
	Minimum	9.00
	Maximum	68.00
	Skewness	-.24
	Kurtosis	.04
EQ Cognitive Empathy (range of scores = 0 – 22)	Mean	11.57
	Median	12.00
	Std. Deviation	4.73
	Minimum	.00
	Maximum	21.00
	Skewness	-.42
	Kurtosis	.02
EQ Emotional Reactivity (range of scores = 0 – 22)	Mean	10.70
	Median	11.00
	Std. Deviation	4.60
	Minimum	.00
	Maximum	20.00
	Skewness	-.37
	Kurtosis	-.31
EQ Social Skills (range of scores = 0 – 12)	Mean	5.88
	Median	6.00
	Std. Deviation	2.44
	Minimum	.00
	Maximum	12.00
	Skewness	-.07
	Kurtosis	-.17

4.3.4 B2: Interpersonal Reactivity Index

The total scores for the IRI show kurtosis beyond that of a normal distribution (1.26) and a very slight negative skew (-.87). This pattern of distribution is mirrored in the participants' scores on the empathic concern sub factor (comparable to emotional empathy) with a kurtosis above that expected of a normal distribution (1.20) and a negative skew (-.82). However, the perspective taking sub factor (which is analogous to cognitive empathy) shows a normal distribution with very little kurtosis. Further exploration of the descriptive data and distributions of the IRI total and sub factors can be found in Table 5 below.

When explored for internal consistency, the IRI total was found to be scoring appropriately between participants when analysed using Cronbach's alpha (28 items: $\alpha = .83$). Furthermore, both the IRI measure of empathetic concern (7 items: $\alpha = .77$) and perspective taking (7 items: $\alpha = 79$) score well on the Cronbach's alpha measure of reliability. Again the descriptive statistics revealed results aligned closely to previous research for both the IRI total and the four sub-factors (Berthoz et al., 2008; Davis, 1983; Davis, 1980).

In conclusion, analysis of the IRI sub factors of empathic concern and perspective taking reveals that both measures show suitable variance, distribution and internal reliability suggesting that both provide a sensitive and appropriate measure of participant empathy and are suitable for continued use within the psychometric and processing ability analysis.

Table 5:

Descriptive statistics exploring the IRI total and sub factor results.

IRI Total and Sub Factors		Result
IRI Total (range of scores = 0-112)	Mean	68.81
	Median	71.00
	Std. Deviation	12.42
	Minimum	21.00
	Maximum	92.00
	Skewness	-.87
	Kurtosis	1.26
IRI Empathic Concern (range of scores = 0 – 28)	Mean	20.10
	Median	20.50
	Std. Deviation	4.60
	Minimum	3.00
	Maximum	28.00
	Skewness	-.82
	Kurtosis	1.20
IRI Fantasy (range of scores = 0 – 28)	Mean	18.15
	Median	18.00
	Std. Deviation	5.09
	Minimum	5.00
	Maximum	28.00
	Skewness	-.23
	Kurtosis	-.52
IRI Personal Distress (range of scores = 0 – 28)	Mean	12.97
	Median	12.50
	Std. Deviation	4.58
	Minimum	2.00
	Maximum	27.00
	Skewness	.47
	Kurtosis	.52
IRI Perspective Taking (range of scores = 0 – 28)	Mean	17.64
	Median	18.00
	Std. Deviation	4.63
	Minimum	3.00
	Maximum	28.00
	Skewness	-.19
	Kurtosis	-.003

4.3.5 Analysis of Association between and Within the Measures of Empathy and Callous and Unemotional Traits

The APSD Callous and Unemotional scale and ICU was correlated in order to investigate the association between the recruited measures of callous and unemotional traits. As the measures satisfy the requirements for parametric data, a Pearson's correlation was used to analyse the CU trait self-report measures. The ICU and APSD Callous and Unemotional scale show a moderate, significant correlation with each other ($r= .44$ (2-tailed), $p<.001$).

The associations between the measures of empathy will be considered using correlational analysis. Firstly, the EQ and IRI emotional empathy subscales were correlated, revealing a significant, strong correlation ($r= .70$ (2-tailed), $p<.001$), suggesting that these measures are congruent with each other in the construct they are measuring.

Analysis of the EQ and IRI cognitive subscale measures of empathy showed a weak but significant correlation between the two scales ($r= .17$ (2-tailed), $p = .028$). The IRI perspective taking subscale was more strongly correlated with the EQ emotional reactivity scale and, additionally, the IRI subscales have a higher coefficient within themselves (*see Table 6*). Furthermore, the cognitive empathy sub factor of the EQ was observed to correlate more strongly with the IRI empathic concern scale and its own emotional reactivity sub factor (*see Table 6*). Therefore, it is possible that the two purported measures of cognitive empathy are measuring slightly different definitions of the cognitive empathy construct.

Table 6:

A correlation matrix showing the relationship between the various sub scale measures of emotional empathy, cognitive empathy and callous and unemotional traits.

Correlations between the IRI, EQ, APSD and ICUT		IRI Empathic concern	EQ Emotional reactivity	IRI Perspective taking	EQ Cognitive empathy	APSD Callous unemotional	ICUT
IRI Empathic Concern	Pearson Correlation	1	.70**	.61**	.33**	-.27**	-.59**
	Sig. (2-tailed)		<.001	<.001	<.001	.003	<.001
EQ Emotional Reactivity	Pearson Correlation	.70**	1	.46**	.56**	-.26**	-.63**
	Sig. (2-tailed)	<.001		<.001	<.001	.004	<.001
IRI Perspective Taking	Pearson Correlation	.61**	.47**	1	.17*	-.36**	-.53**
	Sig. (2-tailed)	<.001	<.001		.028	<.001	<.001
EQ Cognitive Empathy	Pearson Correlation	.33**	.56**	.17*	1	.01	-.25**
	Sig. (2-tailed)	<.001	<.001	.028		.476	.003
APSD Callous Unemotional	Pearson Correlation	-.27**	-.26**	-.36**	.01	1	.44**
	Sig. (2-tailed)	.003	.004	<.001	.952		<.001
ICUT	Pearson Correlation	-.59**	-.63**	-.53**	-.25**	.44**	1
	Sig. (2-tailed)	<.001	<.001	<.001	.006	<.001	

**. Correlation is significant at the .01 level (2-tailed).
*. Correlation is significant at the .05 level (2-tailed).

As hypothesised, all of the sub factor measures emotional empathy significantly negatively correlated with the measure of callous and unemotional traits (*see Table 6*). The IRI and EQ scale measures of cognitive empathy also showed a consistent significant, though more moderate, negative correlation with the measures of callous and unemotional traits (*see Table 6*). The APSD shows less consistency in its findings than the other selected measures with no significant correlation observed between it and the cognitive empathy scale of the Empathy Quotient; however a stronger association was recorded with the perspective taking sub scale than either of the measures of emotional empathy (the empathic concern factor and the emotional reactivity scale). As such, the Antisocial Process Screening Device measure may not be as reliable a measure of the callous and unemotional trait construct as the Inventory of Callous and Unemotional Traits.

4.3.6 Final Measures of Callous-Unemotional Traits and Empathy

Given the low internal reliability of the APSD scale and its consistently lower correlations with the empathy measures, it was considered that the ICU would be used as a measure of callous and unemotional traits in further analysis to remove any systematic weakening of the CU trait construct by the APSD. As the EQ and IRI measures of cognitive and emotional empathy have been found to be internally reliable and show consistent correlations within and between the measures, thus it is appropriate that an amalgamated score was used to further explore the constructs of emotional empathy and cognitive empathy. Using this assimilated score of the predefined measures limits the reliance on any one measure and, thus, will produce a more valid measure of each construct (Reniers et al., 2011). To form these amalgamated measures, the empathetic concern scale of the interpersonal reactivity index and emotional reactivity sub factor of the Empathy Quotient combined to produce a score for emotional empathy, and the perspective taking factor of the Interpersonal Reactivity Index and Cognitive Empathy sub scale of the Empathy Quotient were assimilated to produce a measure of cognitive empathy.

The Descriptive for these final measures of cognitive empathy, emotional empathy and CU traits can be seen in Table 7. These measures reveal that emotional empathy significantly negatively correlated with the measure of callous and unemotional traits ($r = -.66$ (2-tailed), $p<.001$). Interestingly, cognitive empathy also showed a significant though more moderate correlation with the measure of callous and unemotional traits ($r = -.51$ (2-tailed), $p<.001$), suggesting that those individuals scoring highly on either the cognitive or emotional measures of empathy were likely to score low on measures of CU traits and vice versa. Furthermore, the association between emotional empathy and cognitive empathy was significant (r= .69 (2 tailed), p<.001). Thus, those participants who scored highly on the measures of emotional empathy tended to score highly on cognitive empathy.

Table 7:

Descriptive Statistics for the Final Measures.

Descriptive Statistics for the Final Measures		Statistic
Emotional Empathy	Mean	30.85
	Median	32.00
	Std. Deviation	8.51
	Skewness	-.56
	Kurtosis	.36
Cognitive Empathy	Mean	29.25
	Median	30.00
	Std. Deviation	7.16
	Skewness	-.20
	Kurtosis	.42
Callous and Unemotional Traits	Mean	18.03
	Median	17.50
	Std. Deviation	6.38
	Skewness	.55
	Kurtosis	.33

When gender is considered as a variable the expected differences are observed; females having higher mean scores in emotional and cognitive empathy and males higher CU trait scores (*see Table 8*). However, within the male and female groups, the negative relationship between CU traits and emotional and cognitive empathy is preserved (*see Table 9*).

Table 8:

Differences in the male and female scores on the self-reported measures of CU traits and empathy.

	Mean		T-test for Equality of Means			
	Female	Male	t	df	P value	Cohen's d
CU Traits	16.65	20.93	-3.65	122	<.001	.67
Emotional Empathy	33.25	25.80	4.51	60.89	<.001	.91
Cognitive Empathy	30.72	26.15	3.47	122	.001	.65

Table 9:

The relationship between the self-reported measures of CU traits and empathy in males and females.

CU Trait Correlations		Emotional Empathy	Cognitive Empathy
Female	Pearson Correlation	-.63	-.50
	Sig. (2-tailed)	<.001	<.001
Male	Pearson Correlation	-.59	-.40
	Sig. (2-tailed)	<.001	.005

The relationships between the CU traits, emotional and cognitive empathy, and affective response will subsequently be reported. Alpha values were not adjusted over the following analysis as each comparison and experiment is looking at a separate possible relationship between the variables, as set out prior to the experiment in the methodological design; unnecessary adjustment would lessen the power of the analysis and, therefore, is not advisable when the comparisons have been balanced with the magnitude of effect, the protocol of the study and with findings from other studies (Feise, 2002). Ensuring such factors of the paradigm were strategised before undertaking the research act to prevent Type I error inflation (O'Keefe, 2003).

4.3.7 Disassociation between Emotional and Cognitive Empathy with regards to Callous and Unemotional Traits

The potential disassociation between cognitive and emotional empathy in those with elevated CU traits will be considered using two methods; a parametric correlation to compare the association and an independent t-test to explore whether there is a difference between the emotional and cognitive empathy of a high and low CU trait group. Correlational analysis revealed that the amalgamated emotional empathy measure significantly negatively correlated with the measure of callous and unemotional traits (r = -.66 (2-tailed), p<.001). However, the cognitive empathy measure also showed a significant though more moderate correlation with the measure of callous and unemotional traits (r = -.51 (2-tailed), p<.001). Furthermore, the ICU data was assimilated into a high and low CU traits split at the mean ($\dot{X}$=18.03). These groups were then analysed using an independent t-test. The t-tests revealed that there was a significant difference between the high and low CU trait groups for both cognitive empathy (t(122) = 5.16, p<.001, *d* = .94) and emotional empathy (t(91.76)= 7.52, p<.001, *d* =1.39).

To explore the potential disassociation of emotional and cognitive empathy processing within the CU trait construct a Steiger's Z test was conducted (Steiger, 1980). The Steiger's Z is used to compare dependent correlation coefficients for statistical differences. By inputting the correlations of the CU trait measures with emotional empathy (r(124) = -.66 (1-tailed), p<.001) and cognitive empathy (r(124) = -.51, p<.001) into a Steiger's Z calculation a significant difference was observed between the two coefficients (ZH (124)= 2.13, p = 0.03). This finding suggests that a disassociation may exist between the cognitive and emotional empathy processing in CU traits, with a dysfunction in emotional empathy being correlated more strongly with higher CU trait manifestation than cognitive empathy.

Furthermore, the amount of variation in CU trait scores explained by emotional and cognitive empathy was evaluated using a multiple regression analysis (standard entry method). The regression revealed that the amount of the variation in CU traits explained by the two empathy type predictors was significant ($F(2,123) = 47.40$, $p < .001$). The correlation between the predicting empathy type and CU traits was 0.663 with an adjusted multiple R^2 of 0.43, indicating that 43% of the variation in CU trait scores could be explained by cognitive and emotional empathy. However, inspection of the regression coefficients and associated beta values revealed that only emotional empathy scores are a significant predictor of CU trait score ($\beta = -.59$, $t = 6.28$, $p < 0.001$). Conversely, cognitive empathy was not a significant predictor of CU trait scores ($\beta = -.10$, $t = 1.01$, $p = .316$).

Although there is a negative correlation between CU traits and both emotional and cognitive empathy, it appears that emotional empathy is significantly more strongly associated with CU traits than cognitive empathy. Furthermore, only emotional empathy is significantly predictive of CU trait score. A disassociation between emotional and cognitive empathy processing is, therefore, associated with CU trait manifestation.

Both moderation and mediation analysis were run to observe whether CU traits indirectly effected the relationship between cognitive and emotional empathy, however CU traits were not observed to mediate nor moderate this relationship.

4.3.8 Results of the Facial Expression Empathy Task (C1)

The first empathy task measured 3 variables; whether the participant could correctly identify facial expressions, whether the participant felt negative or positive during the observation of the photographic stimuli, and finally the intensity of feeling present when viewing the stimuli. Facial expression recognition data was calculated as a percentage of correct responses. Analysis of the data revealed that, when considered overall, the ability to correctly identify negative facial expression stimuli (negative stimuli included depictions of disgust, fear, pain, anger and sadness) (X= 86.15, SD = 8.92) was significantly, positively associated with emotional empathy (r = .25 (2-tailed), p=.006), but did not correlate with cognitive empathy (r=.15 (2-tailed), p=.093) nor levels of callous and unemotional traits (r= -.167 (2-tailed), p=.065). Although it was postulated that indirect measures of emotional empathy would positively correlate with a participant's ability to correctly identify negative facial expression and that there may not be a relationship between this direct recognition measure and indirect measures of cognitive empathy, a negative relationship was expected and hypothesised between recognition ability and CU traits, which was not found.

There is no correlation between the accuracy in recognition of facial expression depicting anger, disgust, nor sadness and any of the indirect measures of callous and unemotional traits (see *Table 10*). But, when considered individually, the recognition scores for fear stimuli do show a pattern of relationship with the measure of emotional empathy and CU traits. The fear recognition data (*X*= 83.25%, *SD* = 18.09) correlates negatively with callous and unemotional traits and positively with emotional empathy (see *table 10*). No relationship was observed with cognitive empathy. Pain recognition data (*X* = 72.28%, *SD* = 19.56) was found to be negatively associated with emotional empathy, although no further significant associations were found with neither cognitive empathy nor callous and unemotional traits (see *Table 10*). Finally, as hypothesised, there were no significant correlations with any of the indirect measures and the recognition of expression of happiness.

Table 10:

Correlation matrix showing the relationship between the facial expression recognition accuracy and participants scores on the measures of emotional empathy, cognitive empathy and callous and unemotional traits.

Facial Expression		Emotional Empathy	Cognitive Empathy	CU Traits
Anger	Pearson Correlation	.23	.19	-.06
	Sig. (2-tailed)	.012*	.033*	.468
Disgust	Pearson Correlation	.05	.00	-.05
	Sig. (2-tailed)	.607	.974	.553
Fear	Pearson Correlation	.22*	.13	-.31**
	Sig. (2-tailed)	.015	.156	.001
Happiness	Pearson Correlation	.11	.07	-.05
	Sig. (2-tailed)	.210	.443	.563
Pain	Pearson Correlation	.19*	.11	-.05
	Sig. (2-tailed)	.032	.221	.604
Sadness	Pearson Correlation	-.02	-.02	.04
	Sig. (2-tailed)	.842	.828	.641

**. Correlation is significant at the .01 level (1-tailed).
*. Correlation is significant at the .05 level (1-tailed).

A correlation design was used to consider the relationship between the 9 point positive-negative scale of the SAM and the measures of emotional empathy, cognitive empathy and CU traits. Within the scale a score of 1 was the most positive score and 9 the most negative. When assimilated into one category the negative facial expressions

(X = 6.4, SD = .91) initiated increased negative scoring, and thus high emotional valence, from participants with higher emotional empathy (r = .40 (2-tailed), p= <.001) and from those with higher cognitive empathy (r = .21 (2-tailed), p = .018). Correspondingly, those reporting higher callous and unemotional traits were reporting less negatively on the scale (r = -.24 (2-tailed), p = .009), suggesting lower affective valence in those with higher CU trait scores. As shown in Table 11 below, this pattern of response is borne out over all 5 negative emotions. The reverse pattern is seen in the participant responses to facial expressions of happiness, with those individuals high in callous and unemotional traits giving less positive responses and those high in emotional empathy and cognitive empathy being associated with a more positive report (*see table 11*).

Table 11:

Correlation matrix showing the relationship between the facial expression stimuli and participants scores on the positive-negative scale of the Self-Assessment Manikin. A lower score indicates a more positive response and a higher score a more negative one.

Positive to Negative Scale		Emotional Empathy	Cognitive Empathy	CU Traits
Anger	Pearson Correlation	.35**	.17	-.25**
	Sig. (2-tailed)	<.001	.058	.006
Disgust	Pearson Correlation	.30**	.19*	-.18*
	Sig. (2-tailed)	.001	.035	.047
Fear	Pearson Correlation	.33**	.16	-.18*
	Sig. (2-tailed)	<.001	.076	.048
Happiness	Pearson Correlation	-.44**	-.28**	.39**
	Sig. (2-tailed)	<.001	.001	<.001
Pain	Pearson Correlation	.35**	.16	-.18
	Sig. (2-tailed)	<.001	.074	.052
Sadness	Pearson Correlation	.45**	.27**	-.27**
	Sig. (2-tailed)	<.001	.002	.002

**. Correlation is significant at the .01 level
*. Correlation is significant at the .05 level

Intensity was also reported using the Self-Assessment Manikin's second 9 point scale as the participant observed each facial expression stimulus and again was assessed using a correlational design; 1 on the scale indicated high intensity and 9, low intensity. Assimilation of intensity data for the negative expression ($X = 5.37$, $SD = 1.68$) revealed a significant association between reported intensity of feeling and emotional empathy ($r = -.30$ (2-tailed), $p=.001$). Participants reporting higher emotional empathy also report increased emotional valence in response to observing the stimuli depicting negative emotions. No association was found between cognitive empathy or CU traits and the intensity of response.

When considering the stimuli groups individually this pattern of association is replicated in stimuli depicting anger, disgust, fear and pain (see *Table 12*). Conversely, the average intensity for the stimuli presenting sadness and happiness was significant across all three indirect measures, with significant correlations being observed between intensity, emotional empathy and cognitive empathy; these indicated that participant's scoring highly on measures of emotional and cognitive empathy were likely to rate their intensity as higher also. Lower intensities were observed for those with higher level of reported callous and unemotional traits (see *Table 12* for analysis). Therefore, it appears there are significant differences in the emotional responses of participants to the stimuli, depending on their reported emotional empathy, cognitive empathy and callous and unemotional traits.

Table 12:

Correlation matrix showing the relationship between the facial expression stimuli and participants scores on the intensity scale of the Self-Assessment Manikin. A lower score indicates a more intense response and a higher score a less intense one.

Intensity Scale		Emotional Empathy	Cognitive Empathy	CU Traits
Anger	Pearson Correlation	-.27**	-.10	.13
	Sig. (2-tailed)	.001	.288	.146
Disgust	Pearson Correlation	-.24**	-.07	.02
	Sig. (2-tailed)	.007	.461	.792
Fear	Pearson Correlation	-.19*	-.04	.06
	Sig. (2-tailed)	.034	.652	.504
Happiness	Pearson Correlation	-.33**	-.18*	.22*
	Sig. (2-tailed)	<.001	.042	.016
Pain	Pearson Correlation	-.28**	-.10	.13
	Sig. (2-tailed)	.002	.256	.162
Sadness	Pearson Correlation	-.40**	-.24**	.19*
	Sig. (2-tailed)	<.001	.006	.032

**. Correlation is significant at the .01 level
*. Correlation is significant at the .05 level

4.3.9 Results of the Emotional Response Task (C2)

A correlation design was used to consider the relationship between the 9 point positive-negative scale of the SAM and the measures of emotional empathy, cognitive empathy and CU traits. Within the scale, a score of 1 was the most positive possible score and 9 the most negative. The analysis revealed that there was a negative association with CU traits and the negative images (*X*= 6.53, *SD* = .93) (r= -.33 (2 tailed), p<.001) indicating that those with higher CU traits were more likely to score themselves more positively on the scale when viewing negative images. Furthermore, the CU traits positively correlated with the average positive-negative score on the positive images (*X*= 2.56, *SD* = .91) (r=.45 (2 tailed), p<.001); indicating that those individuals with CU traits tended to score the experience more negatively than low CU trait individuals, when viewing positive images. The measures of empathy are also significantly correlated with the participants positive-negative scale scores for the negative images. Emotional empathy was observed to positively correlate with participant's scores when viewing negative images (r = .50 (2 tailed), p<.001); suggesting that those participants scoring more highly on the measures of emotional empathy were more likely to score themselves as feeling more negative when viewing the negative images. This relationship is also found, but with a lower coefficient, between the measures of cognitive empathy and the positive-negative scores in regards to the negative images (r= .32 (2 tailed), p<.001). When further broken down into the constituent categories, this pattern is borne out throughout the data, though to a lesser degree in response to animal fear (see *Table 13*).

Table 13:

Correlation matrix showing the relationship between the negative stimuli and participants scores on the positive-negative scale of the Self-Assessment Manikin.

Photographic Stimuli Category		Emotional Empathy	Cognitive Empathy	CU Traits
Human fear	Pearson Correlation	53**	.37**	-.46**
	Sig. (2-tailed)	<.001	<.001	<.001
Pet animal fear	Pearson Correlation	.16	.09	.04
	Sig. (2-tailed)	.083	.334	.703
Livestock animal fear	Pearson Correlation	.23**	.19*	-.12
	Sig. (2-tailed)	.009	.033	.197
Human pain	Pearson Correlation	.32**	.15	-.22*
	Sig. (2-tailed)	<.001	.104	.012
Pet animal pain	Pearson Correlation	.42**	.28**	-.29**
	Sig. (2-tailed)	<.001	.002	.001
Livestock animal pain	Pearson Correlation	.35**	.31**	-.21**
	Sig. (2-tailed)	<.001	<.001	.020

**. Correlation is significant at the .01 level
*. Correlation is significant at the .05 level

The positive image scores were also found to have significant associations with the emotional and cognitive measures of empathy. Emotional empathy scores were negatively correlated with the scores on the positive-negative scale for positive images ($r = -.50$ (2 tailed), $p < .001$). This pattern of correlation was also observed for measures of cognitive empathy ($r = -.41$ (2 tailed), $p < .001$). This indicates that the individuals scoring themselves highly on measures of cognitive and emotional empathy were likely to score themselves as feeling more positive when viewing positive images. This pattern of response is present in all categories of stimuli when considered separately (see *Table 14*).

Table 14:

Correlation matrix showing the relationship between the positive stimuli and participants scores on the positive-negative scale of the Self-Assessment Manikin.

Photographic Stimuli Category		Emotional Empathy	Cognitive Empathy	CU Traits
Positive human	Pearson Correlation	-.47**	-.40**	.49**
	Sig. (2-tailed)	<.001	<.001	<.001
Positive pet animal	Pearson Correlation	-.42**	-.31**	.29**
	Sig. (2-tailed)	<.001	.001	.001
Positive livestock animal	Pearson Correlation	-.31**	-.28**	.24**
	Sig. (2-tailed)	.001	.002	.006

**. Correlation is significant at the .01 level
*. Correlation is significant at the .05 level

Intensity of the participants' feeling was reported using the Self-Assessment Manikin's second 9-point scale; 1 on the scale indicated high intensity and 9, low intensity. CU traits were positively correlated with self-scored intensity on both the positive ($X = 4.54$, $SD = 2.15$) ($r = .17$ (2 tailed), $p = .32$) and negative ($X = 4.87$, $SD = 1.66$) ($r = .24$ (2 tailed), $p = .008$) images. This result suggests that those scoring highly on the CU trait measure tend to score themselves as experiencing less intensity of emotion when viewing both positive and negative images. The opposite association was observed with emotional empathy, which negatively correlated with both positive (r = -.27 (2 tailed), p=.002) and negative (r = -.47 (2 tailed), p <.001) images. These relationships suggest that those individuals who have higher emotional empathy, as measured by self-report, are likely to report increased intensity of emotional response when viewing both positive and negative images. Cognitive empathy results mimic this pattern with smaller coefficients for both the positive (r = -.19 (2 tailed), p= .034) and negative (r = -.27 (2 tailed), p=.002) images. Furthermore, this pattern of results continues when the intensity scale results are considered within the individual categories of stimuli (see *Table 15*).

Table 15:

Correlation matrix showing the relationship between the positive stimuli and participants scores on the intensity scale of the Self-Assessment Manikin.

Photographic Stimuli Category		Emotional Empathy	Cognitive Empathy	CU Traits
Fear human	Pearson Correlation	-.37**	-.25**	.26**
	Sig. (2-tailed)	<.001	.006	.003
Fear pet animal	Pearson Correlation	-.30**	-.16	.12
	Sig. (2-tailed)	.001	.082	.110
Fear livestock animal	Pearson Correlation	-.34**	-.19*	.11
	Sig. (2-tailed)	<.001	.031	.248
Pain human	Pearson Correlation	-.42**	-.16	.20*
	Sig. (2-tailed)	<.001	.074	.026
Pain pet animal	Pearson Correlation	-.42**	-.26**	.22*
	Sig. (2-tailed)	<.001	.003	.013
Pain livestock animal	Pearson Correlation	-.49**	-.34**	.214*
	Sig. (2-tailed)	<.001	<.001	.017
Positive human	Pearson Correlation	-.30**	-.23*	.21*
	Sig. (2-tailed)	.001	.012	.020
Positive pet animal	Pearson Correlation	-.24**	-.15	.10
	Sig. (2-tailed)	.007	.087	.255
Positive livestock animal	Pearson Correlation	-.16*	-.10	.10
	Sig. (2-tailed)	.034	.281	.266

**. Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level

Conclusion

The distributions for empathy quotient, IRI, ICU and APSD can be considered normal. The final CU measure revealed that emotional empathy negatively correlated with CU traits. However, cognitive empathy also presented a significant correlation with the measure of CU traits. Although, further analysis suggests a weaker negative relationship between CU traits and CE, than between CU traits and EE. Only the fear recognition data correlated negatively with callous and unemotional traits and positively with emotional empathy. No relationship was observed with cognitive empathy. Negative facial expressions initiated reporting less negatively on the SAM scale by those with higher CU traits. Furthermore, those individuals high in callous and unemotional traits gave less positive responses to happiness expressions. The intensity data for the negative expression revealed a significant association between reported intensity of feeling and emotional empathy; though significant effects were observed across measures for happiness and sadness expressions. A universal deficit in affective valence and intensity was observed in association with higher manifestation of CU traits for the emotional response task. A negative association was reported between CU traits and the negative images. Furthermore, the CU traits positively correlated with the average positive-negative score on the positive images. Individuals with CU traits tended to score the experience more negatively than low CU trait individuals when viewing positive images and vice versa. CU traits positively correlated with intensity on both the positive and negative images. Suggesting that high CU trait individuals score themselves as experiencing less intensity of emotion when viewing both positive and negative images.

4.4 Discussion of Findings Investigating Callous and Unemotional Traits and the Relationship with Empathy Processing and Affective Valence.

Consideration of the ICUT indirect measure of CU traits suggests that not only do CU traits and empathy processing manifest throughout the general population. Such measurement seems to suggest that CU traits present in a continuous distribution and within the parameters necessary to be considered normally distributed through the general population. This finding is in agreement with previous research into CU traits (Hare & Neumann, 2008; Edens et al., 2006; Marcus et al., 2004; Skeem et al., 2003; Lynam, 2002; Lilienfeld, 1994). Therefore, disorders which are associated with the manifestation of high CU traits may represent the extreme high tail of this distribution, rather than an isolated population of individuals with high levels of CU traits. However, given that callousness is often described within the context of psychopathology and, therefore, a negative skew might be expected, it may be that the personality trait described as callousness is may be better considered as a reduced empathy rather than true callousness. Further research would be required to explore the construct of callousness in context of psychopathy, psychopathology and personality, to address this divergence in how the concept is considered and reported.

Within the clinical disorders of Conduct Disorder, Antisocial Personality Disorder and Psychopathy there is an established disassociation of emotional and cognitive empathy constructs with regards to the effect of CU traits on the function of their processing (Blair, 2008; 2005). Emotional empathy is evidenced, consistently and reliably, to be dysfunctional within high CU traits clinical patients, however, cognitive empathy is usually reported intact (Hastings et al., 2008; Marsh & Blair, 2008; Blair, 2005). Despite this established empathy paradigm existing within the clinical populations, the results of this research into the general population suggest more complexity in the association with the emotional and cognitive empathy, edifying instead that both emotional empathy and cognitive empathy negatively correlated with CU traits, but the association with cognitive empathy is more tenuous and is more sensitive to the analysis performed. Limited research into specifically sub-clinical traits, rather than high CU trait disorders has also evidenced this negative association with cognitive empathy measures (Ali & Chamorro-Premuzic, 2010; Dadds et al., 2009). Such a finding tentatively suggests that perhaps CU traits are indicative of a dysfunction in both emotional and cognitive empathy processing in the general population, though this proposition requires much more examination through a diverse range of emotional and cognitive empathy measures.

However, it is also observed that the negative correlation between the indirect measure of emotional empathy and CU traits is significantly larger than the corresponding CU trait correlation with cognitive empathy; as analysed using Steiger's Z inferential testing to compare the coefficients. Furthermore, regression analysis reveals that only emotional empathy scores on indirect measures predict outcomes on CU trait measures. Thus, the outcomes of the research suggest that a reduction in both self-reported cognitive and emotional empathy is associated with higher CU trait manifestation in a general population, but that the reduction in self-reported emotional empathy is independently correlated with CU traits when multiple predictors are considered. Such a finding implies a disassociation in the magnitude of empathy processing dysfunction rather than the more commonly reported preservation of cognitive empathy with dysfunction of empathy processing being restricted to emotional empathy components (Blair, 2008; 2005).

Dissociation in the magnitude of dysfunction of cognitive and emotional empathy could be a unique trait of the general demographic; though it is also possible that the findings of this study, and by extension those of wider literature looking at empathy and CU traits, may be indicative of test specific outcomes. The current finding was based on self-report measures of cognitive empathy, however, previous research has used Theory of Mind tasks (e.g. the Reading the Mind in the Eyes Test) to explore the cognitive empathy of those with high CU traits (Dadds et al., 2009; Blair, 2008; 2005). Further research using a range of direct and indirect measures of cognitive empathy would be required to consider the impact of the measure on the outcome with regards to CU traits. In addition, the analysis and power of the research may mediate whether a disassociation between emotional and cognitive empathy is observed; correlations performed in the analysis of this research suggest a global negative association between emotional and cognitive empathy and CU traits, however, regression analysis suggests that only emotional empathy reductions predict CU trait scores. Therefore, the number of predictors used in the analysis performed may also govern the reported outcome of research into the relationship between CU traits and empathy. Despite potential differences in results associated with the measures recruited for research paradigms and the analysis performed, emotional empathy deficiencies appears to be independently associated with high levels of CU traits, whereas cognitive empathy dysfunction varies across and within research.

It is interesting, that CU traits did not mediate nor moderate the relationship between cognitive empathy and emotional empathy. Further research using a larger sample and comparing the subclinical population with a clinical population with pathologically elevated CU traits might be useful in determining whether it is usual that CU traits do not interact with this relationship or whether it is limited to the subclinical population.

The ability to correctly identify negative facial expression stimuli was only significantly, positively associated with emotional empathy and did not correlate with the measure of cognitive empathy nor levels of callous and unemotional traits. Some facial expression recognition tests are used as a measure of cognitive empathy; for example, Richell et al (2003) scrutinised the ability of persons with psychopathy to recognise expressions from stimuli in which the expression information was reduced to only that given by the eye region, known as the 'Reading the Mind in the Eyes' task (Baron-Cohen et al., 1997). Psychopathic individuals were not impaired on this test and it is concluded that this is because of the preservation of cognitive theory of mind ability; however, given that the recognition of negative facial expressions of emotion was only correlated with emotional empathy perhaps such measures are not measuring purely the cognitive element of the empathy construct.

Fear recognition data positively associated with emotional empathy and negatively with callous and unemotional traits, no relationship was observed with cognitive empathy. The dysfunction in fear recognition accuracy associated with high

CU traits within the presented research demonstrated patterns of response and disassociation in symmetry with clinical research, which has established a reliable dysfunction in the ability of those with high CU trait conditions to recognise fearful facial expressions (Hastings et al., 2008; Marsh & Blair, 2008; Blair, 2005). Reduced fear recognition accuracy associated with higher CU trait manifestation within the general demographic suggests that CU traits present similarly with regards to fearful facial expression response in both clinical and general populations. It was also found that a reduced response to fear was associated with low emotional empathy and high CU traits, but was not correlated with cognitive empathy suggesting a relationship between emotional empathy, CU traits and the recognition of fear, that does not correlate with cognitive empathy. Despite evidence of reduced recognition of fearful expression, no further dysfunction in recognition was observed for the other expressions, which might have been expected given research into high CU trait disorders (Dawel et al., 2012; Fairchild et al., 2010; Hastings et al., 2008; Blair, 2005).

General demographics, therefore, may be specifically sensitive to modulation in fearful expression recognition with regards to CU trait manifestation, by comparison to other facial expressions; This finding agrees with previous literature which looks specifically at CU trait manifestation, rather than psychopathic traits or high CU trait clinical disorders and reports reduced recognition exclusively with regards to fearful expressions (Leist & Dadds, 2009; Muñoz, 2009). However, contemporary papers contest this conclusion suggesting that either a more omnipresent dysfunction in expression recognition or even positive association with fear recognition (e.g. Prado et al., 2015; Del Gaizo & Falkenbach., 2008). Considering this contradiction in outcomes, further research may be required to consider fully the relationship between CU traits and facial expression recognition in non-clinical, general demographics.

Research into general manifestations of CU traits has also indicated that there are neurological, as well as psychological, interactions between these traits and empathy and affective processes; for example, in a test of several sub-regions of the frontal cortex and the amygdala were associated with less activity in general participants' presenting with high psychopathic traits, suggesting that unique neural correlates are associated with increased CU traits (Gordon et al., 2004). This signature seems to reflect the more extreme deficiency in amygdala and frontal cortex region function observed in psychopathy (Blair, 2003) and thus acts as a precedential finding supporting the theory that psychopathic individuals may indeed be depicted as extremes of a continuous distribution across the general population, and that general individuals may not present with large differences in behavioural responses. This theory will be tested further in the series of electrophysiological research studies described in section 2.

The interactions of CU traits in the general data mirrored the clinical populations with regards to the affective responding of the participants. Relationship between affective valence and CU traits were observed both within the facial expressions of emotion task and the emotional valence task. Furthermore, differences were observed on both the positive-negative and intensity scales of the SAM used to indirectly measure emotional responding. Those high in CU traits consistently revealed a lower level of emotional valence in response to both positive and negative affective stimuli.

Negative facial expressions initiated less negative scoring in those participant's scoring more highly in the measure of callous and unemotional traits; furthermore, this effect was observed in response to the emotional valence task also. A less negative emotional valence in response to negative affect provoking images was associated with those reporting higher CU traits. This universal negative relationship between emotional valence and CU traits was observed in response to both human and animal stimuli. This result is symmetrical to the reduction in emotional responding reliably evidenced in high CU trait disorders, such as psychopathy and conduct disorder; such disorders are associated with reduced empathetic responding towards humans and sentient non-humans (Dadds et al., 2006; Soderstrom, 2003).

No affective relationship was seen with CU traits in the responding to fearful facial expressions, however this maybe because the lack of recognition prevents further emotive response from higher CU trait individuals. It is unknown what expression the high CU trait scoring participants misrecognise fearful facial affect as; this is research that could be under taken in the future.

CU traits were associated with reduced positive valence in response to positively affective images in the general demographic tested. Higher CU traits were consistently correlated with less positivity and intensity of reported emotion when viewing both positive and negative images. Thus, reductions in both positive and negative affect associated with higher CU trait presentation suggest that CU traits are associated with a universal reduction in affective valence and emotional responding when measured indirectly. This pattern of interaction between emotional valence in response to affect inciting images and CU traits is consistent with the clinical data and thus maybe a stable and permeating factor associated with CU trait manifestation (Dadds et al., 2006; Soderstrom, 2003).

However, there are limitations to the chosen methodology. Firstly, the self-reported elements of the research paradigm are open to misrepresentation, explicit or implicit, by the participant. The results suggest that a consistent pattern of response within the participant sample. Therefore, it is unlikely that any misrepresentation has perturbed the overall results. Secondly, the gender is not 50% male and female as would be ideal; however the large sample ensures a good number of both sexes in the sample. Finally, the participants were predominately psychology students, a broader and, thus, more representative sample of the general population demographic would be ideal.

To conclude, CU traits have been found to present in a continuous distribution in the general population and this presentation is associated with certain interactions with empathy processing. Particularly, a lower reporting of both cognitive and emotional empathy is evidenced in those with higher CU traits. However, this finding lies counter to the disassociation of the construct processing associated with clinical populations. A generalised deficit in affect recognition was not strongly evidenced in the results; instead the findings suggest that higher CU trait manifestation is related to a specific reduction in the recognition of fearful expressions. Deficiencies in emotional valence associated with elevated CU trait individuals were supported through indirect measurement of affect in the general population. As a constellation of results the assimilated data suggests that CU traits are associated with modulations in both the empathy processing and affective valence of the general population. However, these interactions may manifest in a different manner to that observed within clinical populations.

SECTION 2:

ELECTRO-NEUROLOGICAL CORRELATES OF EMPATHY PROCESSING ABILITY AND AFFECTIVE VALENCE WITH REGARDS TO CALLOUS AND UNEMOTIONAL TRAITS.

The second section of this thesis is concerned with the electrophysiological research, which explored the mediating effect of CU traits on the neural correlates of empathy and emotion. Selection of appropriate candidates for the research, who represent higher, lower and control presentations of CU traits without comorbid or confounding psychological traits, is described in chapter 5. These recruited participants formed the research groups for experimental electrophysiological research into whether the manifestation of CU traits modulates empathetic responses and emotional valence as measured through event related potential (ERP) analysis (see chapter 6-8).

Chapter 5:

Participant Selection, Electroencephalographic Recording and Event Related Potential Analysis Protocols

The three electrophysiological research studies which form the second section of this thesis all involve the same participants (n=29). This ensures a consistency and validity when looking across the studies to considered the wider research area. Furthermore, using the same participant cohort for all four studies allows for thorough exploration of the participant group for suitability and potential confounds.

As described previously the participants of the original psychometric experiments were analysed for their self-reported manifestation of Callous-Unemotional personality traits using the Inventory of Callous–Unemotional Traits (Frick, 2004). The score on this measure of CU traits was the primary recruiting tool for the electrophysiological research. The participants were selected from the lower quartile, upper quartile and mean of the CU trait distribution from the first experimental demographic as defined in chapter 4.

In total 29 participants were recruited into this second programme of studies: 10 in the high and low CU trait groups, and 9 participants formed a control group with scores within +-2 points of the mean (17.78). These group numbers are consummate with other electrophysiological studies into empathy and emotional valence (Suway et al., 2013; Cheng et al., 2012; Frenkel & Bar-Haim, 2011; Schupp et al., 2004).

Descriptive for the CU trait experimental groups can be found in table 16.

Table 16:

The CU trait descriptive statistics for the three experimental groups.

ICUT Recruited Experimental Group			Statistics
High N = 10	Mean		29.30
	95% Confidence Interval for Mean	Lower Bound	25.83
		Upper Bound	32.77
	Median		28.00
	Variance		23.57
	Std. Deviation		4.85
	Minimum		24.00
	Maximum		38.00
	Skewness		.63
	Kurtosis		-.92
Control N = 9	Mean		17.78
	95% Confidence Interval for Mean	Lower Bound	16.94
		Upper Bound	18.62
	Median		17.00
	Variance		1.19
	Std. Deviation		1.09
	Minimum		17.00
	Maximum		20.00
	Skewness		1.29
	Kurtosis		.77
Low N = 10	Mean		9.20
	95% Confidence Interval for Mean	Lower Bound	6.80
		Upper Bound	11.60
	Median		10.50
	Variance		11.29
	Std. Deviation		3.36
	Minimum		2.00
	Maximum		12.00
	Skewness		-1.36
	Kurtosis		1.15

The participants ranged in age between 18 and 30 years with a mean of 23.27 and a standard deviation of 3.92. There was no significant difference between the age of participants in the 3 experimental groups ($F(2,26) = 1.86$, $p = .180$). 14 female and 15 male participants were recruited for the electrophysiological research. The gender demographic split in each experimental group can be seen in table 17 below. There were no significant differences in scores in each group associated with gender (see table 18).

Table 17:

The gender demographic split in each experimental group and related descriptives.

CU Trait Group	Gender	N	Mean	Std. Deviation
High	Female	4	29.50	5.26
	Male	6	29.17	5.10
Control	Female	5	17.40	.55
	Male	4	18.25	1.50
Low	Female	5	10.40	1.82
	Male	5	8.00	4.30

Table 18:

The gender score differences by group as explored by independent t-test.

CU Trait Group	T	df	P Value	Cohen's d
High	.100	8	.923	.06
Control	1.077	3.643	.347	.75
Low	1.149	5.383	.299	.73

5.1 Exploring the Uniqueness, Empathy Processing and Affective Valence of the Recruited Experimental Groups

Using the original psychometric data, the groups were explored for three key factors; whether the manifestation of CU traits was significantly different between the groups, the emotional and cognitive empathy of the three groups and the emotional valence manifestation in the experimental groups. This analysis was undertaken to ensure that three distinct experimental groups had been recruited, as well as considering the interaction of empathy and emotional valence with these experimental groups.

To briefly reiterate, the participants were analysed for their self-reported manifestation of Callous-Unemotional personality traits using the Inventory of Callous–Unemotional Traits (Frick, 2004). Furthermore, empathetic ability was scored using the Empathy Quotient (EQ) (Baron-Cohen and Wheelwright, 2004) and The Interpersonal Reactivity Index (IRI) (Davis, 1983). Two tasks explored the participant's recognition of and response to facial expressions and their self-reported emotional valence to affective stimuli. An independent measures design was used to explore whether the ICUT scores, and thus indirect measurement of CU traits, were significantly different between the groups. There were significant differences between the high, low and control experimental groups ($F(2,26) = 81.78$, $p < .001$, $\eta p^2 = .86$); indicating a considerable difference in CU trait manifestation across the groups (see *Figure 10*). Post hoc bonferroni analysis with an alpha value of $p = .017$ indicated that there was a significant difference between all three groups. The high and control CU trait groups had a significant difference in their CU trait scores ($t(10.01) = 7.30$, $p < .001$, $d = 3.28$), as did the control and low groups ($t(11.07) = 7.64$, $p < .001$, $d = 3.22$) and the high and low ($t(18) = 10.77$, $p < .001$, $d = 4.71$).

Analysis of the three sub factors of the ICUT; Callous, Uncaring and Unemotional indicates that the three groups are significantly different on all sub factors ($F(2,26) = 12.28$, $p < .001$, $\eta p^2 = .49$; $F(2) = 35.98$, $p < .001$, $\eta p^2 = .74$; $F(2,26) = 21.64$, $p < .001$, $\eta p^2 = .63$, respectively).

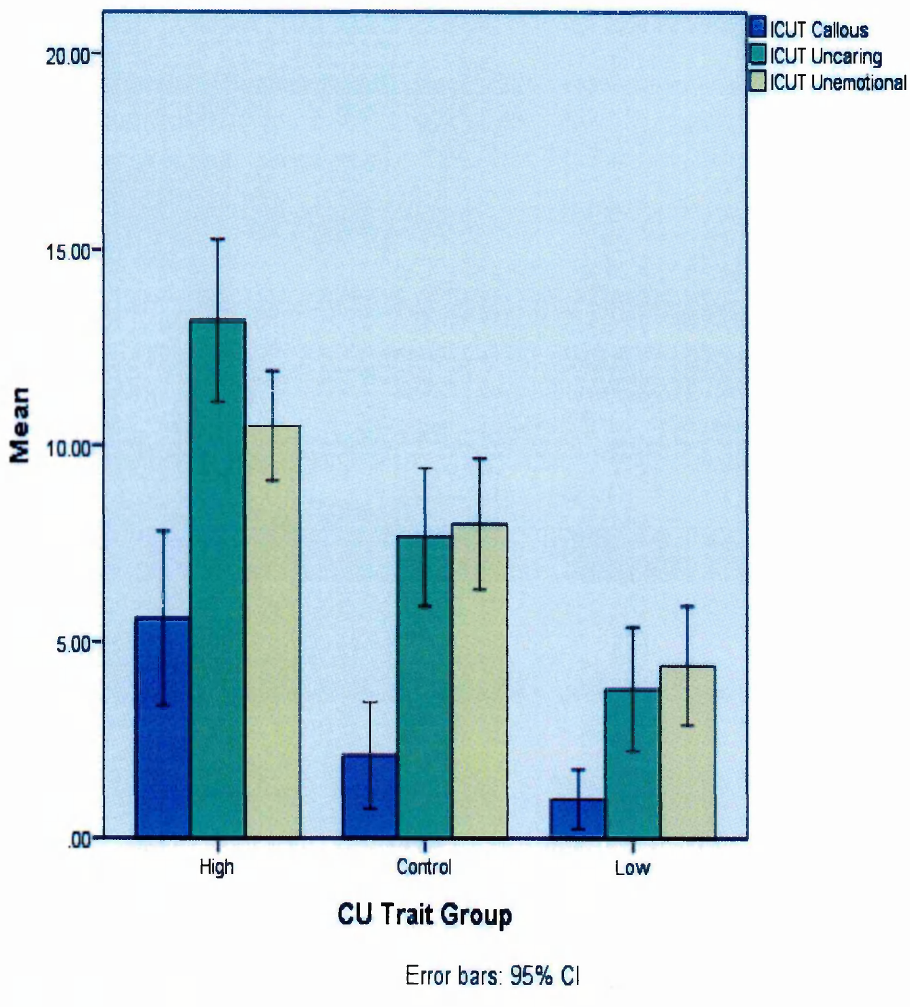

Figure 10: The differences between the mean scores of the Callous, Uncaring and Unemotional sub-factors of the ICU across the experimental groups

Both the high and low CU trait groups differ significantly from the mean and, therefore, may represent personality types that differ in their processing of empathy and emotional valence. This factor needed to be considered with regards to group selection and in the analysis of any electrophysiological research.

Empathy was explored indirectly through the composite measures of emotional and cognitive empathy described in chapter 4. An independent measures design was used to explore whether the empathy was significantly different between the high, low and control CU trait groups. The composite emotional empathy (EE) and cognitive empathy (CE) scores offer a measure of the empathy constructs that do not rely solely on the validity of a single measure. Emotional empathy was assimilated by the sum of the EQ emotional empathy scale and IRI empathetic concern sub factor. The cognitive empathy score was formed through the amalgamation of EQ cognitive empathy and IRI perspective-taking sub factors.

Analysis of the EE measure found a significant difference between the scores of the high, low and control CU traits groups ($F(2) = 13.62$, $p < .001$, $\eta p^2 = .51$). Post hoc analysis with a corrected alpha level of .017 showed a significant difference between the high and low experimental groups ($t(18) = 4.45$, $p < .001$, $d = 2.00$), as did the high and control groups ($t(12.55) = 3.71$, $p = .003$, $d = 1.67$). However, the control and low groups showed no significant difference in their EE scores ($t(13.44) = 1.85$, $p = .086$, $d = .83$). For descriptives see Table 19:.

Consideration of the CE results show a significant difference was found between the high, control and low CU trait experimental groups ($F(2) = 3.92$, $p = .032$,

ηp^2 = .23); however, post hoc analysis (alpha value correct to .017) reported a no significant difference between the high, low and control CU traits groups cognitive empathy scores; the high CU trait group reported no difference in the cognitive empathy scores when compared to the low group (t(18) = 2.52, p = .021, *d* = 1.13) (although this effect is approaching significant and has a large effect size) nor between the cognitive empathy scores of the low and control groups (t(17) = 1.31, p = .209, *d* = .61) nor the high and control groups (t(17) = 1.66, p = .116, *d* = .77). For descriptive statistics see Table 19:.

Table 19:

The emotional and cognitive empathy descriptives of the high, low and control CU trait groups.

Group		N	Mean	Std. Deviation
Emotional Empathy	High	10	20.10	9.56
	Control	9	32.44	4.16
	Low	10	38.00	8.41
Cognitive Empathy	High	10	23.30	8.67
	Control	9	29.11	6.25
	Low	10	34.70	11.37

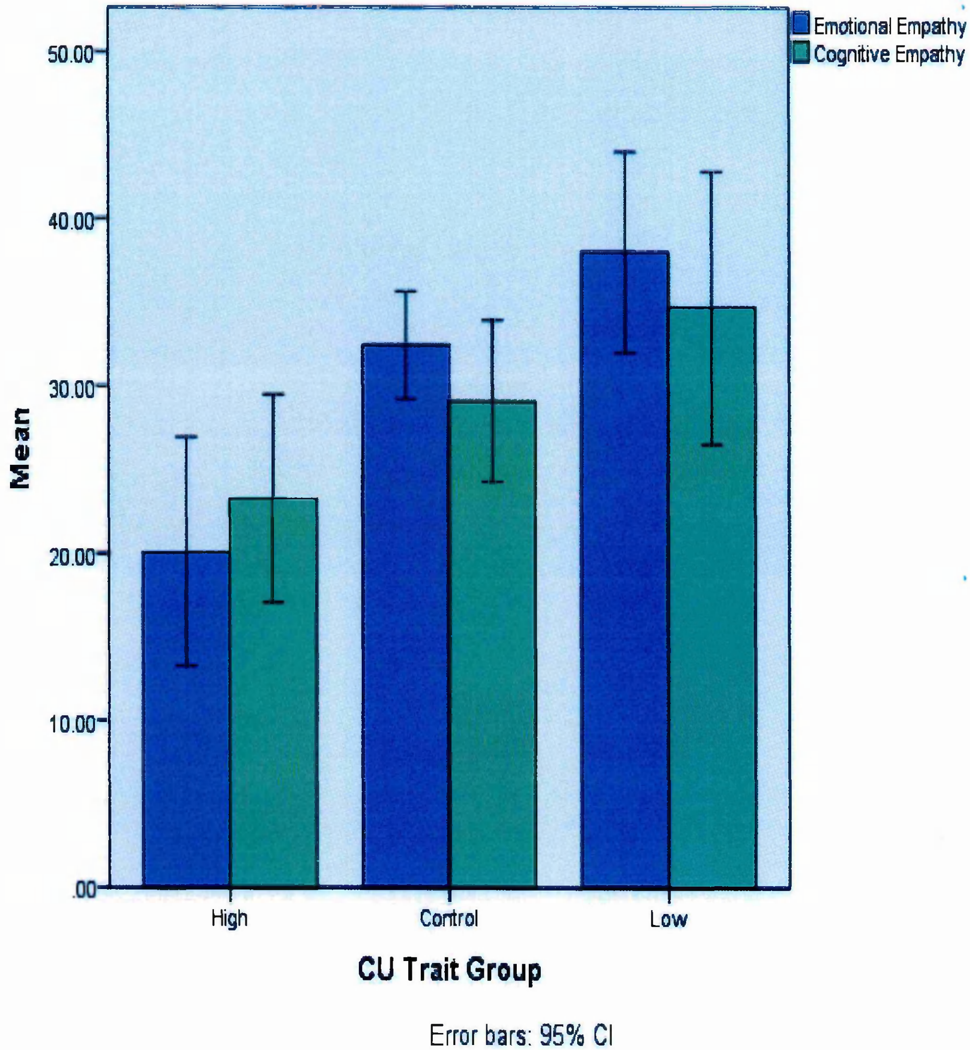

Figure 11: A graph showing the self-report empathy values for the emotional and cognitive empathy components

To conclude, an overall pattern of higher self-reported empathy being found within lower CU trait manifestation groups, and vice versa, can be observed in the data (see figure 11). Specifically, a significant difference is found between the manifestations of emotional empathy within the different CU trait groups. However, whereas the EE scores of the high CU trait group are significantly lower than in the low and control CU trait groups, the difference between the low and control group is not significant, though this might be an issue of power due to the small group sizes. The cognitive empathy measurement only observed no significant differences between the CU trait groups. Such results suggest that a pattern of lower emotional empathy in the higher CU trait experimental group, by comparison to the low CU trait group and control group and expedites a difference between the EE scores of the high and control CU trait groups, which is not seen for cognitive empathy. Furthermore, the effect size of the difference across the CU trait groups is much larger for emotional than cognitive empathy. These findings lend evidence to the hypothesis that there may be a disassociation between the cognitive and emotional facets of the empathy within CU trait manifestation with the emotional component being reduced in those higher in CU traits while the cognitive abilities are preserved when explored through post-hoc t-tests.

5.2 Task 1: Results Exploring the Recognition and Affective Response of CU Trait Groups to Facial Expressions of Emotion

The first empathy task measured 3 variables; whether the participant could correctly identify facial expressions, whether the participant felt negative or positive during the observation of the photographic stimuli and, finally, the intensity of feeling present when viewing the stimuli.

In symmetry with the results exploring the previous general population, there were only differences in the correct recognition of emotional facial expressions between high, low and control CU trait groups for expressions depicting fear (see *table 20*). One-way ANOVA analysis showed a significant difference between the high (X = 63.75, SD = 26.65), low (X = 97.22, SD =5.51) and control (X =91.67, *range* = 6.25) experimental groups. Post hoc analysis (alpha value corrected to .017) revealed that there was a significant difference between the high and low CU trait groups (t(17) = 3.69, p= .002, d = 1.74), as well as the high and control groups (t(17)= 3.06, p = .007, d = 1.44). However, there was no significant difference between the control and low groups (t(16) = 2.00, p = .063, d = .94). Therefore, although an ascending ability to recognise expressions of fear can be seen from the high to the control to the low CU trait groups, only the difference between the high and low and high and control groups are found to be significant.

Table 20:

Analysis of between group differences in facial emotion recognition

% of Correct Expression Compared Across Groups	df	F	Sig.	ηp^2
Negative Expressions	2,26	2.01	.155	.14
Disgust	2,26	.51	.604	.04
Anger	2,26	.19	.828	.02
Fear	2,26	11.15	<.001*	.47
Sadness	2,26	.31	.738	.02
Pain	2,26	1.29	.294	.09
Happiness	2,26	.48	.626	.04

* = Significant at $p < .01$

When analysing the participants self-reported experience when viewing the emotional expression stimuli using the positive-negative scale of the SAM, a score of 1 was the most positive score and 9 the most negative. The Positive- Negative scale results show significant difference in the response of the high, low and control experimental groups for expressions of anger ($F(2,26) = 4.68$, $p = .018$, $\eta p^2 = .27$), disgust ($F(2,26) = 6.25$, $p = .006$, $\eta p^2 = .33$) and happiness ($F(2,26) = 4.22$, $p = .026$, $\eta p^2 = .25$), though interestingly not for fear ($F(2,26) = 1.65$, $p = .212$) (see *table 21* for descriptives). The lack of recognition of fear could potentially inhibit affective responding to fearful emotions in others.

Post hoc analysis of these results was Bonferroni corrected to a p value of 0.017. Results exploring the anger expressions results observed a significant difference between the high and low CU trait groups with the alpha correction ($t(18) = 2.75$, $p = .013$, $d = 1.22$), indicating only a difference between groups with the low groups score more negatively in response to expressions of anger than the high CU trait group. Analysis of the controls verses the high group and the controls verses low CU trait groups observed no significant differences between groups (t(17) = 2.19, p = .042, *d* = 1.01; t(17) = .51, p = .614, *d* = .24 respectively). Furthermore, the results for expressions of disgust show a significantly more negative score on the positive-negative scale in the low CU trait group than the high (t(18) = 4.48, p < .001, *d* = 2.00); although the high-control and control-low CU trait group comparisons were not found to be significant (t(17) = 1.66, p = .116, *d* = .75; t(10.78) = 1.42, p = .185 *d* = .67, respectively). Overall, an ascension in negative scoring responses to anger and disgust expressions can be observed from the high to the control to the low CU trait groups, but only the difference between the high and low experimental groups is significant (see *figure 12 and table 21*).

Post hoc analysis of the scores for expressions of happiness shows the opposite pattern emerging from the data. Again only the difference between the high and low groups was significant (t(18) = 3.10, p = .006, *d* = 1.38) and shows a trend for more positive scoring in the lower CU trait group and scoring around neutral in the higher CU trait groups (see *figure 12 and table 21*). However, again no significant differences were observed between the high - control and low – control CU trait groups (t(17) = 1.89, p = .075, *d* = .86; t(17) = .69, p = .500, *d* = .31, respectively).

Table 21:

Descriptives for the Positive-Negative scores for expressions of anger, disgust and happiness across the high, low and control CU trait groupings.

Expression Scored on the Positive –Negative Scale of the SAM		N	Mean	Std. Deviation
Anger	High	10	5.58	1.24
	Control	9	6.69	.94
	Low	10	6.91	.91
Disgust	High	10	5.53	.77
	Control	9	6.25	1.12
	Low	10	6.83	.50
Happiness	High	10	4.16	.89
	Control	9	3.29	1.11
	Low	10	2.99	.80

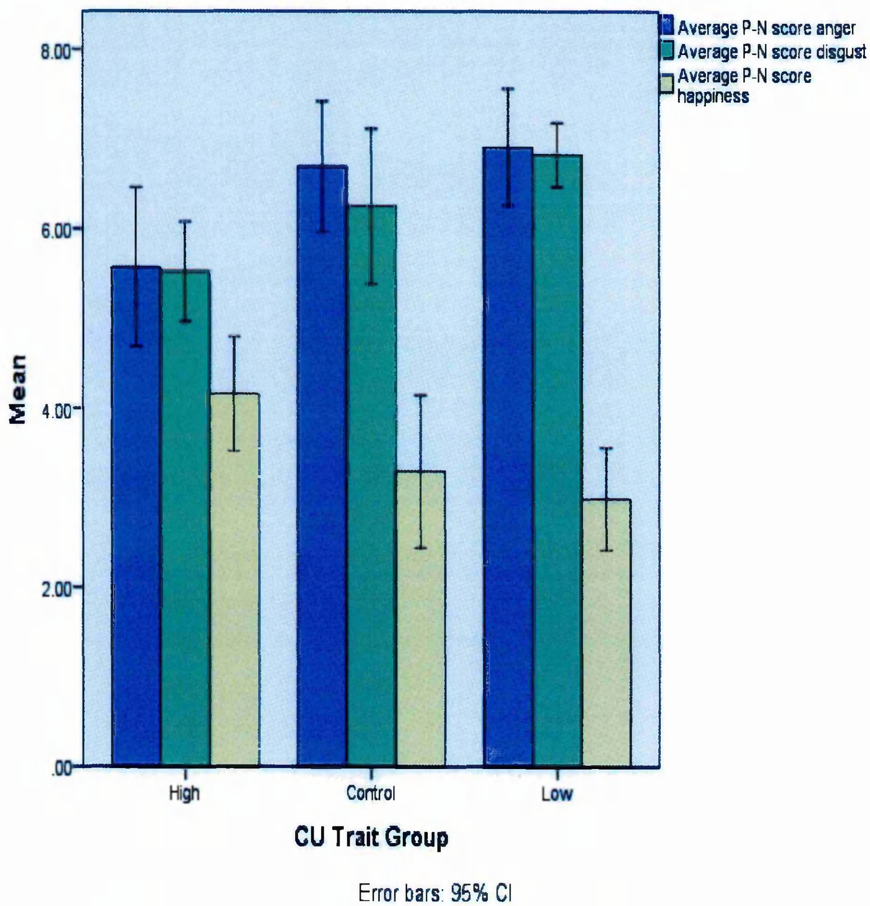

Figure 12: Graph showing the Positive (1)-Negative (9) scale scores for the CU trait experimental groups for expressions of anger, disgust and happiness

Intensity was also reported using the Self-Assessment Manikin's second 9 point scale as the participant observed each facial expression stimulus and, again, was assessed using a correlational design; 1 on the scale indicated high intensity and 9, low intensity. When the SAM results for intensity were analysed for differences across the experimental groups only the result for anger was significant ($F(2,26) = 3.77$, $p = .037$, $\eta p^2 = .23$). Post hoc comparisons showed no significant difference between the high (*X*= 7.09, *SD* = 1.80) and low (*X* =4.90, *SD* =2.12) CU trait groups ($t(18) = 2.49$, $p = .023$, $d = 1.11$) with the alpha value corrected to .017, though the low CU trait group scored themselves as feeling more intensity when viewing the expressions of anger than high CU trait participants. However, the control group (*X* = 5.43, *SD* =1.57) scored between the scores of the high and low groups and was not significantly different from either ($t(17) = 2.12$, $p= .049$, $d = .98$; $t(17) = .61$, $p = .547$, $d = .030$, respectively).

5.3 Task 2: Results Exploring the Affective Response of CU Trait Groups to Emotive Stimuli

A between measures design was used to consider the relationship between the 9 point positive-negative scale scores of the SAM and the affective valence of the high, low and control CU trait experimental groups. Within the scale, a score of 1 was the most positive score and 9 the most negative. Analysis observed that there was no significant difference between the scores of the groups to negative emotive stimuli (see table 22). However, the positive stimuli do report a significant difference between the groups; the high (*X* = 3.90, *SD* = 1.10), low (*X* = 2.35, *SD* = .89) and control (*X* = 2.96, *SD* = 1.24) showed a pattern of more positive responding in the low CU trait participants to positive human stimuli and less positive valence from the control and high groups. For a greater break down of the results see table 22. However, only the difference between the high and low CU trait participants was significant at a corrected alpha value of .017 (t(18) = 3.43, p = .003, *d* = 1.55).

Table 22:

Differences across the high, low and control CU trait groups with regards to their scores on the Positive-Negative score on the SAM.

	Happiness Animal	Happiness Human*	Pain Animal	Pain Human	Fear Animal	Fear Human
F	1.88	6.01	1.53	.13	1.62	5.14
Df	2, 26	2,26	2,26	2,26	2,26	2,26
P Value	.172	.007 (ηp^2 = .32)	.234	.881	.217	.076

* = Significant at p < .05

The intensity of the participants' feelings when observing the stimuli was reported using the SAM's second 9 point scale as the participant observed each photographic stimuli and, again, 1 on the scale indicated high intensity and 9, low intensity. One way between measures analysis reported that significant differences were seen for the negative (F(2,26) = 3.52, p = .044, ηp^2 = .21) stimuli with regards to the high, low and control participants reporting of affective intensity when viewing the stimuli. High CU trait participants scored themselves as feeling less intensity than the low CU trait groups when viewing negative stimuli (t(18) = 2.34, p = .031, *d* = 1.04), though none of the planned comparisons were significant at the .017 correction. When the stimuli are considered within the individual conditions this pattern of the high CU trait group exhibiting less affective intensity than the controls and low CU trait participants is consistent across stimuli depicting fearful humans and fearful animals;

however, no significant differences in experienced affective intensity are observed for stimuli containing depictions of pain and positivity (see *table 23 and figure 13* below for a further breakdown of the results).

Table 23:

Differences across the high, low and control CU trait groups with regards to their scores on the Intensity scale of the SAM; 1 on the scale indicated high intensity and 9, low intensity.

CU Trait Group		Positive Animal		Positive Human		Pain Animal		Pain Human		Fear Animal		Fear Human	
X/SD	High	4.90	2.38	5.87	2.39	6.35	2.33	5.87	2.95	6.27	2.25	6.28	2.29
	Control	4.92	1.74	4.89	2.40	5.58	1.30	4.22	1.41	5.76	1.23	5.75	1.29
	Low	3.85	1.52	4.15	1.43	4.63	1.65	4.93	1.48	4.15	1.60	4.18	1.55
F		.99		1.66		2.23		1.48		3.80		3.75	
Df		2,26		2,26		2,26		2,26		2,26		2,26	
P Value		.384		.209		.127		.247		.038* (ηp^2= .22)		.037* (ηp^2= .22)	

* = Significant at $p < .05$

A fairly consistent pattern of higher intensity scoring by the low CU trait participants and less intensity of response by higher CU trait participants, with controls scoring between the groups, was observed in response to the negative and positive stimuli. This paradigm of reported affective valence was observed both in response to the totality of the negative stimuli and when the various conditions are considered separately (see *figure 13*).

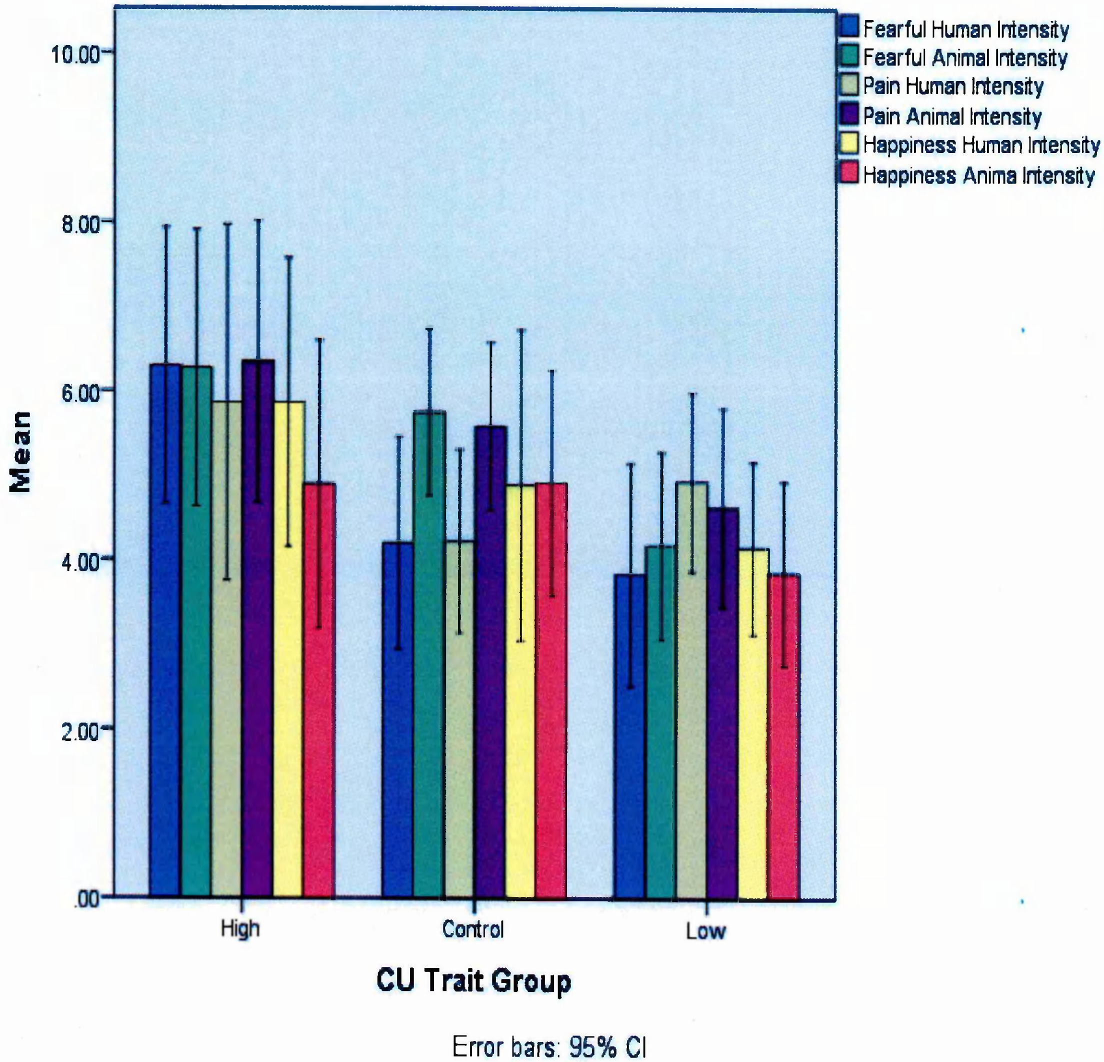

Figure 13: showing the participants' responses on the intensity scale of the SAM to negative emotive stimuli (1 indicating the most intense experience and 9 the least).

5.4 Conclusion

When assimilated through the original psychometric analysis the high, low and control groups selected for the electroencephalographic (EEG) research show that they are significantly different groupings with regards to their CU trait manifestation. Evidence that these groups are distinct groups, presenting with differing manifestations of CU traits, supports the use of these groups in EEG studies into the responses of high, low and control CU trait individuals in the general population demographic to empathetic and emotive stimuli. Furthermore, the selected grouping shows a pattern of self-reported empathy which is both in line with clinical and general research findings and consistent with the primary studies of the research programme. Higher emotional empathy and cognitive empathy was reported by low CU trait participants when compared to the high CU trait experimental group. This difference in empathy across the experimental groups was greater for emotional than cognitive empathy, with only emotional empathy differentiated between the groups in the post hoc planned comparisons.

The first task, in parallel with the results of the original psychometric testing, reported recognition differentials only for facial expression of fear. Where, as expected, higher CU trait participants were less able to recognise these expressions than their low CU trait counterparts. When considering the self-reported affective valence of the experimental groups, differences are observed between the high and low groups for disgust, anger and happiness. High CU trait individuals report a less negative response to images depicting expressions of anger and disgust than low groups. The opposite direction of response was observed for positive images, with high CU trait participants reporting less positive responses than those in the low CU trait groups who responded with increased positivity. Anger is the only expression to invoke a difference in the reporting of intensity of emotion, with high CU trait individuals reporting less intensity of emotion to expression of anger than low CU trait participants. The lower valence response to expressions of anger in those with high CU trait manifestation may be a contributing factor to the reduced effectiveness of punishment in those with high CU trait disorders (Blair et al., 2006; Hawes & Dadds, 2005; Blair et al., 2004; Frick 1998); though more research would be required to explore this hypothesis. Finally, the second task investigating affective valence to emotive scenes showed a difference in response to negative and positive stimuli, again with those manifesting high CU traits responding less positively than those with low CU traits. Higher intensity scores and a global increase of affective valence by the low CU trait participants and, conversely, a less reactive response by higher CU trait participants, with controls scoring between the groups, was observed in response to the depictions of fear in both humans and animals and negative stimuli when the negative stimuli are assimilated. This pattern of affective valence mimics that observed in clinical samples (Lorenz & Newman, 2002; Herpertz et al., 2001; Levenston et al., 2000).

In conclusion, the participants selected for the electrophysiological research are suitable for that purpose. As experimental groups, they not only are significantly different in the level of manifestation of CU traits, but also show a profile of empathy that would be expected for groups selected specifically on this basis. The next chapter looks specifically at potential confounding factors within the experimental groups.

5.5 Control of Confounding Variables for Electrophysiological Research

In addition to the psychometrics collected during the first experiments, the following psychometrics will be included here to further the understanding of the represented demographic and limit confounding factors:

- Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994)
- The Hospital Anxiety and Depression Scale (HADS)
- National Adult Reading Test (NART) IQ Test
- Levenson Self-Report Psychopathy Scale (Levenson et al., 1995)]

The reason for the inclusion of each of these measures and the outcomes of the psychometric testing will be considered individually in the next chapter.

5.5.1 Alexithymia

Alexithymia is a personality trait characterised by an inability to identify, designate and define emotions in the self (Sifneos, 1973). Symptoms of alexithymia include a dysfunction in emotional awareness in the person themselves and in their response to social peers, a lack of social attachment, and difficulty in interpersonal relating (Taylor, 2003). Such symptoms can result in a reduced ability to recognise emotions in others, a reduction in empathy and decreased emotional valence (FeldmanHall et al., 2013). Personality traits associated with alexithymia overlap with the defined constructs associated with CU traits. It is, therefore, necessary to ensure that the high CU trait experimental group participants recruited for the electrophysiological research do not manifest increased alexithymia when compared to the low CU trait and control groups. Increased alexithymia could indicate that the experimental groupings are divided along the manifestation of the alexithymia rather than CU traits, or are comorbid with CU traits, rather than having clear experimental grouping s categorised by CU traits alone.

Using the Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994), the experimental groups where tested for their manifestation of alexithymia. No significant difference was observed in the prevalence of alexithymia traits between the low (X = 44.10, SD = 13.70), high (X = 48.20, SD = 11.98) and control (X = 47.00, SD = 9.19) experimental groups ($F(2,26) = .32$, $p = .73$, $\eta p^2 = .02$). Therefore, it has been ensured that the experimental groups are not testing for differences in the manifestation of alexithymia traits rather than the required CU traits.

5.5.2 Depression and Empathy

Depression has been associated with some changes in empathetic processing; for example, a recent systematic review of relevant research by Schreiter et al (2013), reviewing all available studies on empathy in depression with participants both with a primary diagnosis of major depressive disorder and general depressive symptoms, observed that depression was associated with differences in reported empathy. Depression was correlated with higher intensities of personal distress at empathetic stimuli, a factor in affective empathy. However, differences in empathic concern were not associated with depression. Depression was related to reduction in cognitive empathy ability; Schreiter et al (2013) particularly note poor perspective taking, theory of mind, and empathic accuracy in those with depression.

In addition to differences in observed levels of cognitive and affective empathy in the literature, depression is associated with difference in response to facial expressions of emotions. Suslow et al (2001) applied the face-in-the-crowd task to 15 clinically stabilised depressed inpatients and 15 normal subjects using displays of schematic faces to explore the responses of depressed people to expressions of emotion. Although a small sample, the depressed participants showed no performance variances in the recognition of negative facial expressions and no differences in latency for neutral faces compared to control participants; however, significantly slower responses to positive expressions than control participants were observed in depressed individuals. The authors concluded that a lowered vigilance for facial expressions of joy and happiness may affect those with depression. More recent research in 2004 by Leppänen et al recruited 18 depressed patients and 18 matched healthy controls and tested a forced-choice response to neutral, happy, and sad facial expressions. Conversely to Suslow et al's research, Leppänen et al report that although the depressed participants and controls were equally precise at recognising happy and sad faces, depressed patients recognised neutral faces less accurately than the controls. Furthermore, it was observed that depressed individuals were slower to respond to neutral faces than controls. This research suggests that expressions of emotion, particularly happiness and neutral expression maybe misrecognised by those with depression.

Finally, the affective valence and emotional processing of those with depression may differ from control individuals: for example, depressed individuals tend to exhibit improved memory for negative information (Matt et al., 1992), to infer events as negative (Norman et al., 1988) and present with intrusive negative thoughts (Wenzlaff et al., 1988). FMRI research by Siegle et al (2002) found that control, non-depressed individuals presented amygdala responses to all emotive word stimuli, these decayed within 10 sec. However, depressed individuals exhibited unremitting amygdala responses to negative words, these responses often lasted into subsequent trails, up to 25 seconds later. It is concluded that depression is associated with sustained amygdala activity to negative emotional stimuli.

Depression is evidenced to affect empathy processing and affective valence; therefore, if levels were to differ between the CU trait experimental groups used in the electrophysiological research it may confound potential results. To test for further comorbid manifestations of depression that could influence the participants responding to emotional and empathetic stimuli, the participants were asked to complete the Hospital Anxiety and Depression Scale (HADS). Bjelland et al (2002) reviewed 747 identified papers that used HADS to assess depression and found that the factor analyses demonstrated a two-factor solution in good accordance with the HADS subscales for Anxiety (HADS-A) and Depression (HADS-D); furthermore, Cronbach's alpha for HADS-D varied between from .67 to .90 (mean .82). Measures of convergent validity found that correlations between the HADS and other similar measures were in the range of .49 to .83 (Bjelland et al., 2002). As such the HADS was considered appropriate for assessing the symptom severity of depression in both clinical and general populations.

The HADS was used to assess the manifestation of depressive symptoms in the experimental groups used for this research. Outcomes showed that the high (X = 8.50, SD = 3.21), low (X = 7.00, SD = 5.73) and control (X = 8.22, SD = 3.35) groups recruited showed no difference in regards the participant presentations with depression, as examined via ANOVA ($F(2,26) = .34$, $p = .712$, $\eta p^2 = .03$). Therefore, depression should not be a confounding factor within the electrophysiological research.

5.5.3 Anxiety, Empathy and Affective Valence

Anxiety has also been connected to modulation in empathetic processing, although less thoroughly than depression. Research by Danford (1991) tested participant's personality traits, empathic reactions to videotapes of distressed people both before and after a mood induction, and measured their responses to the Mood Adjective Checklist. It was observed that an anxious mood was associated with lower empathy scores. The authors also reported that anxiety and neuroticism interactions were particularly negatively correlated with the empathy scores (Danford, 1991).

Highly socially anxious individuals self-report elevated affective empathy tendencies on indirect measurement scales of anxiety (Tibi-Elhanany & Shamay-Tsoory, 2011). Although, when the authors controlled for general anxiety confounds, they observed that social anxiety was associated with increased cognitive empathy measures, but not emotional empathy. Furthermore, compared with low anxiety participants, Tibi-Elhanany & Shamay-Tsoory report higher accuracy when attributing emotional states in high social anxiety participants. However, conversely, less accuracy was observed in these participants in cognitive mental state attribution conditions

(Tibi-Elhanany & Shamay-Tsoory, 2011).

Jarros et al (2011) found that adolescents with anxiety disorders had a higher number of errors when identifying angry faces in comparison to controls, but not other negative attribution affects in response to expressions of sadness, disgust, happy, surprise and fear. Further, the authors report that participants with clinical anxiety accurately attributed neutral emotion more precisely than adolescents without anxiety diagnosis. Anxiety disorder research has found negative associations with negative emotion recognition (Easter et al., 2005; Mullins & Duke, 2004). In 2010, a review of 18 studies provided evidence that adults with anxiety disorders had a significant impairment in emotion recognition (d = −0.35); however, this effect was more subtle than for major depression (d = −0.58) (Demenescu et al., 2010). Though, these findings are not consistently reliable (Philippot & Douilliez, 2005; Manassis & Young, 2000). Despite a deleterious effect of negative emotion attribution in patients of anxiety disorders, trait anxiety has been associated with increased recognition ability with regards to negative emotions, particularly fear but not anger (Sylvers et al., 2011).

To conclude, anxiety, both trait anxiety and anxiety disorders, can potentially affect areas of affective and cognitive empathetic processing; therefore, it is necessary to ensure that the levels of anxiety do not significantly differ across the CU experimental groups recruited for the electrophysiological research.

Again, the Hospital Anxiety and Depression Scale (HADS) was used to measure the participants' anxiety levels. Bjelland et al (2002) reviewed 747 papers that used the HADS to assess anxiety and concluded that the HADS was a reliable measure of anxiety

(Cronbach's alpha = .68 - .93; mean .83) and had convergent validity with other measures of anxiety (correlation coefficients ranged from = .49 to .83). The results of measuring the HADS across the high, low and control CU trait experimental groups showed that there was no significant difference in the levels of anxiety between the high (X = 9.30, SD = 4.72), low (X = 7.70, SD = 6.58) and control (X = 7.78, SD = 3.96) groups ($F(2,26)= .29$, $p= .750$, $\eta p^2 = .02$). Therefore, trait anxiety levels should not act as confounding factor in the electrophysiological research.

5.5.4 IQ Testing

It is important when looking at aspects of cognition that the IQ of the participants recruited does not vary greatly between groups and confound the independent variable for tasks exploring cognitive empathy; particularly as IQ has been found to modulate cognitive empathy processing ability (Schwenck et al., 2014). The National Adult Reading Test (NART) IQ Test was used to explore participants IQ between the experimental groups. The National Adult Reading Test (NART) is used to estimate premorbid IQ (Crawford et al., 2001). Nelson (1982) developed the NART as a measure of familiarity with words, and used this measure to predict the participant's IQ. Reliability analysis has observed the NART to have appropriate split-half reliability of .93 (Crawford et al., 2001; Nelson, 1982), inter-rater reliability of .96–.98 (O'Carroll, 1987), and test–retest reliability of .98 (Crawford et al., 1989). In addition, a small practise effect has been reported (less than .75 of a NART error) (Crawford et al., 1989). The NART comprises 50 phonetically irregular words (that is the words cannot be pronounced by commonly known rules of pronunciation). The NART was presented to each participant and words were read aloud. Errors were recorded and the error score used to estimate the participant's IQ.

Application of the NART to the high, low and control CU trait experimental groups observed that the high (X = 119.50, SD = 6.31), low (X = 119.80, SD = 4.71) and control groups (X = 120.00, SD = 4.66) recruited into the electrophysiological section of the research showed no significant difference with regards to the IQ of the participants ($F(2,26) = .02$, $p = .979$, $\eta p^2 = .002$). Therefore, the IQ of the participants should not act as a confounding factor in the research.

5.5.5 Psychopathy

Finally, the groups were explored with regards to the manifestation of psychopathic traits; since CU traits are a core factor in psychopathy, it would be expected that the CU trait experimental groups would also differ when explored for psychopathy. A lack of any difference would suggest that the groups are not strongly differentiated with regards to CU traits. The Levenson Self-Report Psychopathy (LSRP) (Levenson et al., 1995) measures psychopathy as a personality trait for use in psychological research; it is not a diagnostic tool. It measures on two scales; primary and secondary psychopathy. The test consists of twenty-six statements rated on a five point Likert scale from 1(strongly disagree) to 5 (strongly agree). Investigation of the reliability and validity of the Levenson Self-Report Psychopathy Scale has revealed that the test–retest reliability of the LSRP, with an average of 8 weeks separation between tests, was appropriate ($r = .83$, $p < .01$) (Lynam et al., 1999). Furthermore, convergent validity of the LSRP with the Hare Self-Report Psychopathy Scale has been observed to be moderately high (rs = .64, .66, and .42, ps < .001 for the LSRP total scale, primary psychopathy and secondary psychopathy, respectively) (Lynman et al., 1999).

The high (*X*= 54.20, *SD* = 8.95), low (*X* = 40.50, *SD* = 7.37) and control (*X* =52.67, *SD* = 8.87) groups recruited for this electrophysiological research revealed a significant difference in their manifestation levels of total psychopathy ($F(2,26) = 7.87$, p=.002, $\eta p^2 = .38$). Though post hoc analysis with a Bonferroni correction to an alpha value of .017 observed that there was no significant difference between the high and control group ($t(17) = .37$, p=.71, *d* = .17), a difference was revealed between the high and low groups, and the control and low experimental groups ($t(18) = 3.74$, p=.002, *d* = 1.67 and $t(17) = 3.26$, p= .005, *d* = 1.62 respectively) (see *figure 14*).

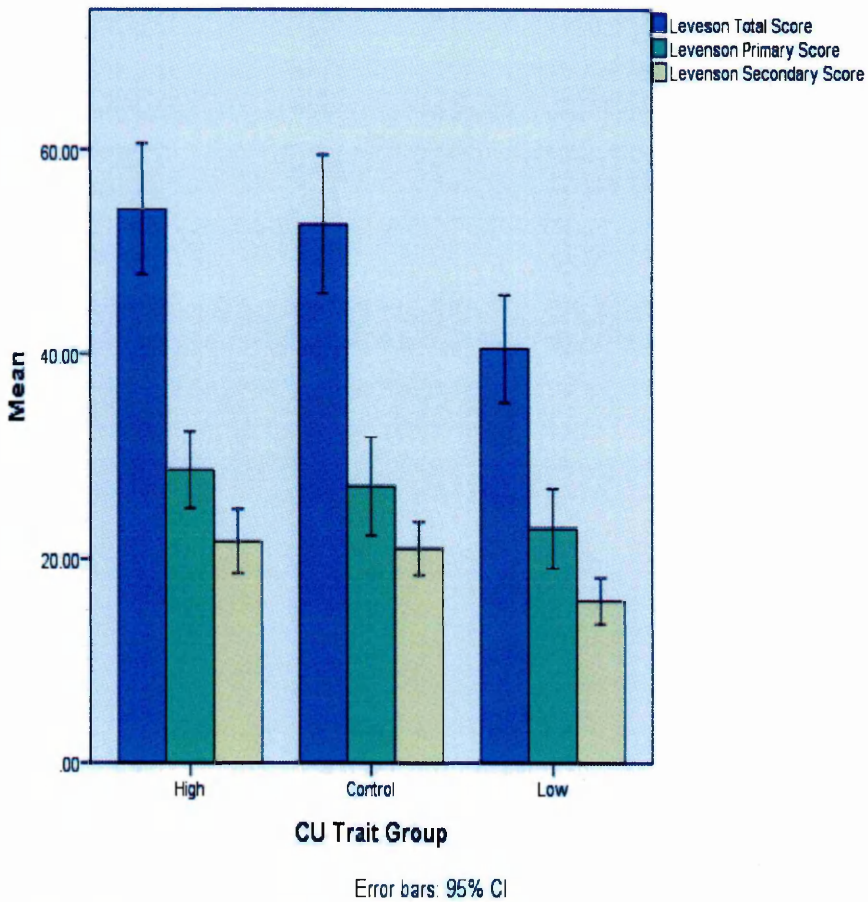

Figure 14: A graph showing scores on the Levenson Self-Report Psychopathy measure (including sub factors) for the experimental groups

When compared to the CU trait scores on the ICUT via correlational analysis, significant correlations are found for the Levenson total, as well as for the primary and secondary scale sub-factors (*see table 24)*.

Table 24:

Showing the correlations between the ICUT scores and Levenson results (Pearson's).

Measures		Coefficient and P value
Levenson Total	Correlation Coefficient	.61
	Sig. (2-tailed)	<.001**
Levenson Primary Scale	Correlation Coefficient	.44
	Sig. (2-tailed)	.016*
Levenson Secondary Scale	Correlation Coefficient	.60
	Sig. (2-tailed)	.001**

* = Significant at $p < .05$
** = Significant at $p < .01$

Conclusion

These further psychometric results suggest that there should be no confounding variables affecting the electroencephalographic data collection with regards to manifestations of alexithymia, depression levels, trait anxiety nor IQ, within the CU trait experimental groups. Additionally, the results of the Levenson Self-Report Psychopathy scale provide some evidence that the groups are significantly different with regards to their CU trait and psychopathic trait presentation, with good convergent validity seen between the two measures. It was concluded, in light of the collected psychometric data, that these CU trait groups were suitable candidates for the collection of electrophysiological data.

5.6 Electroencephalographic Recording and Event – Related Potential Analysis

All the electrophysiology data was recorded and analysed using the same equipment and techniques to ensure consistency. Both the recording set up and data preparation technique are described below.

5.6.1 Electroencephalograph Recording Equipment and Technique

Responses to the stimuli (described in chapters 6, 7 and 8) were recorded on an electroencephalographic (EEG) system recording from the 64 electrode sites shown on the topographic map in figure 15. A 64 channel WaveGuard cap of ANT BV (www.ant-neuro.com, Enschede, Netherlands) was used. The electrodes are arranged over the WaveGuard cap according to 10-10 International System which covered the participant's scalp from the left ear mastoid to the right ear mastoid and from the nasion to the inion. All recording channels on the system were referenced to the IZ electrode. The electrode cap comprises of 64 shielded Ag/AgCl sintered pin electrodes plus GND ('Patient Ground').

Before recording each electrode in the cap was prepared with conductive gel and applied to the scalp ensuring that each electrode met impedance criteria; impedances averaging 1-5 KOhm over each of the 64 electrodes were obtained before the commencement of EEG recording. A shielded connector cable was attached to the electrode cap, leading to a 64 channel EEG/ERP ASA-Lab amplifier system (ANT Neuro BV, www.ant-neuro.com, Enschede, Netherlands).

EEG data were recorded with a DC amplifier and digitized at a sampling rate of 512 Hz using an ANT-Neuro BV amplifier. No frequency filters were applied during recording, therefore, full band DC EEG was attained during recording. The 64 channels were continuously recorded and streamed directly to the computer's hard drive; data was recorded and analysed using ASA Advanced Source Analysis (ANT Neuro BV, www.ant-neuro.com, Enschede, Netherlands) software version 4.7.8.

A second network integrated computer interfaced with the EEG recording machine via a parallel port. This PC used e-Prime software to present the stimuli and log accurate stimuli timing markers via the parallel port to the EEG recording machine. Each task was presented via E-Prime 2.0 software (Psychological Software Tools, Pittsburgh, PA) on computer running Windows 7. Responses were recorded through 4 numbered buttons on a game pad. This network allowed the porting and storing of specific trail information associated with the recorded EEG data; this information included: the stimuli conditions, participant responses and response reaction times.

Participants were sat alone in the recording room, approximately half a meter from the presentation screen to reduce the effect of external stimuli. One the cap of electrodes was applied the participants were instructed to remain as still as possible to limit extraneous artefacts and to blink in the inter-stimuli intervals if required.

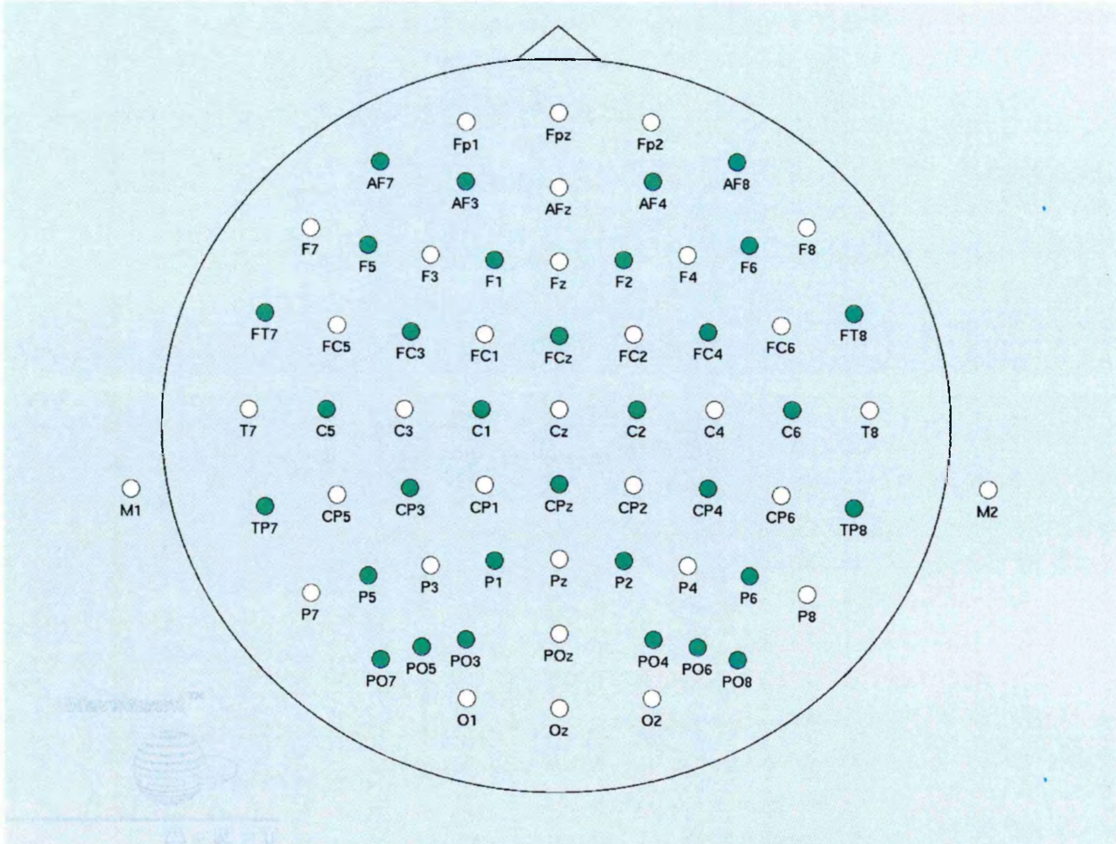

Figure 15: Map of the electrode sites of the 64 channel cap used in the research (Source Ant-neuro.com).

5.6.2 Data Filtering and Artefact removal

The results were analysed using ANT-Neuro: ASA software. The EEG recorded samples were filtered for frequencies outside of parameters of 1-40Hz, such filtering ensures that slow direct current (DC) shift was excluded from trials. The low-pass filter was established at 1Hz, the high-pass filter at 40 Hz to remove the 50-60Hz noise. Data was digitally filtered at a band pass of 1-40Hz to reduce potential artefacts caused by extraneous electrical environmental noise. The recorded continuous EEG data was then demarcated into epochs. The length of the epochs ranged from 1000ms to 1500ms depending on the requirements of the research; therefore, the exact epoch length is described separately in each study (see chapter 6, 7 and 8).

Sampled EEG above 90µV and below -90µV were automatically identified as artefacts due to muscle noise or environmental interference. Single-trial data on which the EEG surpassed the -90µV - 90µV parameters were rejected from the average to ensure an authentic waveform. The artefact amplitude thresholds remove the peak voltages created by muscular movements originating from the scalp, face and neck. Artefact correction procedures were performed using ANT-Neuro: ASA software.

These data then underwent a correction procedure to remove the detected artefacts and were further corrected to a 100ms pre-stimulus baseline. Baseline correction of the epoch trail potentials was achieved by subtracting the averaged 100ms of pre-stimulus recording from the recorded epoch waveform. Each stimulus' trail epoch was considered within the period 100ms before the stimulus onset until the completion of the stimuli presentation (described for each research study in the methodologies of chapter 6, 7 and 8).

Waveforms were averaged across experimental conditions for each participant.

These processing technique are performed in line with recent advice on EEG data filtering for ERP analysis (Luck, 2014; Nidal & Malik, 2014).

5.6.3 Data analysis

Subsequent to the artefact removal process, the epochs were computed into ERPs. Averaging the epoch trails of each condition described for the study, which were time-locked to stimuli, formed the final grand-averaged ERP waveforms (e.g. Cong, 2015; Luck, 2014; Nidal & Malik, 2014). For the epoch time used see chapter 6, 7 and 8. Each experimental condition's average participant's ERPs were computed separately through the 'grand average' process available through the ASA software; the experimental conditions are described for each research study in the methodologies of chapter 6, 7 and 8.

The resulting ERP waveforms were explored for present ERP components through visual inspection of group averaged condition ERPs and individual participant data. These ERP peaks were the defined with regards to the latency of their maximal amplitude and the cortical region over which the ERP components occurred. Although, EEG recording is not reliable in regards to procuring data with refined spatial resolution, broad cortical location categories can be considered for the purpose of exploring ERP components (e.g. Taroyan & Nicolson, 2009). There were three groups of electrodes used for analysis, as this is where ERP responses were evident; these included electrodes over the right occipital-parietal, the left occipital- parietal and fronto-central region (the exact electrodes included in the analysis are described separately within each study). The ERP waveforms were averaged over these groups of electrodes.

The present components are then analysed with consideration to the mean amplitude and peak latency of each ERP component across conditions (Luck, 2014; Nidal & Malik, 2014; Hoormann et al., 1998). Using mean amplitude removes the biased that can lead to larger values in conditions with greater noise; mean amplitude is an unbiased measure which has been shown to produce reliable and valid results even when noise levels differ across conditions (e.g. Luck, 2014). Peak latency was measured at time in milliseconds that the peak's maximum amplitude occurred (Luck, 2014). The windows used for the calculation of each mean amplitude and latency are reported in the results section of each study chapter. The ERPs were assessed through visual inspection of the grand averaged waveforms to ensure the waveform component was captured in its entirety within the window, but are consistent with those generally recommended for best analytical practice and reported in the literature (e.g. Cong, 2015; Luck, 2014; Nidal & Malik, 2014).

CHAPTER 6:

THE ELECTRO-NEUROLOGICAL CORRELATES OF FACIAL AFFECT PROCESSING IN RELATION TO CALLOUS AND UNEMOTIONAL TRAITS

6.1 Aim

As considered earlier, facial affect recognition ability forms a key component of empathy and, logically, it is evidenced that facial emotion processing may be limited, or disrupted, in those with high CU trait disorders who present with a reduction in empathetic responding (Wilson et al., 2011; Hastings et al., 2008; Blair, 2005; 1995). Furthermore, the research by Lethbridge and colleagues, described in chapter 4, found that fear recognition data correlated negatively with CU trait prevalence. Those higher in CU traits also reported less negative affect in response to negative facial expressions in others and gave less positive responses to expressions of happiness. Therefore, it appears that CU traits may impair both the recognition of fearful expressions and the affective response to a range of positive and negative expressions of emotion. The deficit of affect recognition and valence, associated with CU traits in the behavioural research literature, is now supported by limited numbers of neurological papers, providing substantiation of neural response differentiations to facial affect with regards to CU traits (Blair, 2010; Gordon et al., 2004). The limited research which does exist exploring the neural correlates of CU traits amongst the general population indicates that there is the potential for the adaptation of the neural response to facial emotion, potentially manifesting in modulation of the ERP components of facial affect response discussed earlier, specifically the P1, N170 and P300 (see chapter 1).

The aim of the study was to explore potential ERP electrophysiological correlates of facial affect response and their adaptation with regards to CU trait manifestation. It was expected that expressions of fear would invoke a different neural response in participants with high levels of CU traits by comparison to low CU trait participants and controls, in line with the reduction in fear recognition observed in this group in previous behavioural testing. The previous research into valence suggested the possibility of different responses to both negative and positive expressions of emotion.

6.2 Methodology

Given that the primary research revealed different patterns of response to facial expression stimuli with regards to CU traits manifestation, responses to facial stimuli was further investigated through ERP exploration of the electrophysiological correlates of facial affect processing. This research used similar methodology to that of Batty and Taylor (2003) and Utama et al (2009), both of these studies explored ERP responses to the six basic emotional expressions (anger, happiness, sadness, fear, surprise, disgust) and a neutral expression.

6.2.1 Participants

Participants were selected as described in chapter 5. One participant was lost from the control group due to excessive artefacts occurring during recording. Total participants, therefore, equalled 28; 10 high CU trait participants, 10 low CU traits participants and 8 controls. The difference between the group's level of CU trait manifestation remained significant (F(2,25) = 80.17, p < .001).

6.2.2 Design

A quasi-experimental design was used to explore the relationship between naturally presenting levels of CU traits across three experimental groups and the neural electrophysiological response to expressions of facial affect stimuli.

6.2.3 Materials

360 photographs were selected from the NIMSTIM facial affect stimuli set (Tottenham et al., 2009). The stimuli portrayed 5 core expressions of emotion (sadness, disgust, happiness, fear and anger) and a neutral expression (Tottenham et al., 2009), allowing a range of expressions to be explored. The NIMSTIM stimuli set, unlike previous grey scale sets stimuli, such as Ekman and Friesen (2002), is formed of digital, colour photographs of males (17 individuals) and females (13 individuals) of a variety of ethnicities and ages; they are cropped close to the hair and presented on a plain, pale background, a grey sheet covers the persons clothing (*see figure 16*).

Use of the NIMSTIM stimuli set to investigate responses to expression in others has been validated with regards to its use with ERP techniques (Smith et al., 2013; Suway et al., 2013; O'Toole & Dennis, 2012; Frenkel & Bar-Haim, 2011). In line with Smith et al's (2013) analysis of the NIMSTIM's use with ERP study of electrophysiological correlates of emotional expression, the stimuli were not altered before presentation. This presentation of facial expression stimuli has been employed successfully in previous research (Smith et al., 2013; Batty & Taylor, 2003). Retaining the colour of the stimuli ensures no loss of emotional response (Cano et al., 2009). 60 novel stimuli of each emotional expression were presented to the participant on a blank background of identical hue using E-prime software.

6.2.4 Procedure

These stimuli were arranged into 6 blocks of 60 random presentations; within each block, 10 pictures of each facial expression were randomly presented to the participant. Each photo was centrally positioned in the screen. Between each expression stimuli a fixation point on a blank screen filled the inter stimuli interval. Stimuli were presented, using a 20" computer screen (resolution 1080p) via e-prime software, to the participants for 1000ms, with an inter stimuli interval of 1000ms and a fixation cross of 500ms before stimuli presentation. The task totalled a running time of 15minutes.

The photographs were presented under a passive viewing condition to eliminate task effects and movement artefacts; a passive viewing required the participant to simply observe the stimuli. EEG recording was undertaken using the 64 channel system. The recorded data was analysed using ASA-Lab software version 4.9. For more details see the description of EEG recording and ERP analysis procedures provided in chapter 5. This design allowed the consideration of the effect of callous and unemotional trait manifestation on participants' response to facial affect.

6.2.5 Ethics

Before participating in the study participants were briefed as to the purpose and procedure of the research (including examples of similar stimuli), informed as to their rights as a participant (see *appendix D*) and given time to ask questions, thus ensuring that the participant's informed consent was given when signing the consent form (*see appendix E).* After the data collection, the participants were debriefed (see *appendix F)*. These ethical procedures were sanctioned by the Sheffield Hallam University Research Ethics Committee.

Figure 16: Examples of NIMSTIM stimuli for angry, happy and neutral expressions ordered from the top to bottom (Tottenham et al., 2009).

6.3 Results:

6.3.1 Present Waveforms

Average ERP waveforms for the experimental groups were constructed by separately averaging electrophysiological responses for the 6 expression conditions (neutral, angry, disgusted, fearful, happy, and sad). Analyses of ERPs were conducted on the basis of mean amplitude (μV) and latency (ms) for a given ERP component's time parameters. Consistent with Smith et al's (2013) NIMSTIM expression research, three principal ERP components were observed in the left and right occipital-parietal areas (OPL and OPR); P1, N170 and P2. The OPL activation area consisted of electrodes O1, P3/5/7 and PO3/5/7. Activation in the right OP area was an assimilation of electrodes O2, P4/6/8 and PO4/6/8. P1 was analysed as the mean peak amplitude and peak latency from 80–150ms, where the P1 competent was typically maximal. N170 was observed to be of maximum peak between the 150 and 190ms post stimuli. Finally, the P2 component was observed to be maximal between 190 and 250ms.

N1, P170 and N2 components were also observed in the fronto-central (FC) electrodes sites including: FC1/2, Fz,Cz, and FCz; again reflecting the waveforms observed by Smith et al (2013). The N1 was observed between 80-150ms, the P170 between 150-190ms and the N2 between 190 and 250ms. Assimilation of the mean peak amplitudes and peak component latencies were explored for significant main effects.

Similarity of the waveform components to those observed by Smith et al (2013) suggests both reliability of the ERP waveforms produced by the NIMSTIM stimuli and the validity of ERP waveforms collected for the purposes of exploring responses in the selected CU trait experimental groups. Example wave forms can be seen below for each of the electrodes used in the analysis.

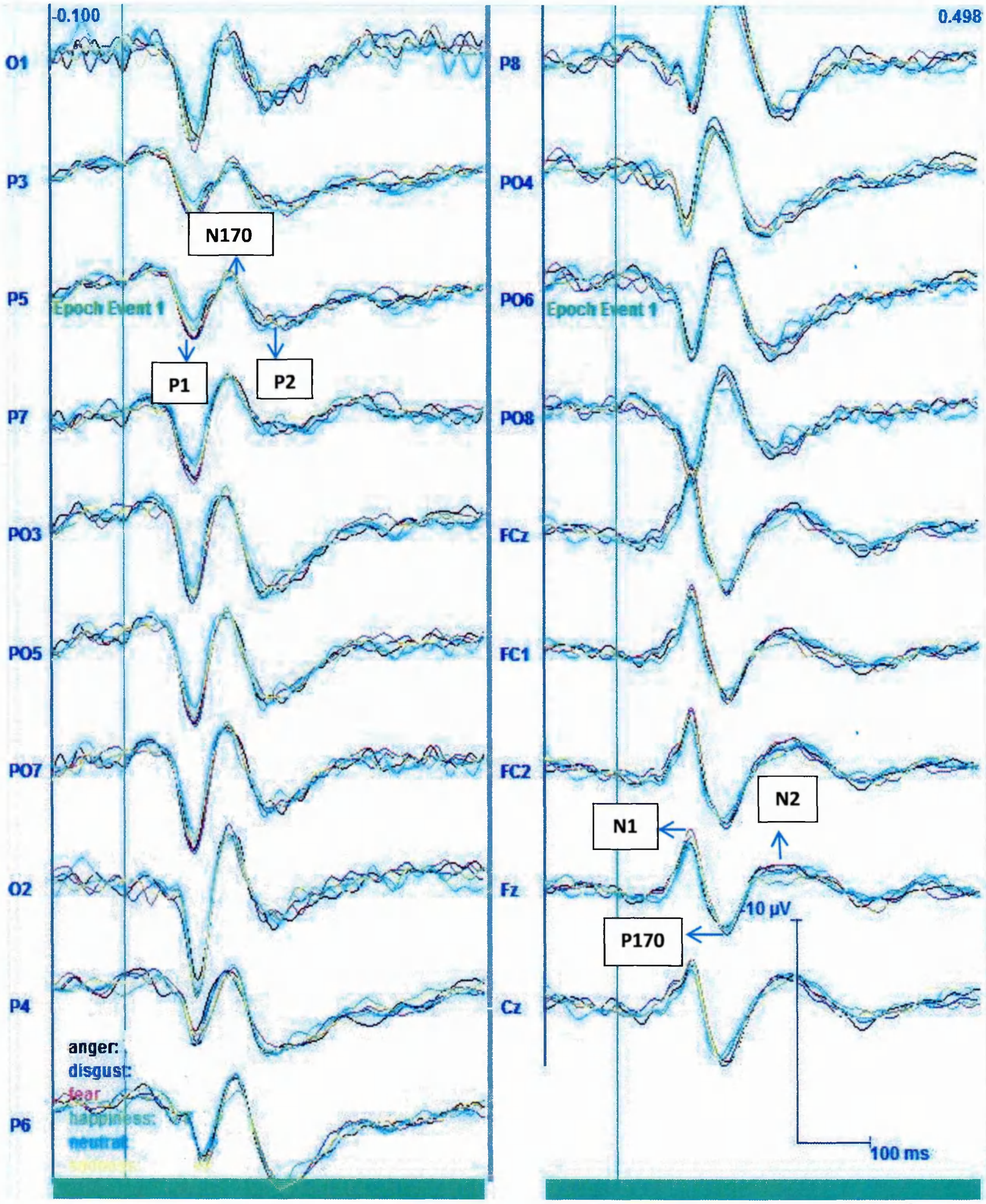

Figure 17: Grand averaged waveforms of the expression conditions for the control CU trait group.

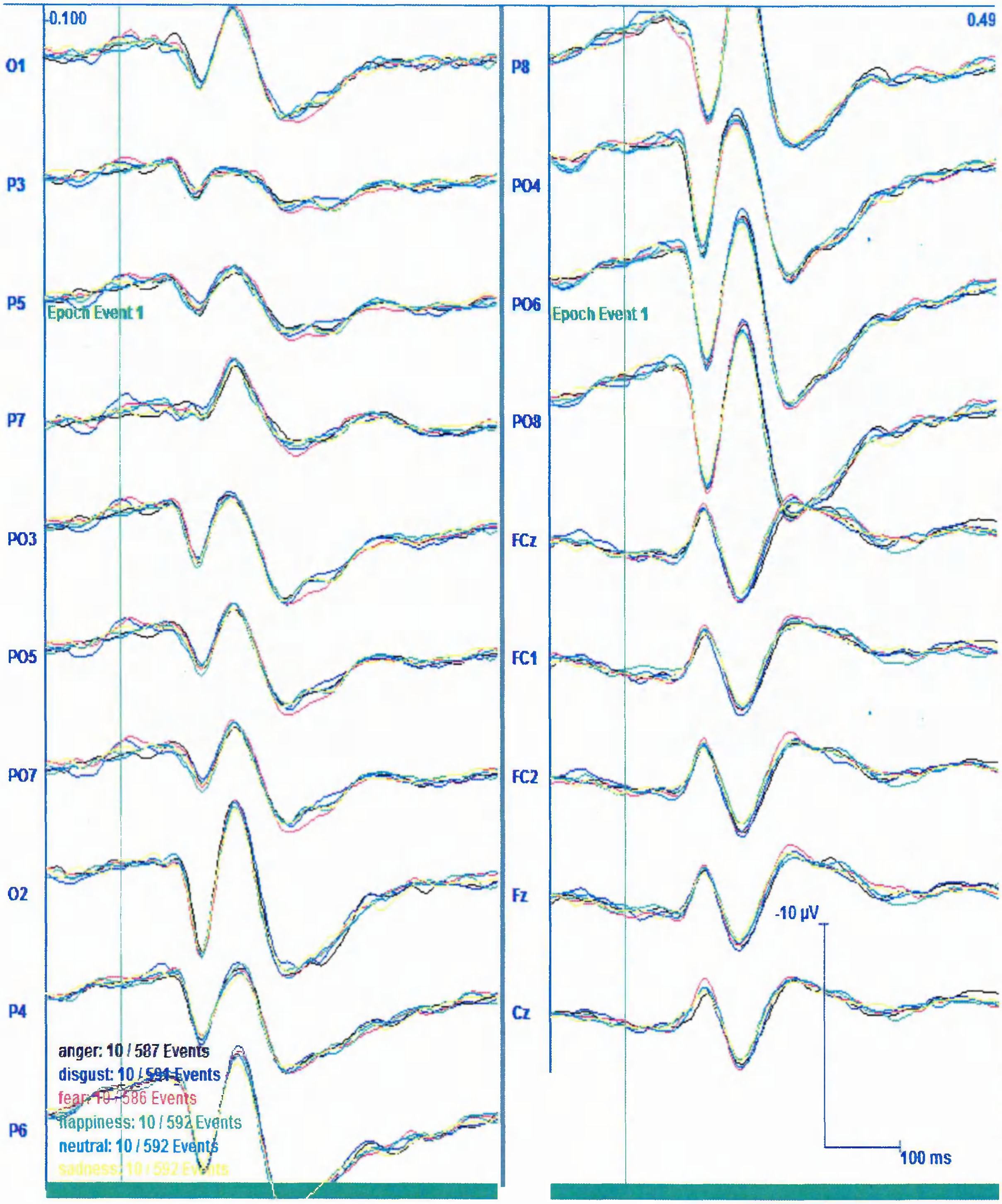

Figure 18: Grand averaged waveforms of the expression conditions for the high CU trait group

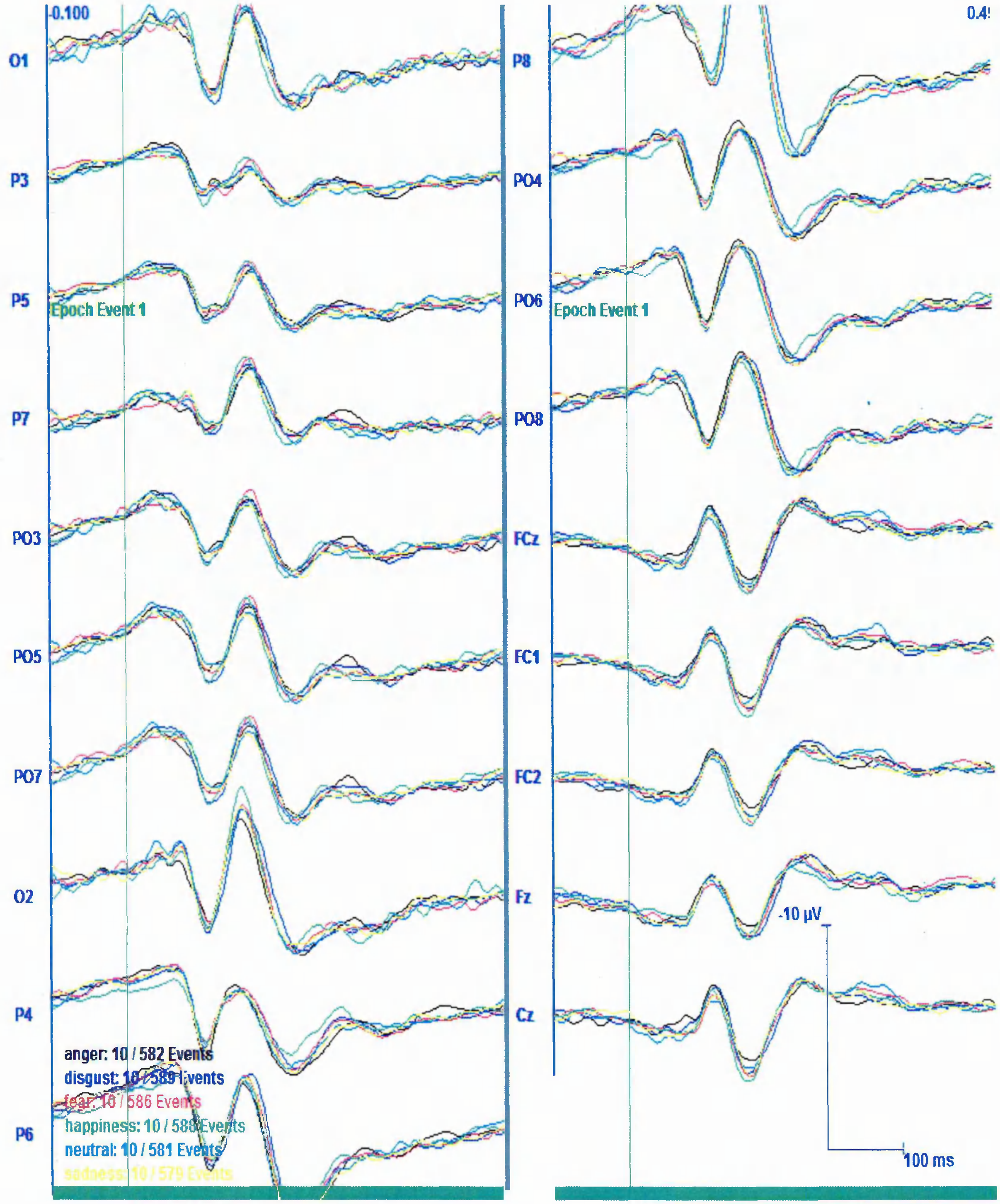

Figure 19: Grand averaged waveforms of the expression conditions for the low CU trait group.

6.3.2 Between Groups Analysis of Facial Expression Response:

Analysis conducted using a 3 x (6) factorial ANOVA to explore the relationship between the six expression conditions and the three experimental groups revealed no significant pattern of differences in the electrophysiological responses to emotion. There was also no interaction with the CU trait groups at an alpha level of $p < .05$. However, further hypothesis-driven, a priori analysis reveals subtle differences in the CU trait groups when higher powered analysis techniques are employed, reflecting previous ERP research (e.g. Smith et al., 2013).

3 x (1) ANOVAs were used to more specifically explore the relationships between the six expressions and the ERP response of the three experimental groups.

Fearful Expressions

The ANOVA suggests there was a significant difference in the latency of the P1 over the left OP electrodes ($F(2,25) = 4.01$, $p = .031$, $\eta p^2 = .24$). Post hoc analysis (Bonferroni corrected to an alpha level of .0167) reveals that the difference is not significant at this level. However, the P1 component for the low group (X = 120.79; SD =14.46) would have been significantly longer than the high group (X = 106.14; SD =11.09) at an alpha value of .02 ($t(18) = 2.54$, $p = .020$, $d = 1.14$).

The N170 component over the left OP electrodes was different in latency for the high (X = 158.41; SD =14.26), low (X = 169.85; SD = 10.22) and control (X = 155.59; SD =9.46) CU trait groups ($F(2,25) = 3.94$, $p = .033$, $\eta p^2 = .24$). However, only the difference between the N170 latency of the control and low CU trait groups was significant, with an alpha level correction of .0167 (t(16)=3.04, p=.008, *d* = 1.16). The difference between the high-control and high-low CU trait groups were not significant (t(16)= .48, p= .637, *d* = .23; t(18)=2.06, p=.054, *d* = .92 respectively).

It seems that the low CU trait group shows an increased latency of the P1 and N170 components over the left OP electrodes compared to the high group and control groups respectively.

Expressions of Disgust

The P1 component over the left OP was modulated for the three experimental groups with regards to the peaks mean amplitude (F(2,25)= 5.02, p = .015, ηp2 = .29). The high group (*X* = -.27; *SD* =1.28) was significantly lower in mean amplitude of the P1 than the control groups (*X* = 1.43; *SD* = 1.18) in post hoc analysis (α = .017) (t(16)= 2.88, p = .011, *d* = .94). However, the mean amplitude of the P1 peak for the low group (*X* = .68; *SD* = .93) was not significantly different from the control groups (t(16) = 1.50, p = .153, *d* = .71). The high and low CU trait amplitudes also showed no difference in P1 amplitude (t(18) = 1.89, p = .074, *d* = .33).

Expressions of Sadness

The P1 component of the left OP ERP waveform responses between high, low and control experimental groups showed differences in its latency between groups (F(2,25)= 4.16, p = .028, ηp^2 = .25). In post hoc analysis (α = .017) it is revealed that the low group has a significantly longer latency of the P1 peak (*X* = 118.14, *SD* = 13.35) than the high group (*X* = 103.66, *SD* = 8.58) (t(18)= 2.89, p=.010, *d* = 1.29). There were no significant difference between the latencies of the high and control groups, nor the control and low groups ($t(16) = .94$, $p = .361$; $t(16)= 1.64$, $p=.121$ respectively).

Angry Expressions

The Stimuli depicting angry expressions showed no significant differences in the ERP waveform responses between high, low and control experimental groups ($p > .05$).

Expressions of Happiness

Again expressions of happiness were not associated with any differences in the ERP waveform components recorded for high, low and control CU trait groups ($p > .05$).

Neutral Expressions

Neutral expressions (used as comparisons for the below pair-wise analysis) also showed no baseline difference between the high, low or control groups for any of the waveform components ($p > .05$).

To conclude, the analysis reveals most differences in the group's response to fear. However, disgust and sadness also exhibit differences. No significant differences were observed for expressions of anger, happiness or neutrality. All of the differences occurred over the left occipital-parietal electrodes. The disgust and sadness expressions evoked differences in CU trait group responses only in the P1 ERP component, whereas, the fearful expressions were associated with differences both the P1 and N170 components.

6.3.3 Results Within Groups Analysis

Pair-wise comparisons using the neutral expression stimuli as a baseline for the expression stimuli were performed to investigate modulation of the ERP waveform components in response to expressions. These comparisons were performed separately for the three experimental groups.

Fearful Expressions

Modulations were seen in the N1 and N2 ERP components between neutral and fearful expression stimuli in the high CU trait group. The latency of the N1 component in the FC region was significantly different, with a later peak observed for neutral stimuli (*X* = 110.16; *SD* = 9.86) than for fear (*X*= 107.30; *SD* = 8.72) ($t(9) = 3.04$, $p = .014$, *d* = .31) in the high group. The other significant difference observed between the expression conditions of neutral and fear in the FC electrodes was in the mean amplitude of the N2 component ($t(9) = 2.47$, $p = .036$, *d* = .14). The amplitude of the fear N2 component (*X* = -1.84; *SD* = 2.51) of the FC response was larger than for neutral stimuli (*X* = -1.51; *SD* = 2.37). Therefore, modulation of the response for fearful expressions seems to be manifesting primarily in the FC cortical areas.

By comparison, neither the control nor low experimental groups showed differences in the FC electrodes waveforms when comparing neutral and fear expressions. However, both showed significant effects in the OP waveform components. The control groups showed a significant effect of the P1 latency in the right OP electrodes ($t(7) =2.41$, $p = .046$, *d* = .18); the neutral expression P1 component latency (*X* = 109.02; *SD* = 12.37) was observed to be shorter than for fear (*X* = 111.46 *SD* = 14.58).

By comparison, the low group showed differential response within the P1 component of the left OP electrodes. The mean amplitude of the P1 component of the left OP was significantly smaller for the neutral stimuli (*X* = .38; *SD* = 1.21) than fearful ones (*X* = .74; *SD* = .94) conditions (t(9) = 2.48, p = .035, *d* = .33). Overall, a larger amplitude of the P1 component was observed in the left OP electrodes for expression of fear in low CU trait participants.

It, therefore, appears that high CU trait individuals show response for fearful expressions seems to be manifesting primarily in the N1 and N2 of the FC cortical areas, when compared to neutral expressions. By comparison the high and low CU trait groups responses were observed to differentiate between neutral and fearful stimuli in the parietal electrodes in the P1 component.

Disgusted Expressions

High and control CU trait experimental participants showed no significant difference in their waveform components for disgusted and neutral expressions. Only the low CU trait group showed the adaptation of the waveform components in response to the disgusted condition stimuli verses the neutral baseline. The N170 component of the right OP electrodes showed a significant difference in amplitude (t(9) = 2.29, p =.048, *d* = .39); neutral expressions (*X* = -.53; *SD* = 1.48) invoked a smaller mean N170 amplitude than did those of disgust (*X* = -1.13; *SD* = 1.57). The right OP area also showed adaptation of the N170 component latency ($t(9) = 2.66$, $p = .026$, $d = .33$). Neutral expressions were again associated with a quicker peaks response ($X = 154.20$; $SD = 10.69$), than those of disgust ($X = 158.27$; $SD = 13.59$). These findings suggest a larger, slower N170 peak to expressions of disgust in the low CU trait group.

Sadness Expressions

The high CU trait group showed changes in the sadness stimuli evoked ERPs, in the P1 component. The P1 over the left OP electrode showed an increased latency in response to the expressions of sadness ($X = 103.66$; $SD = 8.58$) by comparison to neutral faces ($X = 99.89$; $SD = 11.88$) ($t(9) = 2.72$, $p = .024$, $d = .36$).

By comparison, control participants showed modulation of the N2 FC amplitude ($t(7) = 2.94$, $p = .022$, $d = .31$); with expressions of sadness associated with a reduction in mean negative peak response ($X = -.14$; $SD = 1.18$) compared to neutral stimuli ($X = -.51$; $SD = 1.19$).

The low CU trait group only showed modulation of the P2 peak over the left OP electrodes ($t(9) = 3.13$, $p = .012$, $d = .67$); sad faces were associated with a slower P2 peak latency ($X = 230.60$; $SD = 13.59$) than neutral comparisons ($X = 221.81$; $SD = 12.80$).

Angry Expressions

For expressions of anger the high CU trait group showed an increase of the latency of the P1 left OP component for angry expressions ($X = 109.80$; $SD = 13.33$) when compared to the neutral baseline ($X = 99.89$; $SD = 11.88$) ($t(9) = 2.49$, $p = .036$, d

= .78). This suggests that the P1 response of high CU trait participants to angry faces was slower. The control and low CU trait groups by comparison showed no difference in the components of the waveforms produced for neutral and angry expressions.

Happiness Expressions

For happiness expressions the high CU trait participants showed adaptations of the P2 ERP component. The right OP P2 latency was significantly different for expression of happiness ($t(9) = 2.41$, $p = .039$, $d = .40$), with a happiness expressions being associated with increased latency of the P2 peak ($X = 226.50$; $SD = 12.85$) by comparison to the neutral baseline ($X = 221.33$; $SD = 12.85$).

Control participants again showed little difference in their ERP waveforms for neutral and happiness condition stimuli. However, the N2 component in the FC was significantly different in amplitude ($t(7) = 3.25$, $p = .014$, $d = .38$) for happiness ($X = -.08$; $SD = 1.07$) than the neutral comparisons ($X = -.51$; $SD = 1.19$) with lesser responses of the N2 observed for happy expressions. The low group showed no difference in their ERP responses to neutral and happy expressions.

6.4 Discussion

The facial expression stimuli revealed distinct waveforms with ERP components at 100ms, 170ms and 200ms. Three principal ERP components were observed in the left and right occipital-parietal areas (OPL and OPR); P1, N170 and P2. Furthermore, N1, P170 and N2 components were also observed in the fronto-central (FC) electrodes sites. Comparison of the waveform components with those observed by Smith et al (2013), who employed a similar presentation of the NIMSTIM expression stimuli, suggest both reliability of the ERP waveforms produced by the NIMSTIM stimuli when presented in this un-augmented manner and the validity of ERP waveforms collected for the purposes of exploring responses in the selected CU trait experimental groups. In addition, the findings replicate the P1 and N170 components identified by previous research as being implicated in facial expression response (Blau et al., 2007; Eimer & Holmes, 2007; Balconi & Pozzoli, 2003; Batty & Taylor, 2003). However, no ERP waveform components were observed at 300ms or above in the neural electrophysiological response, as have been observed in some previous research (Balconi & Pozzoli, 2003; Sato et al., 2001); although these two studies used a task based EEG recording methodology rather than passive viewing, thus these later components could be indicative of the greater semantic processing of some task procedures rather than being associated with the expressions themselves. This would explain the lack of such components in this research and that by Smith et al (2013), both of which employed a passive viewing research paradigm.

Differences in the group responses to stimuli are subtle. When considering the between group comparisons of the ERP waveforms analysis of the variance revealed difference between the CU trait groups for expressions of fear, disgust and sadness, though none for expressions of neutrality, happiness or anger. Previously, it was discussed that the CU trait groups differed with regards to their ability to correctly recognise fearful expressions. Highly callous-unemotional participants were less able to correctly identify fearful faces by comparison to low and control CU trait groups (see chapter 4). Analysis of the left OP P1 and N170 components of the waveform response to fearful stimuli showed increased latencies of the peak for the low group in both instances. Whilst differences in the P1 and N170 components may have been expected, as these have been identified as central to emotional expression processing (Blau et al., 2007; Eimer & Holmes, 2007; Balconi & Pozzoli, 2003; Batty & Taylor, 2003), it is unclear why the low CU trait group shows an increased latency of the P1 and N170 components over the left OP electrodes than the high group and control groups and why this slower peak would be associated with a group with higher recognition ability for this expression type. Slower peaks are usually indicative of a slower response, although, Muller et al (2003) found increased activity of the OP cortical area to negative valence images in psychopaths using fMRI. Therefore, a quicker P1 and N170 peak observed in high CU trait participants may be a reflection of this over activation in the occipital-parietal cortex; it would then seem less surprising that the slower peak was observed in the low CU trait experimental group. Furthermore, recent research into the ERP responses of those with varying levels of psychopathic traits have also revealed the modulation of the N170 response to fearful expressions with regards to the presence of the cold-heartedness dimension of psychopathic traits (Almeida et al., 2014). Furthermore, Almeida et al (2014) found only response at the 100, 170 and 200ms in reaction to the expression stimuli.

Previous behavioural findings for expressions of disgust revealed a significantly more negative scoring on the positive-negative scale in the low CU trait group than the high. Analysis of between group effects observed that the P1 component over the left OP was modulated; the high group was significantly lower in mean amplitude of the P1 than the control, suggesting a smaller response to expressions of disgust. Again, the distinguishing of the responses to disgusted expressions between the experimental groups occurs over the left OP parietal area, suggesting that responses in this region may be key to the behaviour differences observed in general CU trait manifestation. Furthermore, despite no behaviour differences in their responses to expressions of sadness between the experimental groups, the P1 component of the left OP ERP waveform showed adaptation in its response across the high and low CU trait groups. Similarly, to expressions of fear the low CU trait participants were associated with a significantly longer latency of the P1 component than the high group. In summary, three of the four negative expressions explored (fear, sadness and disgust) showed differentiation between the groups in the P1 and/or N170 component over the left occipito-parietal electrodes. These components in the left OP cortical area may, therefore, be key to understanding general differences in facial expression response related to callous-unemotional trait manifestation.

There were no differences in the responses of the experimental groups to expressions of anger, happiness or neutrality. Despite previous behavioural differences in self-reported responses observed for expressions of anger, with the high CU trait group reporting reduce affective valence and intensity to angry expressions than the low CU trait group, there were no neural differences in response detectable with the EEG recording and ERP analysis technique. The same is true of the expressions of happiness. Though, given the convoluted nature of previous literature regarding CU traits and the behaviour and neurological responses to facial expressions of anger and happiness, this is perhaps not unexpected (Fairchild et al., 2009; Hastings et al., 2008; Blair, 2005). The lack of difference of ERP waveform to neutral expressions is not unanticipated, however, as facial stimuli devoid of emotion would not trigger the postulated core empathetic deficits associated with high CU traits; furthermore, facial structure recognition dysfunction is not associated with high CU traits (Fairchild et al., 2009; Blair, 2007).

Differences in the neural electrophysiological waveforms for each experimental group's ERP response to emotional expressions, when compared to the neutral stimuli (used as a baseline) through repeated measures analysis within groups, reveal further differences in response. When comparing the ERP responses to the neutral and fearful expressions in the high group, modulation was observed in the N1 and N2 components over the frontal and central cortical electrodes, with shorter latencies and larger mean amplitudes respectively observed. Therefore, variation of the response for fearful expressions seems to be manifesting primarily in the FC cortical areas in the high CU trait group. By comparison, neither the control nor low experimental groups showed differences in the FC electrodes waveforms when comparing neutral and fear expressions. However, both presented significant effects in the OP waveform components. The control groups showed a significant effect of the P1 latency in the right OP electrodes and the low group showed differential responses within both the P1 component over the left OP electrodes. Overall, a larger negative amplitude of the P1 component was observed in the left OP electrodes for expression of fear in low CU trait participants. The response presenting over the FC cortex and in the N2 component of the waveform suggests a more top-down, semantic processing of the fearful stimuli; findings reflecting this increased activity of the frontal cortical areas and a lack of integration with amygdala in those with psychopathic traits in response to emotion have been recently reported in research using fMRI neuroimaging (Contreras-Rodríguez et al., 2014). The larger P1 over the left OP area manifested by the low CU trait group suggests larger autonomic, visual and emotional responses. These differences may underlie the different behaviour recognition responses to fearful stimuli observed in the previous research studies between these groups.

High and Control CU trait experimental groups exhibited no difference in their waveform components for disgusted and neutral expressions. Only the low CU trait group showed the adaptation of the waveform components in response to the disgusted condition stimuli verses the neutral baseline; though these findings lie counter to the adaptions of the ERP response to disgust observed by Almeida et al (2014). However, the N170 component of the right OP electrodes adapted in its mean amplitude, with neutral expressions invoking a smaller mean N170 amplitude than those of disgust and the N170 component latency with neutral expressions associated with quicker peaks than those of disgust. A larger, slower N170 peak to expressions of disgust in the low CU trait group is therefore observed, suggesting a neural sensitivity to disgust within this low CU trait group.

When analysing the pair-wise comparisons for expressions of neutrality verses sadness, the result seems to be complex. Whereas the high and low CU trait groups showed differences over the left OP electrodes, the control participants' difference manifested over the FC. The high CU trait group presented with an increased latency of the P1 in response to the expressions of sadness by comparison to neutral faces suggestive of a slower response to expressions of sadness. The low CU trait group also revealed latency modulation in the left OP, but in the P2 peak over the left OP electrodes; sad faces were associated with a slower P2 peak latency than neutral comparisons. Therefore, it appears that a slower response in this OP area to expressions of sadness is common to both the high and low CU trait groups, but differentiates to the P1 and P2 respectively. P2 is associated with later semantic processing of complex stimuli (Luck, 2005) and, therefore, the low group may be differentiated in regards to their semantic interpretation of the sadness and neutral expressions. Whereas, a slow P1 suggests slower autonomic, visual response by the high CU trait group. The control participants presented with modulation of the N2 FC amplitude, with sadness associated with a reduction in mean negative peak response when compared to neutral stimuli, again suggesting differentiation in processing of sadness over the FC areas responsible for high-order cognition. Interestingly, all groups show a slower or smaller response to expressions of sadness by comparison to neutral baseline expressions.

The high CU trait group showed an increase of the latency of the P1 left OP component for angry expressions when compared to the neutral baseline expressions. P1 response of high CU trait participants to angry faces was, therefore, slower than for neutral ones. However, no other differences in response were observed for pairwise analysis of angry expressions verses neutral ones.

The high CU trait participants revealed that right OP P2 latency was significantly different for expression of happiness, with a happiness expressions being associated with increased latency of the P2 peak by comparison to neutral ones. This suggests a slower emotional response in higher CU trait participants to expressions of happiness. Whereas, the N2 component in the FC of controls was significantly smaller in amplitude for happiness than the neutral comparisons, suggesting a smaller neural response across the FC electrodes to happy faces. The low group exhibited no difference in their ERP responses to neutral and happy expressions, suggesting this low CU trait group have little neural electrophysiological sensitivity to positive stimuli.

The limitations of the need to be addressed which could be improved in future research. Although the NIMSTIM stimuli are a commonly recruited and well validated stimuli set for examined response to emotional expressions, the numerous presentations and accompanying task formats mean that facial expression literature is variable with regards to its findings; therefore, it is difficult to directly compare findings. Inclusion of a task based methodology may have evoked the later components observed in some other research (Balconi & Pozzoli., 2003; Sato et al., 2001), though it is not clear whether these would have been related to the potentially greater attention paid to the stimuli or, instead, due to the semantic and motor processing required by the task. However, the close symmetry of the current findings to those of Smith et al's (2013) research which also used the passive viewing of a similarly uncropped presentation of the NIMSTIM, suggests the validity of the generated ERP waveforms.

To conclude, the P1 and N170 components of the ERP waveforms seem to primarily modulate the response to expressions of emotion in experimental groups of varying CU traits. Adaptation over the left OP cortical area to negative emotions (fear, anger and disgust) seems to be particularly strongly associated with differing levels of CU trait manifestation. The level of CU trait presentation had, however, no effect on the electrophysiological responses to happiness or neutrality. These findings are not unexpected, given previous research into CU traits. Though when considering differences in responses to emotion compared with neutral expression, the patterns of difference become more complex, extending into the P2 and N2 components as well as varying across the cortical regions.

Chapter 7:

The Modulating Effect of Callous and Unemotional Traits on Responses to Painful Stimuli, Imagined from the Perspective of One's Self and Another.

7.1 Aim

Behavioural findings suggest that, for neurotypical individuals, pain in others is an aversive experience that causes distress, however, those with high CU traits may not experience this aversion (Wolf & Centifanti, 2014). Data from the primary research of this research programme found that, although there was no correlation between CU trait manifestation and the ability to recognise facial expressions of pain, higher manifestations of CU traits were associated with a less negative, self-reported affective response to facial expressions of pain. Furthermore, higher levels of CU traits were consistently correlated with a less negative and less intense self-reported response to affective stimuli depicting humans and animals in pain (see chapter 4). Cheng et al's (2012) research looking at high CU trait offenders suggested that the N120, P300 and LPP empathetic response ERP components would be most likely to be differentiated with regards to CU traits in the general sample in response to pain in others (see chapter 3). The current research study aimed to expand on this previous publication by looking at empathy for painful situations with regards to CU traits in a general population, an area lacking in published literature. This second electrophysiological study adapted the methodology employed by Li and Han's (2010) research into empathy for pain from a self and other imagined perspective. Stimuli were similarly presented in 2 conditions: an imagine-other condition, where the participant imagined another person in the painful situation, and an imagine-self condition, during which the participants imagine themselves in the painful stimuli. Those with high levels of high CU traits may have different responses to the self-other differentiation than controls or low CU trait individuals. The study aimed to investigate empathy for pain as an insight into the cognitive elements of the empathy construct with regards to differential ERP responses regarding CU trait manifestation in a general population.

7.2 Methodology

7.2.1 Participants

The participants were recruited as described in chapter 5. However, one participant was removed from the control groups for the purposes of analysis due to artefacts, leaving 8 participants in the control group. The difference in CU trait manifestation between the groups is still significant at $p < .001$.

7.2.2 Materials

40 pictures showing hands in painful situations and 40 matched pictures of hands in non-painful situations were used to assess empathy for pain in participants. The visual stimuli depicting pain in a peer included 40 high-resolution, digital colour photographic stimuli portraying hands in both potentially painful real-life accidents (for example, a hand trapped in a door or cut by scissors) and environmentally symmetrical,

but non-painful, situations. Both male and female hands were included in the stimuli in equal proportions.

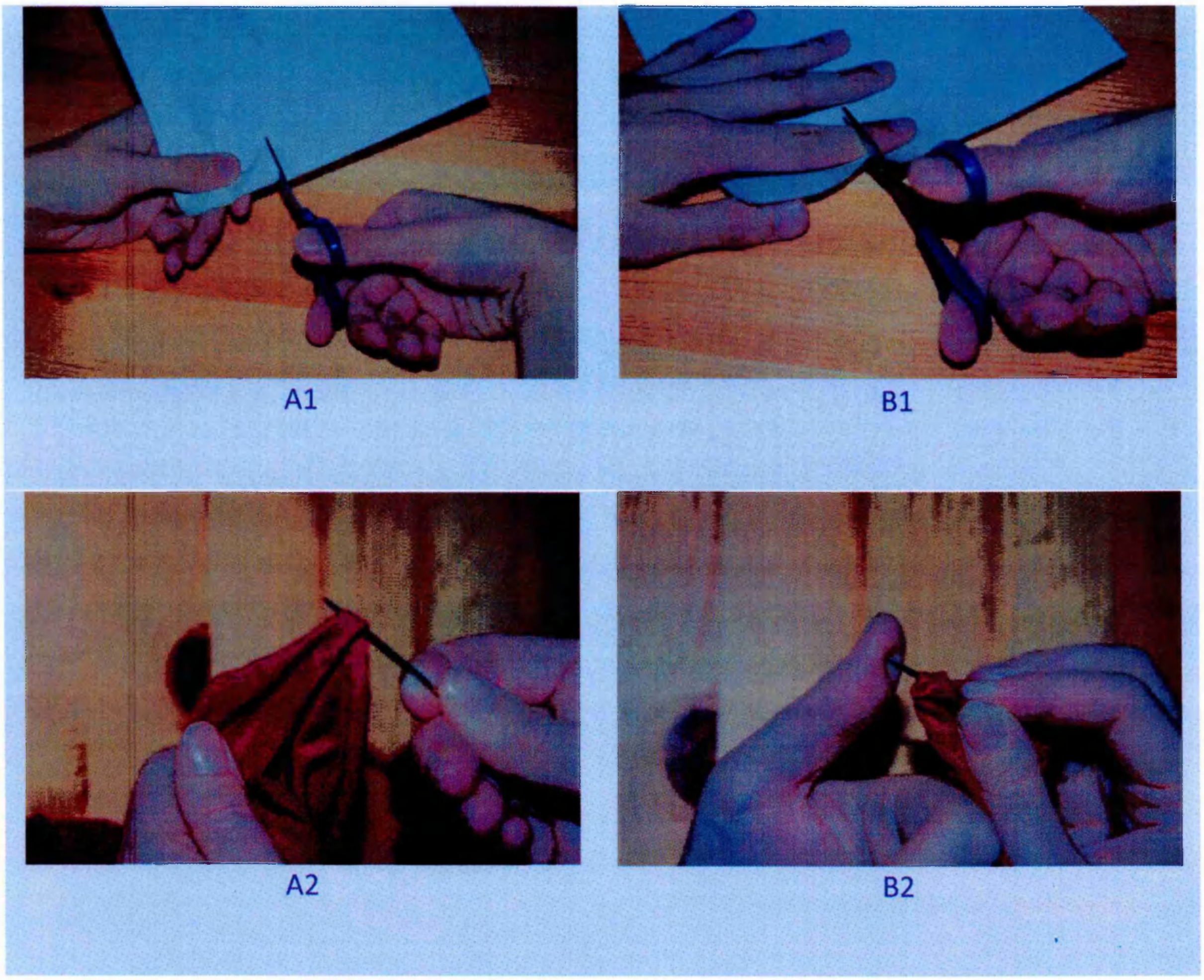

Figure 20: Illustration of painful (B) and non-painful (A) stimuli.

7.2.3 Procedure

Each stimulus picture was randomised and presented for 1000ms, with a pre-stimulus fixation cross of duration 500ms and a 1000ms inter-stimuli interval. A plain background bordered the stimuli and formed the inter-stimuli interval. Stimuli were presented in 2 blocks of 80 trials each, 40 painful stimuli and their matched non-painful stimuli). Prior to each block were instructions to participants to consider the stimuli from a self-perspective ("Imagine that hands shown in the pictures are your own") or the perspective of observing another unfamiliar person ("Imagine that hands shown in the pictures are those of an unfamiliar other person"). The blocks were presented as one for each condition "imagine-self" and "imagine-other" and were randomised in their presentation to prevent the influence of the potential effects e.g. practice and/or fatigue. This created four conditions: self-imagined pain, self-imagined non-pain, other-imagined pain and other-imagine non-pain. The total running time for the experiment was approximately 6.67 minutes. The participants were given as much time as needed to read the instructions and started the task when ready.

To assure attendance to the potential pain element of the stimuli the participants were given a task to categorise the stimuli as painful or non-painful using two buttons on a console controller. For the self-imagined condition the participant pressed 1 for a picture they considered to be depicting pain and 2 for a non-painful picture. The other-imagined condition the participants were instructed to press 3 for a painful picture and 4 for a non-painful one on the console style controller. The response times were also recorded.

7.2.4 Ethics

Before participating in the study participants were briefed as to the purpose and procedure of the research (including examples of similar stimuli), informed as to their rights as a participant (see *appendix D*) and given time to ask questions, thus ensuring that the participants' informed consent was given when signing the consent form (see *appendix E*). After the data collection the participants were debriefed (see *appendix F).* These ethical procedures were sanctioned by the Sheffield Hallam University Research Ethics Committee.

7.3 Results

7.3.1 Analysis of the Stimuli

To ensure that the pain and non-painful stimuli were demonstrably decipherable with regards to whether the hands were in painful or non-painful situations, the responses given to the stimuli were analysed without division by group. For the self-imagined condition the participant pressed 1 for a picture they considered to be depicting pain and 2 for a non-painful picture. The other-imagined condition the participants were instructed to press 3 for a painful picture and 4 for a non-painful one on the console style controller. When looking at the participant population, without partition by group, analysis of the response exclusively to the painful and non-painful stimuli show that a highly significant difference is seen between the responses to the painful and non-painful stimuli for both the self and other imagined stimuli conditions ($Z = -4.28$, $p < .001$ (2-tailed); $Z = -3.54$, $p < .001$ (2-tailed) respectively) (data was non-parametric, therefore appropriate statistical analysis was performed). For descriptives see table 25 below. Such significant results suggest validity in the stimuli's portrayal of the conditions.

Table 25:

A table showing participants' scores for the painful and non-painful stimuli under the self and other imagined conditions.

Condition		Statistic
Self-Imagined Non-pain	Mean	1.81
	Median	1.89
	Range	.88
Other- Imagined Non-Pain	Mean	3.73
	Median	3.89
	Range	1.00
Self – Imagined Pain	Mean	1.26
	Median	1.20
	Range	.79
Other – Imagined Pain	Mean	3.32
	Median	3.26
	Range	.78

7.3.2 Behavioural Data Analysis

When considering the effect of CU trait manifestation on participants' responses to painful verses non-painful stimuli for both the imagine self and imagine other conditions, pair-wise comparison were used to compare the responses. For descriptives see table 26 below. The high CU trait group showed a significant difference between the scores given for pain and non-pain stimuli when imagining the hands in the photographs belonged to themselves ($Z = -2.09$, $p = .037$ (2-tailed)). However, when imagining that the stimuli contained the hands of others in painful and non-painful situations the high CU trait group showed no significant difference in their response ($Z = -1.68$, $p = .093$ (2-tailed)); indicating less accuracy when rating painful and non-painful photos in others.

The control group showed a similar pattern of response to the high group. There was a significant difference in the responses of the control CU trait group to painful and non-painful stimuli when the participant's imagined that the hands were their own (Z = -2.67, p = .008 (2-tailed)), but no such difference was observed between rating of painful and non-painful stimuli when the participants considered the hands to be that of another (Z = -1.96, p = .051 (2-tailed)). Though it is worth noting that the p-value is only .002 from significance.

Finally, the low CU trait group showed a significant difference between both the self-imagined pain and non-painful stimuli (Z = -2.81, p = .005 (2-tailed)) and the other-imagined pain and non-pain stimuli (Z = -2.50, p = .013 (2-tailed)). In addition, low CU trait groups showed the highest significance in the differentials between painful and non-painful responses in both the self-imagined and other-imagined conditions. There were no significant differences for the data exploring reaction times to the stimuli (see *table 26* below).

Table 26:

The descriptive statistics exploring participants' scores for the four stimuli conditions.

Condition	Group		Statistic
Self-Imagined Non-Pain	High	Mean	1.76
		Median	1.87
		Range	.88
	Control	Mean	1.91
		Median	1.94
		Range	.23
	Low	Mean	1.78
		Median	1.87
		Range	.66
Other-Imagine Non-Pain	High	Mean	3.75
		Median	3.92
		Range	1.00
	Control	Mean	3.76
		Median	3.90
		Range	.95
	Low	Mean	3.70
		Median	3.83
		Range	1.00
Self-Imagined Pain	High	Mean	1.30
		Median	1.19
		Range	.74
	Control	Mean	1.25
		Median	1.24
		Range	.34
	Low	Mean	1.22
		Median	1.20
		Range	.41
Other-imagined Pain	High	Mean	3.40
		Median	3.41
		Range	.64
	Control	Mean	3.33
		Median	3.26
		Range	.74
	Low	Mean	3.23
		Median	3.17
		Range	.44

7.3.3 Present Waveforms

In order to compile analysable waveforms, the average ERP waveforms for the experimental groups were constructed by separately averaging electrophysiological responses for the 4 conditions: self-imaged pain, self-imagined non-pain, other-imagined pain and other-imagined non-pain. Analyses of ERPs were conducted on the basis of mean amplitude (μV) and latency (ms) for a given ERP component's time parameters. Three principal ERP components were observed in the left and right occipital-parietal areas (OPL, OPR); P1, N170 and P250. The OPL activation area consisted of electrodes O1, P3/5/7 and PO3/5/7. Activation in the right OP area was an assimilation of electrodes O2, P4/6/8 and PO4/6/8. P1 was analysed as the mean peak amplitude and peak latency from 80–160ms, where the P1 competent was typically maximal. N170 was observed to be of maximum peak between the 150 and 190ms post stimuli. Finally, the P2 component was observed to be maximal between 210 and 290ms.

The fronto-central (FC) electrodes sites including: FC1/2/3/4, FCz, Fz, F3/4 and Cz, also showed ERP responses to the stimuli. This broad ERP response in the FC electrodes included N1, P170 and N250. N1 was observed between 80-150ms, the P170 between 150-190ms and the N250 between 210 and 290ms. Assimilation of the maximal peak amplitudes and peak component latencies were explored for significant main effects. These components were observed to present for each of the experimental groups. Example wave forms can be seen below for each of the electrodes used in the analysis.

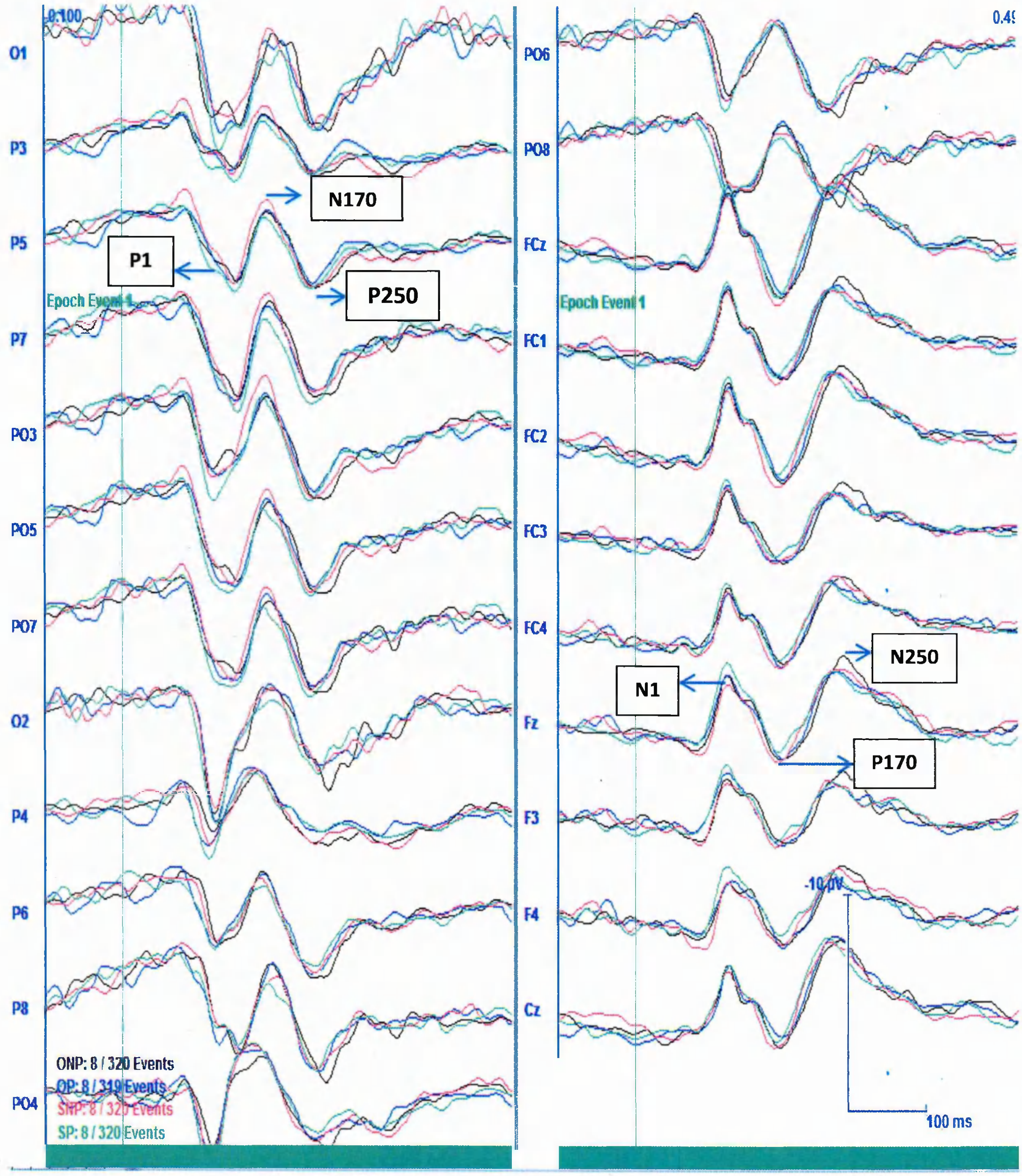

Figure 21: Grand averaged waveforms of the ERPs recorded for the control CU trait group: Black lines: other-imagined, non-painful condition response, blue lines: other-imagined, painful condition response, red lines: self-imagined, non-painful condition response, green lines: self-imagined, painful condition response.

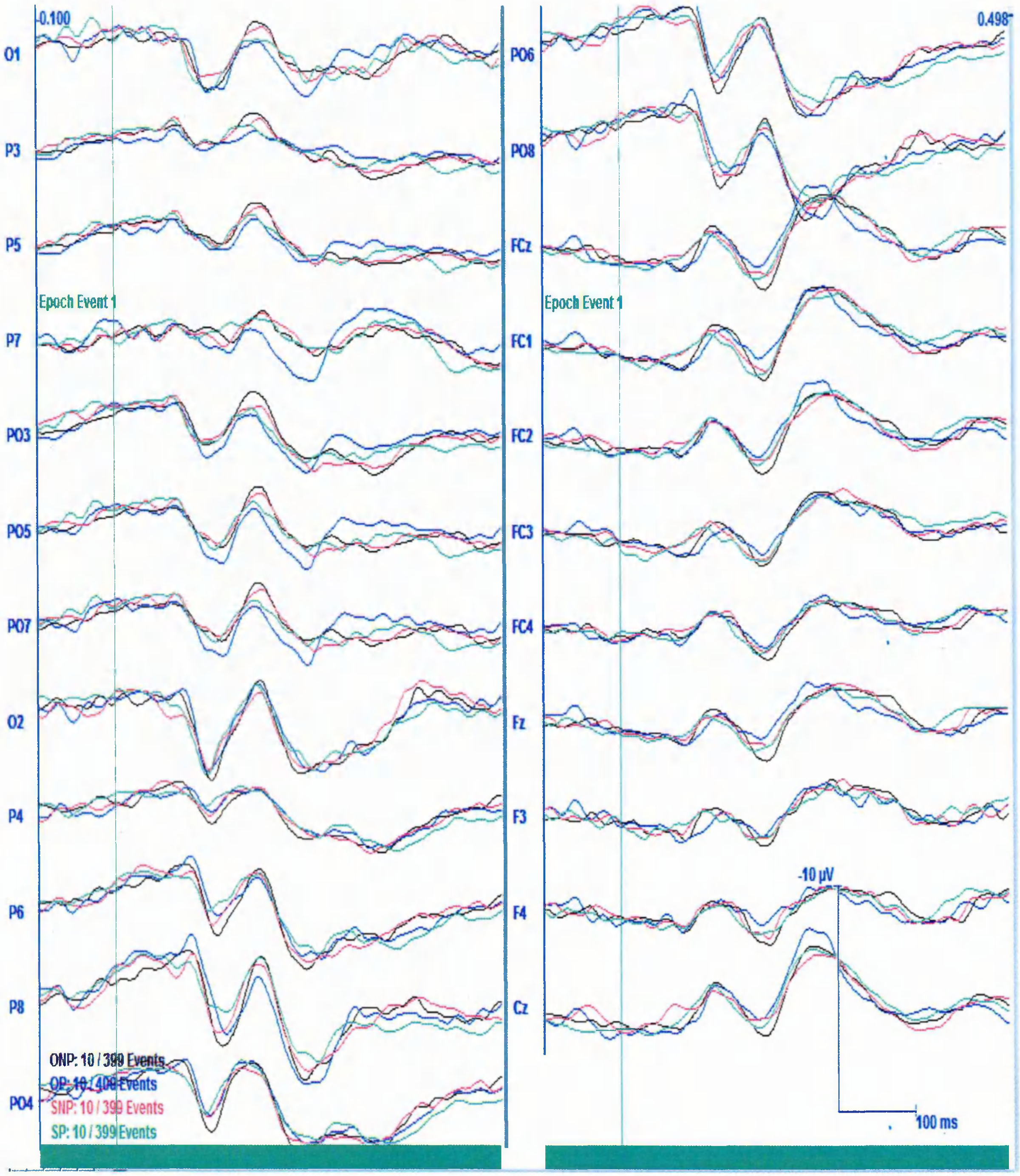

Figure 22: Grand averaged waveforms of the ERPs recorded for the high CU trait group: Black lines: other- imagined, non-painful condition response, blue lines: other-imagined, painful condition response, red lines: self-imagined, non-painful condition response, green lines: self-imagined, painful condition response.

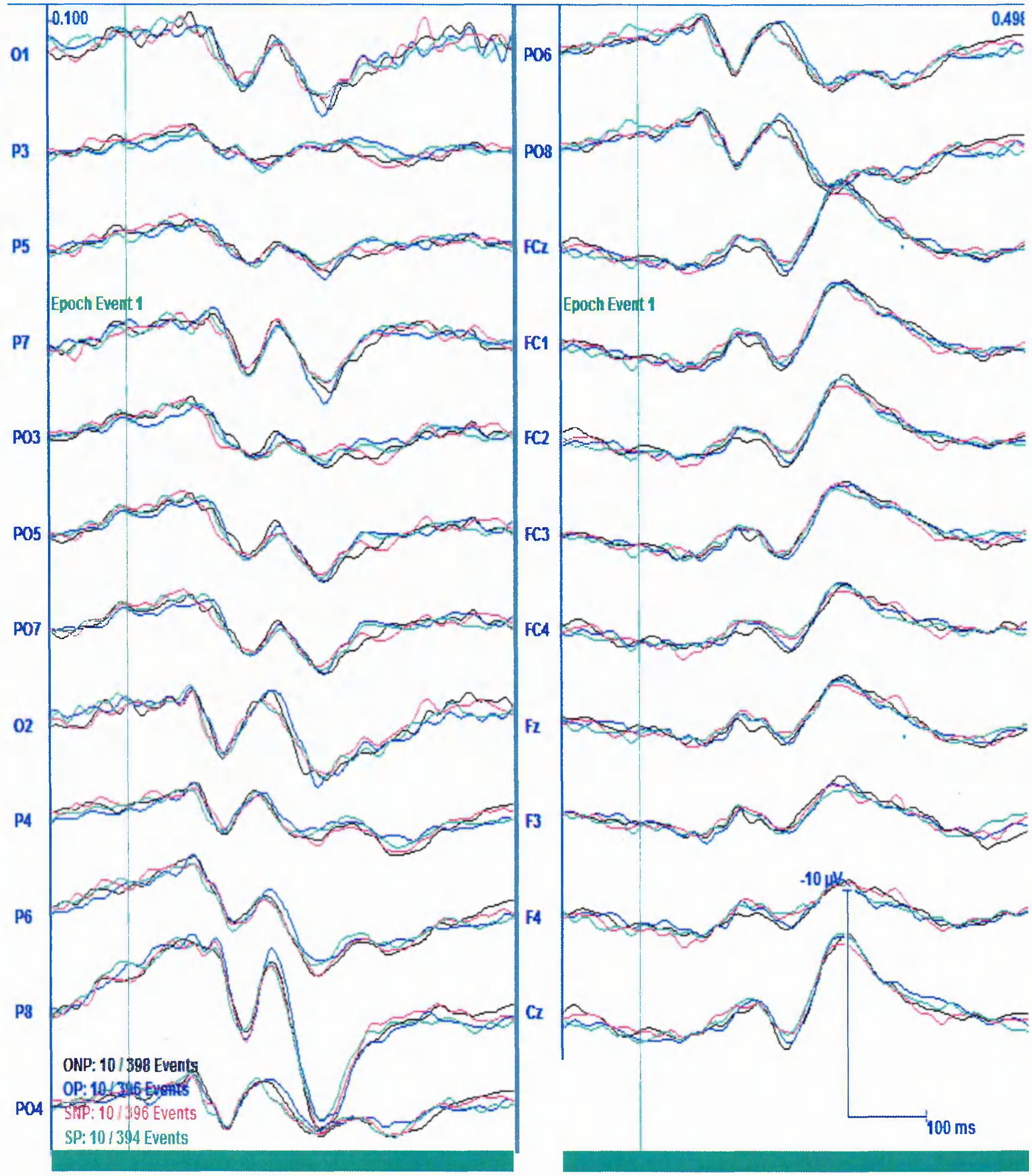

Figure 23: *Grand averaged waveforms of the ERPs recorded for the low CU trait group: Black lines: other- imagined, non-painful condition response, blue lines: other-imagined, painful condition response, red lines: self-imagined, non-painful condition response, green lines: self-imagined, painful condition response.*

7.3.4 Analysis of Responses to Self and Other Imagined Painful and Non-Painful Stimuli

3*(2*2) factorial ANOVA was used to explore the responses to the painful and non-painful conditions when imagined from the self and other perspective conditions; the interaction of these conditions with the three experimental CU trait groups was considered through the ANOVA analysis. Painful stimuli evoked larger mean amplitudes in the N170 over the left occipital-parietal (OP) electrodes and P170 and N2 over the Frontal-cortical (FC) electrodes ($F(1,25) = 9.24$, $p = .005$ $\eta p^2 = .27$; $F(1,25) = 11.86$, $p = .002$, $\eta p^2 = .32$; $F(1,25) = 6.43$, $p = .018$, $\eta p^2 = .21$, respectively) (see *table 27*). The self and other perspectives only revealed a difference in the left OP latency of the P1 component ($F(1,25) = 4.84$, $p = .037$, $\eta p2 = .16$); stimuli imagined from another's perspective evoked a longer P1 ($X = 136.77$ $SE = 2.77$) than the stimuli imagined from the perspective of the self ($X = 133.18$, $SE = 2.42$).

Table 27:

Mean amplitude of the N170, P170 and N2 components in the non- painful and painful conditions.

	Mean Amplitude (μV)					
	N170		P170		N2	
Stimuli Condition	Mean	SE	Mean	SE	Mean	SE
Non Painful	-.492	.295	.047	.251	-1.093	.304
Painful	-.802	.328	.327	.267	-1.258	.321

The factorial analysis of variance was used in order to investigate the difference in ERP response to stimuli by the high, low and control CU trait groups. Interactions between the groups and the conditions were found to manifest in the mean amplitude and latency of the left OP P1 component (F(2,25) = 10.04, p = .001, ηp2 = .45; F(2,25) = 4.61, p = .020, ηp2 = .27, respectively) and the latency of the N170 over the right OP electrodes (F(2,25) = 7.98, p = .002, ηp2 = .39). Post hoc analysis with a corrected alpha value of .0167 was used to explore the interaction between the conditions and the CU trait groups.

Self-Imagined, Non-Painful Stimuli

Post hoc analysis reveals that the control groups (*X* = 2.05, *SD* = 1.04) P1 left OP amplitude was significantly higher than both the high (*X* = .44, *SD* = 1.25) and low (*X* = .40, *SD* = .95) CU trait group (t(16) = 2.91, p = .010, *d* = 1.40; t(16) = 3.53, p = .003, *d* = 1.66 respectively). There was, however, no difference between the high and low CU trait experimental groups (t(18) = .09, p = .928, *d* = .04).

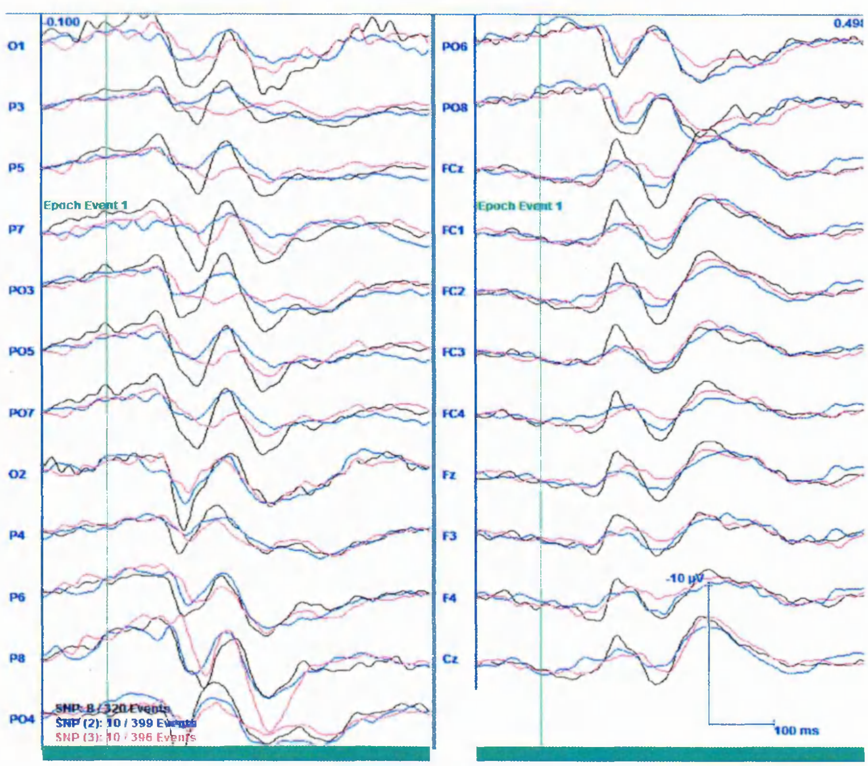

Figure 24: *Comparison of the grand averaged ERP response to the self-imagined, non-painful condition for the high, low and control CU trait groups: Black: control CU trait group, blue: high CU trait group, Red: low CU trait group.*

The self-imagined, painful stimuli modulated the amplitude and latency of the P1 over the left OP electrodes; once more, the post hoc analysis reveals that the control groups (*X* = 3.03, *SD* = 2.46) amplitude was significantly higher than both the high (*X* = .58, *SD* = 1.05) and low (*X* = .31, *SD* = 1.12) CU trait group (t(16) = 2.86, p = .011, *d* = 1.30; t(16) = 3.13, p = .006, *d* = 1.42 respectively). There was, however, no difference between the high and low CU trait experimental groups (t(18) = .56, p = .581, *d* = .25).

The latency of the P1 component over the left OP electrodes varied significantly between the experimental groups; the P1 was shortest for the high (*X* = 124.97, *SD* = 11.88) CU trait group suggesting that they have a significantly faster P1 peak to their own-imagined pain than the low CU trait (*X* = 144.97, *SD* = 12.91) (t(18) = 3.51, p = .003, *d* = 1.61) (alpha value = .017). However, there were no significant differences between the control group's latency (*X* = 134.42, *SD* = 14.91) and that of high and low CU trait groups (t(16) = 1.50, p = .143, *d* = .76; t(16) = 1.53, p = .147, *d* = .68 respectively).

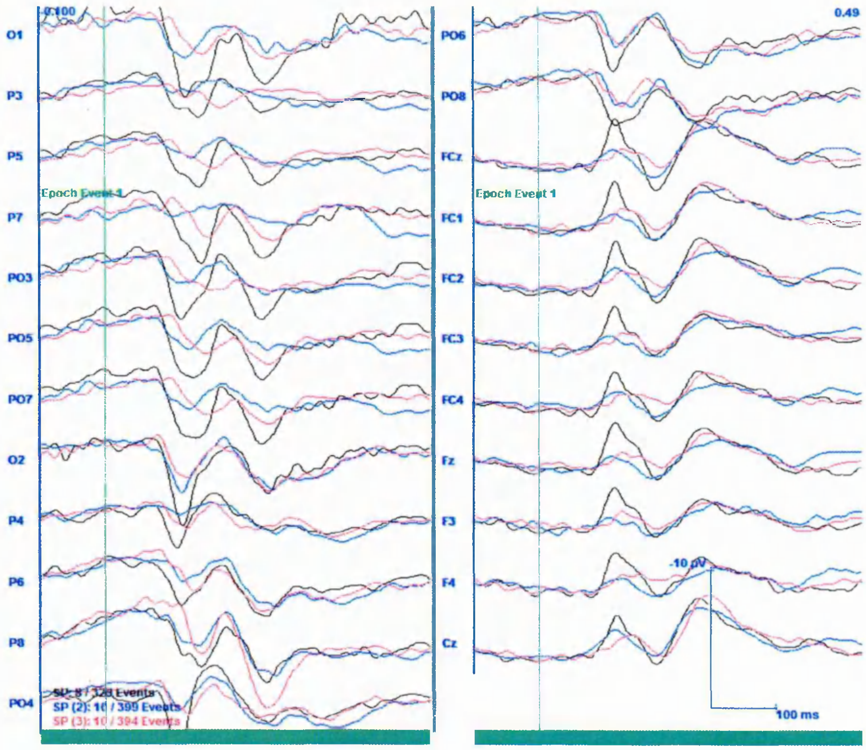

Figure 25: *Comparison of the grand averaged ERP response to the self-imagined, painful condition for the high, low and control CU trait groups: Black: control CU trait group, blue: high CU trait group, Red: low CU trait group.)*

Other-Imagined, Non-Painful Stimuli

Post hoc analysis observed that the control group's (*X* = 2.22, *SD* = 1.39) left P1 amplitude was again significantly higher than both the high (*X* = .26, *SD* = 1.44) and low (*X* = .12, *SD* = .27) CU trait group (t(16) = 2.93, p = .010, *d* = 1.38; t(16) = 4.73, p < .001, *d* = 2.10 respectively). There was, however, no difference between the high and low CU trait experimental groups (t(9.62) = .30, p = .772, *d* = .14). The latency of the N170 component over the right OP electrodes also varied significantly between the experimental groups in response to other-imagined, non-painful stimuli; the low CU trait group's N170 latency was shortest (*X* = 175.01, *SD* = 10.77) when compared to controls (*X* = 190.20, *SD* = 11.81) (t(16) = 4.73, p < .001, *d* = 1.34). Whereas, there were no significant differences between the control group's latency and that of high CU trait participants (*X* = 186.28, *SD* = 14.75) (t(16) = .61, p = .550, *d* = .29) nor the high and low CU trait groups (t(16) = 1.95, p = .067, d = .87).

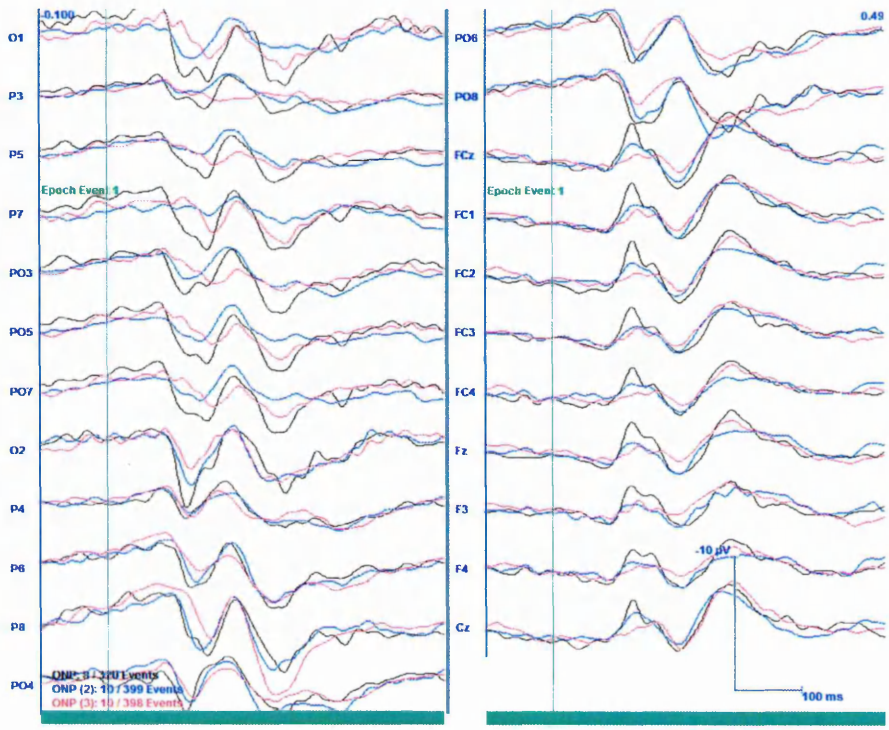

Figure 26: *Comparison of the grand averaged ERP response to the other-imagined, non-painful condition for the high, low and control CU trait groups: Black: control CU trait group, blue: high CU trait group, Red: low CU trait group).*

Other-Imagined, Painful Stimuli

The painful stimuli evoked a faster P1 in the high CU trait group (*X* = 129.66, *SD* = 15.81) than the low group (*X* = 147.21, *SD* = 12.33) (t(18) = 2.77, p = .013, *d* = 1.24). However, there were no significant differences between the control group's latency (*X* = 136.27, *SD* = 17.11) and that of high CU trait participants and low groups (t(16) = .84, p = .412, *d* = .40; t(16) = 1.59, p = .132, *d* = .73 respectively).

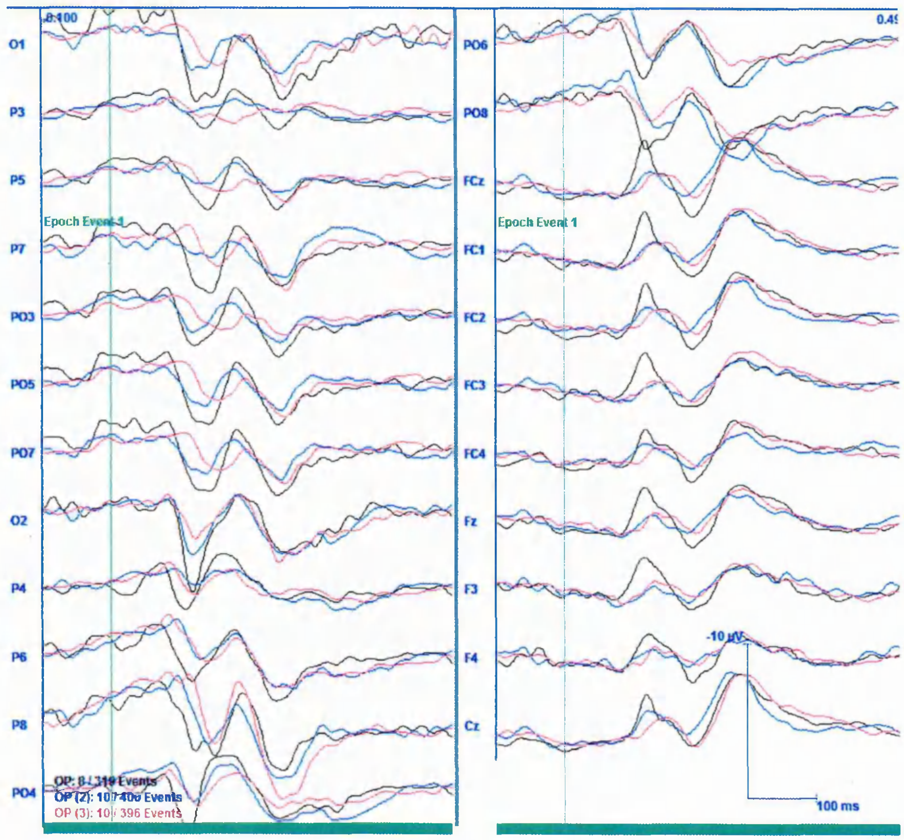

Figure 27: *Comparison of the grand averaged ERP response to the other-imagined, non-painful condition for the high, low and control CU trait groups: Black: control CU trait group, blue: high CU trait group, Red: low CU trait group.)*

7.3.5 Pair-wise Comparisons Painful Verses Non-Painful Stimuli

When the effect of pain is explored without the consideration of the perspective of imagination all three groups show modulation in their ERP response when observing painful and non-painful stimuli. The control group demonstrates a shorter N250 peak latency over the FC cortex area for stimuli showing painful stimuli (*X*= 257.08, *SD* = 12.64) than those showing non-painful situations (*X*= 262.44, *SD* = 9.53) (t(7) = 3.49, p = .010, *d* = .48).

The low group also displays modulations over the FC electrodes, but in the N1 and P170 components. The N1 amplitude is larger for stimuli depicting painful events (*X*= -.43, *SD* = .70) than non-painful ones (*X*= -.23, *SD* = .61) (t(9) = 2.74, p = .023, *d* = .30). P170 latency, however, increases for painful stimuli (*X*= 189.73, *SD* = 8.74) by comparison to non-painful comparisons (*X*= 184.51, *SD* = 9.31) (t(9) = 2.42, p = .039, *d* = .58).

However, the high group shows modulations in both the left OP response and the P170 over the FC. The left OP P1 latency was shorter for the painful stimuli (*X*= 127.32, *SD* = 11.88) than the non-painful stimuli (*X*= 130.99, *SD* = 13.45) (t(9) = 2.72, p = .024, *d* = .29). The amplitude of the left OP N170 component was significantly smaller for painful situations (*X*= -.17, *SD* = 1.80) than non-painful comparisons (*X*= -.70, *SD* = .61) (t(9) = 4.47, p = .002, *d* = .39). The amplitude of the P170 over the FC was also smaller in response to painful events (*X*= .16, *SD* = 1.25) than non-painful equivalents (X= .51, SD = 1.11) (t(9) = 2.52, p = .033, *d* = .30).

Considering the interaction between imagined perspective and the presence of pain, the control groups showed a significant difference in the other-imagined condition between non-painful and painful stimuli in the latency of the P1 component over the right OP electrodes and the N2 over the FC (t(7) = 2.37, p = .049, *d* = .51; t(7) = 2.75, p = .029, *d* = .67 respectively). Over both the P1 and N2 components, the painful stimuli imagined as occurring to another evoked a shorter latency in the painful condition (*X*= 122.91, *SD* = 13.82; *X*= 258.63, *SD* = 12.13) than the non-painful stimuli (*X*= 130.34, *SD* = 15.49; *X*= 265.41, *SD* = 7.54). However, the self-imagined condition invoked no differences in response between the painful and non-painful conditions.

When comparing painful and non-painful stimuli in the other-imagined condition, the high CU trait group showed a significantly different ERP response over the amplitude of N170 over the left OP electrodes and the P170 over the FC ($t(9) = 2.46$, $p = .036$, $d = .37$; $t(9) = 3.75$, $p = .005$, $d = .38$ respectively). The N170 and P170 present with smaller amplitudes in response to others pain ($X = -.25$, $SD = 1.81$; $X = .07$, $SD = 1.45$) by comparison to non-painful events ($X = -.88$, $SD = 1.62$; $X = .58$, $SD = 1.19$). However, there were no differences in the self-imagined, painful and non-painful conditions

The low CU trait participants presented no adaptations to painful stimuli when compared to non-painful stimuli in neither other nor self-imagined conditions.

7.3.6 Pair-wise Comparisons of the Self-Imagined Verses Other-Imagined Conditions

When considered without the interaction of pain, the self and other perspective conditions cause no modulation in the ERP responses in the CU trait experimental groups. Furthermore, when considering the interaction of pain and perspective the control groups and the low CU trait group show no significant differences in their responses to self and other imagined, neither in the painful condition nor in response to non-painful stimuli.

For the painful stimuli, the high CU trait experimental group showed no differences in the ERPs recorded for the self-imagined and other-imagined conditions. However, in the non-painful condition the high CU trait participants demonstrate modulation of their response in the latency of the P170 over the FC electrodes and the amplitude of the left OP P2 ($t(9) = 2.40$, $p = .040$, $d = .42$; $t(9) = 2.57$, $p = .030$, $d = .14$ respectively). The latency of the P170 was found to be shorter for the self-imagined stimuli ($X = 183.16$, $SD = 15.36$) than the other-imagined perspective ($X = 189.19$, $SD = 12.96$). Furthermore, the self-imagined, non-painful condition evoked a larger left OP amplitude ($X = 1.04$, $SD = 2.58$) than the other-imagined ($X = .65$, $SD = 2.83$).

7.4 Discussion

Analysis of stimuli suggests that the painful and non-painful stimuli conditions were demonstratively different with regards to whether the hands were in painful or non-painful situations, in both the self and other imagined perspective conditions. This ensured that the differences in response were due to the CU personality traits under investigation and not instead to the recruited stimuli. Given this, the behavioural data presented group differences in response. The high CU trait group exhibited a difference between the scores given for pain and non-pain stimuli when imagining the hands in the photographs belonged to themselves, however, when imagining that the stimuli contained the hands of others, the high CU trait group showed less accuracy when rating painful and non-painful photos in others. This pattern of response was replicated in the control group, though the difference in the other-imagined condition was close enough to significance to be called into question; for instance, it is possible that with more participants the control group's response to the other's hands might have become significant. However, the low CU trait group presented highly significant differences between both the self-imagined pain and non-painful stimuli and the other-imagined, painful and non-painful stimuli. As the stimuli are highly significant in the scored differences, when the population is considered as a whole, it is unlikely that this difference is due purely to differences in stimuli.

Previous literature exploring psychopathy consistently demonstrates deficits in empathy for pain in others in the neural and behavioural responses of psychopaths, a behavioural inaccuracy paralleling the clinical findings was observed in the reduced response to pain in others in this non-clinical sample demographic (Decety et al., 2013; Marsh et al., 2013). The behavioural response of those high in CU trait suggests a mirrored reduction in concern for others pain in the investigated high CU trait; however, the responses to the condition which required that the participant imagine the stimuli as containing their own hands showed no such inaccuracy in interpreting painful and non-painful stimuli content. Less expected is the borderline significance of the control group in discerning the painful and non-painful stimuli in the other-imagined condition; it is unclear why the control group found the task more difficult that the low CU trait group.

The stimuli-evoked waveform components are similar to those reported by Cheng et al (2012), including waveform components between at 120 -130, 170-190, 250 over the OP and FC areas, suggesting some convergent validity. However, the later peaks at 300ms and 360ms, as well as the LPP peaking at 600ms, were not observed. Li and Han (2010) reported ERP components also similar to the ones described here, the authors observed that stimuli in the painful and non-painful conditions evoked a negative component between 80 and 120ms (N110) at the fronto-central electrodes, followed by a positive component (P160) and a negative deflection later at 220–270ms (N240) latency, suggesting similarity of response across pain empathy research. Although, again the later components described by Li and Han (2010) were not replicated in the presented study. Cheng et al (2012) considered that CU trait manifestation modulated the response to painful stimuli by decreasing the frontal N120 negativity for painful stimuli in the high CU trait participants; furthermore, the central recording sites observed that painful stimuli elicited smaller central LPP amplitudes. Although, it was observed in the between group that the latency of the P1 component over the left OP electrodes varied significantly between the experimental groups, the P1 was shorter for the high CU trait group than the low CU trait; when observing the adaptation of ERPs to painful and non-painful stimuli, the high group shows modulations in the amplitude of the left OP N170 component which was smaller for painful situations than non-painful comparisons, furthermore, the amplitude of the P170 over the FC was also smaller in response to painful events. Therefore, decreases in amplitude (although later 170 verses 130ms) were also observed in this research paradigm. One of these reduced responses to pain adaptations was also observed over the FC electrodes, similarly to the Cheng et al's (2012) research. Both studies suggest a reduction in the amplitude of response to painful stimuli by comparison to non-painful ones in high CU trait participants.

The low CU trait group by comparison exhibited modulations also over the FC electrodes, although in contrast to the high group the N1 amplitude was increased for stimuli depicting painful events than non-painful ones. This finding suggests an increase in response over the FC electrodes peaking between 120 and 130ms. An N100 response is often associated with stimulus predictability or auditory response, however, when observed over the frontal/central cortices, an increased N1 can be associated with attentiveness (Coull, 1998); thus, possibly the low CU trait group exhibit increased attentiveness to painful stimuli. N1 components may also be modulated by emotional saliency (Pourtois & Vuilleumier, 2006). The P170 latency increases for painful stimuli by comparison to non-painful comparisons, which is unexpected. The control group demonstrated a shorter N250 peak latency over the FC cortex area for stimuli showing pain suggesting faster response of the component to painful stimuli.

It is possible that both the high and low CU trait groups have personalities which were somewhat different to the mean and possibly approaching pathologies; the high group approaching psychopathy and the low group hyper empathy, hence the differences in response to painful stimuli imagined from the self and other perspective between the groups may reflect this hypothesis. However, significant research would be required to investigate such a hypothesis fully.

Pair-wise comparisons of the self-imagined verses other-imagined conditions showed no difference when the presence of pain was not considered. The self-other distinction also gave no differences in ERP waveform response in the low and control CU trait groups when the painful and non-painful stimuli were explored for interaction. However, in the non-painful condition the high CU trait participants demonstrate modulation of their response in the latency of the P170, which was found to be shorter for the self-imagined stimuli than the other-imagined perspective. Furthermore, the self-imagined, non-painful condition evoked a larger left OP amplitude than the other-imagined. This finding suggests a smaller, slower response in the high groups P170 component to non-painful stimuli in others. Though, painful stimuli in the high group evoked no difference in waveforms between the painful and non-painful stimuli mirroring the low and control group.

To conclude, there seem to be differences in both the behavioural and ERP waveforms responses of the CU trait experimental groups. The high CU trait group present with a reduced accuracy in discerning painful and non-painful stimuli in others, but not when imagining the stimuli are relevant to themselves. Furthermore, high CU trait participants presented with adaptation of response to painful stimuli centring around the diminishment of the 170-190ms peaks over the left OP and FC electrodes. Consideration of the non-painful stimuli was also associated with larger responses of the P170 to the stimuli considered from the perspective of occurring to oneself than another. Whereas, by comparison, the low group exhibited no difficulty in discerning painful and non-pain stimuli when imagined as oneself or another; this behavioural accuracy is accompanied by an increase in the N1 amplitude, as well as an increase in latency presented in the P170. By comparison, the control group show an unexpected lack of accuracy in determining other-imagined painful and non-painful stimuli. Painful stimuli were associated with quicker N250 component. However, changing the imagined condition from self to other had no effect on ERP waveform response to either the control or low CU trait groups, only the high group as described previously.

Chapter 8:

The Modulating Effect of Attention on Emotional Valence Processing in those with High and Low Levels of Callous and Unemotional Traits

8.1 Aim

Emotional valence to emotion in others is due to the activation of the sympathetic nervous pathway (Blair, 2005; Decety & Jackson, 2004). High CU traits in individuals within both sub-adult CD and adult psychopathic populations are correlated with reduced emotional valence (Loney et al., 2003) and deficient empathetic responding to emotive stimuli (beyond those looking specifically at facial expressions) (Dadds et al., 2009). The primary research of this programme observed a negative association between CU traits and the emotional response. Individuals with higher CU traits tended to score their experience of negative emotional stimuli less negatively than low CU traits individuals; a less positive response to positive images was also observed. Furthermore, CU traits correlated with reduced intensity on both the positive and negative images, suggesting that high CU traits individuals score themselves as experiencing less intensity of emotion when viewing both positive and negative images.

Individuals with psychological disorders resulting in high CU trait personalities reliably present with depleted amygdala function to facial expressions depicting negative emotion, and thusly, reduced emotional valence to affective stimuli (Marsh & Blair., 2008; Blair, 2005). Anderson and Stanford (2012) also observed that controls present with a robust, persistent ERP positivity (200–900ms) to negative affective stimuli when compared to neutral stimuli in both conditions, however, psychopathic participants only exhibited this electrophysiological response when their attention was directed towards the emotional content of the stimuli, though the responses were still smaller than the amplitude of response observed in the control sample. The aim of this final electrophysiological study was to investigate the electrophysiological manifestation of the CU trait associated deficit in emotional valence and the moderating effect of attention.

8.2 Methodology

8.2.1 Participants

Participants were recruited as described in chapter 5. However, 3 participants were lost due to artefacts and recording failure, two from the control group and one from the high group, resulting in a control group of 7 participants and a high CU trait group of 9 participants. The difference between the groups with regards to CU traits is still significant at the $p < .001$ level.

8.2.2 Materials

Emotion evoking stimuli were deployed in order to record the electro-neurological response of participants to positive and negative emotive stimuli which have not been abstracted from environmental factors nor context. The methodology for this study investigated participants' neurological responses to the International Affective Picture System (IAPS) emotive stimuli set (Lang & Bradley., 2007). The IAPS is a valence scored and validated set of emotion evoking photographs. It is well documented that ERP component research recruiting stimuli from IAPS images reports that positive and negative affective images are responded to with different electrophysiological responses, particularly with amplitude and latency modulations in the 100-300ms latency range (Sadeh & Verona, 2012; Cano et al., 2009; Codispoti et al., 2007; Olofsson & Polich, 2007; Carretie et al., 2006, 2004, 2003; Schupp et al., 2003, 2000). These emotive stimuli were viewed with and without attention to the emotive content to observe whether the difference in attentive response associated with psychopathic traits, reported by Anderson and Stanford (2013), is also present in a cross section of the CU trait measure participants. It is postulated that this effect may extend to general individuals high in CU traits and may not be present in low CU trait individuals or controls.

IAPS pictures were selected for 6 conditions; including 80 positive emotions in humans (including scenes of human happiness, affection and achievement), 80 neutral facial expressions and events depicting humans, 80 negative depictions of humans (including scenes of injury and violence equivalent to those that might be observed in a 15 rated movie), 80 negative non-human scenes (including pictures of waste, destruction and decay), 80 depicted positive non-human scenes and objects and 80 neutral non-human scenes. These were presented with a target black–white pattern, presented 40 times. Half of the images in each condition were presented in a condition during which the participant had to only respond to the target image, the other half in a condition during which the participant had to attend to the emotional content of the stimuli. There were, thus, 40 images in every condition to ensure a valid average ERP response. The positive, neutral and negative conditions were matched for average intensity using the IAPS valence scores over the attention-only and emotional attention conditions. Conditions recruited in this manner allowed for the investigation of CU trait interaction with positive, negative and neutral stimuli containing human social information and no human social information.

There was two parts to the experimental paradigm, similarly to Anderson and Stanford (2012); the first part presented the images with a task that did not require the participant to attend to the emotive content of the images, whereas the second part presented images in the same 6 conditions but required the participants to attend to the emotive nature of the content in order to complete the task by categorising the picture as positive, negative or neutral. Given Anderson and Stanford's (2012) findings, it is expected that those with high CU traits would responded in an electrophysiologically different manner when they attend to the emotive stimuli, compared to when the task did not require emotive processing. However, those low in CU traits and the controls would be expected to react similarly regardless of attention, as emotional valence processing is prioritised. The 80 stimuli were therefore divided across the two conditions. However, to ensure no difference in the average valence of the data sets, which may have affected the responses across the non-emotional and the emotional attention conditions, the IAP stimuli were arranged to ensure equal average valence across the conditions to parameters within .2 of a valence score (see *table 28* below).

Table 28:

Average valence scores for each condition.

Condition	Non-emotional Attention Average Valence	Emotional Attention Average Valence
Human Negative	2.42	2.39
Human Neutral	5.15	5.13
Human Positive	7.47	7.41
Scene Negative	3.14	3.16
Scene Neutral	5.16	4.97
Scene Positive	7.07	7.17

Figure 28: *Examples of positive, neutral and negative stimuli (top to bottom) from the IAPS (Lang et al., 2005).*

8.2.3 Procedure

Participants were sat alone in the recording room approximately 50cm from the presentation screen to reduce the effect of external stimuli. Once the cap of electrodes was applied the participants were instructed to remain as still as possible to limit extraneous artefacts and to blink in the inter stimuli intervals if required. Stimuli were presented, using a computer screen and e-prime software.

For the first part of the experiment the target stimulus and the 6 non-emotional attention conditions (human negative, human neutral, human positive, scene negative, scene neutral and scene positive) stimuli were present to the participants randomly and with equally probability. Each condition, as stated previously, consisted of 40 stimuli within this first block. Temporal duration of the presented stimuli was fixed at 1000ms, with an interval of 1000ms and pre-stimulus fixation cross presented for 500ms. The participants were instructed to press a button when they observed the target pattern stimuli. Thus, the stimuli were observed without specific attention to their affective content, or lack thereof. The total running time of this first task was 11.67 minutes.

The second part of the experiment was structured in a similar manner, including 40 trails of each stimuli condition. Though the target stimuli was absent for this task, instead the participants were asked to attend to the emotional content of the stimuli and categorise them into positive, neutral and negative types by pressing predetermined buttons on a response pad (1, 2 and 3 respectively). For consistency, the temporal duration of the presented stimuli was again fixed at 1000ms, with an interval of 1000ms and a pre-stimuli fixation cross shown for 500ms. The total running time of the task was therefore 10 minutes.

It is considered that these stimuli arranged within this research paradigm would allow exploration of whether lower emotional valence to photographic stimuli presenting emotive images would be likely in those with high scores on the measures of callous and unemotional traits; furthermore, whether the opposite is true in those low CU trait individuals, by comparison to high CU trait individuals and controls.

8.2.4 Ethics

Before participating in the study participants were briefed as to the purpose and procedure of the research (including examples of similar stimuli), informed as to their rights as a participant (see *appendix D*) and given time to ask questions, thus ensuring that the participant's informed consent was given when signing the consent form (see *appendix E).* After the data collection, the participants were debriefed (see *appendix F*). These ethical procedures were sanctioned by the Sheffield Hallam University Research Ethics Committee.

8.3 Results

8.3.1 Behavioural data

There were no significant differences between the responses of the high, low and control CU trait groups to the 6 conditions when rating the stimuli ($p > .05$) (see *table 29 & 30*). Furthermore, there were no differences between the groups with regards to response times when categorising the stimuli ($p > .05$) (see *table 31 & 32*). Data was non-parametric and therefore was analysed using appropriate non-parametric techniques.

Table 29:

Descriptive analysis of between group responses to the emotional attention conditions.

Group Response Scores for the Conditions		Minimum	Maximum	Mean	Std. Deviation
High	Human negative	2.38	2.94	2.74	.21
	Human neutral	1.48	2.13	1.95	.18
	Human positive	1.00	2.00	1.44	.34
	Scene negative	2.42	2.95	2.73	.19
	Scene neutral	1.97	2.18	2.06	.07
	Scene positive	1.15	1.97	1.58	.27
Control	Human negative	2.77	3.00	2.86	.07
	Human neutral	1.19	2.08	1.78	.34
	Human positive	1.00	1.91	1.31	.26
	Scene negative	2.44	2.97	2.81	.16
	Scene neutral	1.96	2.32	2.13	.10
	Scene positive	1.06	1.88	1.57	.31
Low	Human negative	2.67	3.00	2.83	.13
	Human neutral	1.40	2.22	1.82	.27
	Human positive	1.00	2.03	1.37	.37
	Scene negative	2.10	3.00	2.72	.32
	Scene neutral	1.68	2.65	2.08	.26
	Scene positive	1.00	1.83	1.48	.30

Table 30:

Descriptive analysis of between group responses to the emotional attention conditions.

Responses to the Emotional Attention Conditions						
	Human negative	Human neutral	Human Positive	Scene negative	Scene neutral	Scene positive
Kruksal-Wallis	1.19	1.00	.95	1.15	2.68	.58
df	2	2	2	2	2	2
P-value	.552	.606	.623	.564	.262	.750

Table 31:

Descriptive analysis of between group reaction times to the emotional attention conditions.

Group Reaction Times Scores for the Conditions		Minimum	Maximum	Mean	Std. Deviation
High	Human negative	589.00	699.40	637.00	34.13
	Human neutral	574.90	725.30	652.23	52.29
	Human positive	584.33	735.58	663.57	52.72
	Scene negative	515.77	774.48	645.59	78.04
	Scene neutral	611.75	779.25	689.21	50.05
	Scene positive	564.75	740.27	629.40	48.66
Control	Human negative	375.77	731.75	636.47	142.57
	Human neutral	305.75	735.08	593.66	134.90
	Human positive	249.22	708.80	618.36	155.63
	Scene negative	381.75	718.20	620.14	118.12
	Scene neutral	538.45	740.10	668.97	58.08
	Scene positive	432.38	741.95	646.76	89.66
Low	Human negative	432.98	797.13	642.97	95.44
	Human neutral	125.72	735.52	546.27	188.12
	Human positive	178.75	722.20	585.71	161.00
	Scene negative	569.05	755.70	649.11	69.26
	Scene neutral	438.40	715.42	608.17	94.19
	Scene positive	310.57	729.75	601.65	117.92

Table 32:

Descriptive analysis of between group reaction times to the emotional attention conditions.

	Reaction Times in Response to the Emotional Attention Conditions					
	Human Negativity	Human neutral	Human positive	Scene negative	Scene neutral	Scene positive
Kruksal-Wallis	3.35	1.16	1.33	.01	4.03	2.74
df	2	2	2	2	2	2
P-value	.188	.559	.514	.996	.133	.254

8.3.2 Electrophysiological results - Present Waveform Components

Average ERP waveforms for the experimental groups were constructed by separately averaging the electrophysiological responses for the 6 attention conditions and 6 emotional attention conditions (human and scene images depicting negative, neutral and positive emotional content). Analyses of ERPs were conducted on the basis of mean amplitude (μV) and latency (ms) for each ERP waveform component's time parameters across the three experimental groups. The control groups showed three core ERP components in the left and right occipital-parietal areas (OPL and OPR); P1, N170 and P2. The OPL activation area consisted of electrodes O1, P3/5/7 and PO3/5/7. Activation in the right OP area is an assimilation of electrodes O2, P4/6/8 and PO4/6/8. P1 was analysed as the maximum peak amplitude and latency from 80–150ms, where the P1 component was typically maximal. N170 was observed to be of maximum peak between the 140ms and 190ms post stimuli. Finally the P2 component was observed to be maximal between 190ms and 260ms (see *figures 29-34*). N1, P170 and N2 components were also observed in the fronto-central (FC) electrodes sights including: FC1/2/3/4, F3/4, Fz, Cz, and FCz. The N1 was observed between 80-150ms, the P170 between 140-190ms and the N2 between 190 and 260ms (see *figure 29-34* below).

8.3.3 Analysis of ERP Waveform Components for Affective Stimuli of Human and Non-Human Scenes and Effect of Attention

3*(3*2*2) factorial ANOVAs were recruited to investigate the effect of emotion (positive, negative and neutral), attention (attending to a non-emotional target or to the emotional content of the image) and the content of the scene (human or non-human); the interaction of these conditions with the three experimental CU trait groups was considered through the ANOVA analysis.

The ANOVA analysis revealed significant outcomes in the P2 over the right occipital-parietal (OP) electrodes ($F(2,23) = 4.10$, $p = .023$, $\eta p^2 = .15$) and the N1 and N2 over the FC electrodes ($F(2,23) = 2.67$, $p = .044$, $\eta p^2 = .19$; $F(2,23) = 2.90$, $p = .032$, $\eta p^2 = .20$, respectively). These components were considered in within groups and between groups post-hoc analyses.

Human Negative Stimuli

Within groups analysis showed no modulation within the P2 over the OP electrodes nor the N1 or N2 of the FC. However, when the negative human images were compared between the attention and emotional-attention conditions the high CU trait participant's showed a modulation in the mean amplitude of the P1 component in the left OP response ($t(8) = 2.90$, $p = .020$, $d = .45$); the attention condition showed a lower amplitude of the P1 to negative images of humans ($X = .36$, $SD = 1.89$) by comparison to the emotional attention condition ($X = 1.11$, $SD = 1.40$). By comparison, the control group and low groups showed no significant shifts in their waveform when analysed between the attention and emotional-attention conditions. Therefore, only the high group increases their neural response significantly to negative affective images between the attention only condition and the emotional attention condition; the control and low CU trait groups show the same neural response to the negative images in both conditions.

Examining the differences between the experimental CU trait groups with regards to their electrophysiological responses to negative images of humans, differences are only observed in the attention only condition. Analysis of variance reveals a significant difference in the amplitude of the P2 over the right OP electrode ($F(2,23) = 4.34$, $p = .025$, $\eta p2 = .27$); post hoc tests reveal that the high CU trait is significantly higher in mean amplitude ($X = 6.45$, $SD = 4.3$) than the control ($X = 2.50$, $SD = 2.82$) and low ($X = 2.65$, $SD = 2.03$) CU trait groups ($t(14) = 2.21$, $p = .45$, $d = 1.09$; $t(17) = 2.51$, $p = .023$, $d = 1.13$ respectively). There was no difference between the control and low groups ($t(15) = .13$, $p = .901$, $d = .06$). Although none are significant if the alpha value is Bonferroni corrected to .017. Furthermore, there were no differences between the CU trait groups' waveforms in the emotional attention condition, suggesting that the high group deviates from the controls' neurotypical response only when their attention is not drawn to the emotional content of the negative stimuli.

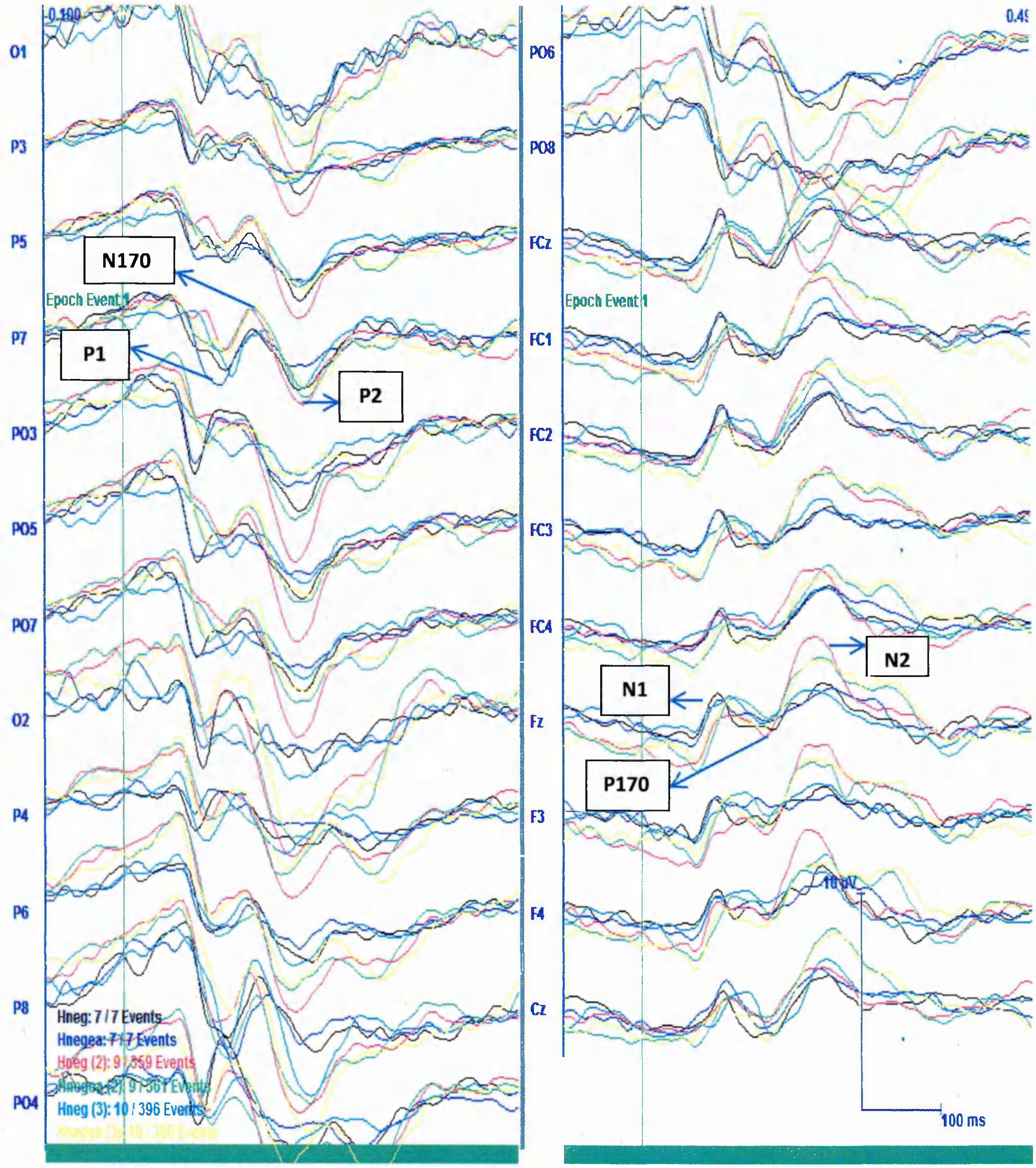

Figure 29: *Comparing CU trait group responses to negative human stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.*

Human Neutral Stimuli

Within groups analysis reveals that the neutral human stimuli invoke ERP waveform modulation between the attention and emotional-attention for the high experimental group, but once again the control and low group show no adaptation in waveform response between the attention and emotional-attention conditions. The high groups show several modulations in their waveform components between the attention and emotional attention conditions. The N1 over the FC electrodes was again larger in amplitude in response to the emotional attention (X = -1.16, SD = 1.48) in comparison to the attention condition (X = .02, SD = 1.33) (t(8) = 4.36, p = .002, d = .84). Emotional attention also invoked a larger N2 response over the FC electrodes (X = -3.54, SD = 2.18 verses X = -2.24, SD =2.08) (t(9) = 3.92, p= .004, d = .61). Such outcomes suggest that again the emotional attention condition has a highly modifying effect on the response of the high CU trait individuals for neutral stimuli. Larger mean amplitudes of the N1 and N2 suggest increased activation of the FC cortical regions when attention is drawn to trying to assess the emotional content of neutral stimuli. However, the attentional conditions to human neutral stimuli have no such modifying effects on the control or low CU trait group.

Between groups analyses reveal no significant differences between the groups with regards to the generated waveforms for neutral human stimuli in neither the non-emotional attention condition nor the emotional attentional conditions; suggesting the groups are responding in a similar neural manner to neutral human stimuli, as is measurable by EEG.

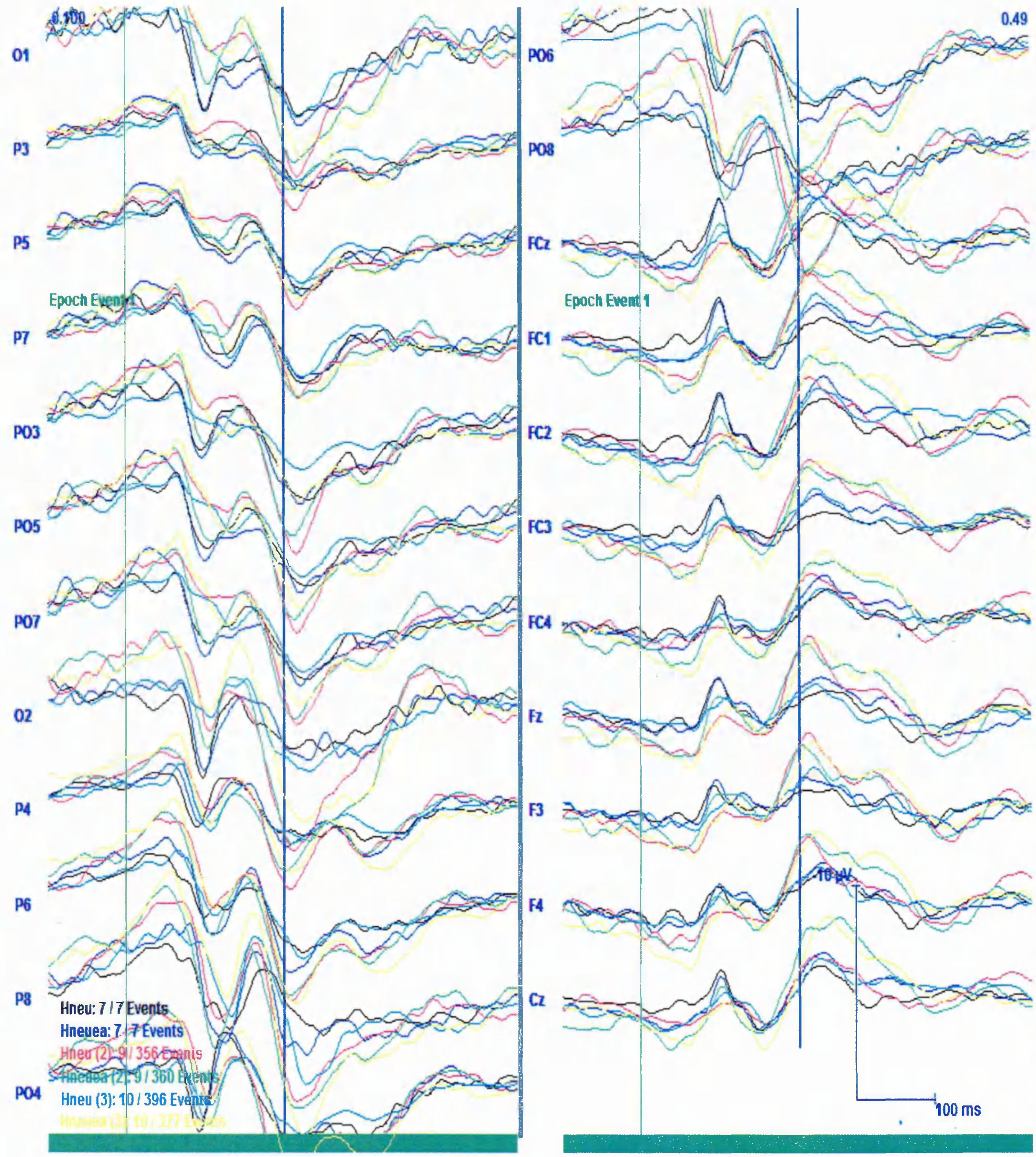

Figure 30: *Comparing CU trait group responses to neutral human stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.)*

Within groups analysis showed no modulation within the P2 over the OP electrodes nor the N1 or N2 of the FC between the attention and emotional attention conditions in the control group for positive human images. However, the high CU trait group showed modulation of the ERP in response to the attention and emotional attention conditions. The N1 response over the FC electrodes was larger in amplitude in response to the emotional attention (X = -1.37, SD = 1.18) condition than the attention condition (X = -.69, SD = .85) (t(8) = 2.73, p = .026, d = .66). The increases in the amplitude of the ERP components in response to the emotional attention condition in the high CU trait group for positive human images mimic the results for the negative and neutral stimuli. Interestingly, the low CU trait participants also showed modulation in response to the positive human stimuli when their attention is drawn to the emotional content of the stimuli. An increase in mean amplitude was seen for the P2 component over OPR electrodes in response to the emotional attention condition (X = 5.39, SD = 4.11) by comparison to the attention condition (X = 2.27, SD = 1.68) (t(9) = 2.60, p = .029, d = .66).

As for negative human stimuli, between groups analysis only reveals differences in the CU trait group's responses to positive stimuli in the attention only condition. The P2 over the right OP electrodes is significantly different between the groups (F(2,23) = 3.56, p = .045, ηp^2 = .24); a larger mean P2 component is observed for the high group (X = 5.36, SD = 3.83) than the low CU trait groups (X = 2.27, SD = 1.68) (t(17) = 2.32, p= .033, d = 1.04). However, there was no significant difference between the P2 amplitude of the high CU trait and the control group (*X* = 2.04, *SD* = 1.85) (t(14) = 1.90, p= .078, *d* = 1.10) nor between the control and low groups (t(15) = .21, p = .837, *d* = .13). The emotional attention condition reveals no significant differences between the groups ERP waveform responses to positive stimuli, suggesting that, similarly the responses to negative stimuli, when the high group's attention is drawn to the emotional content of the stimuli their responses are similar to those in the control and low CU trait groups.

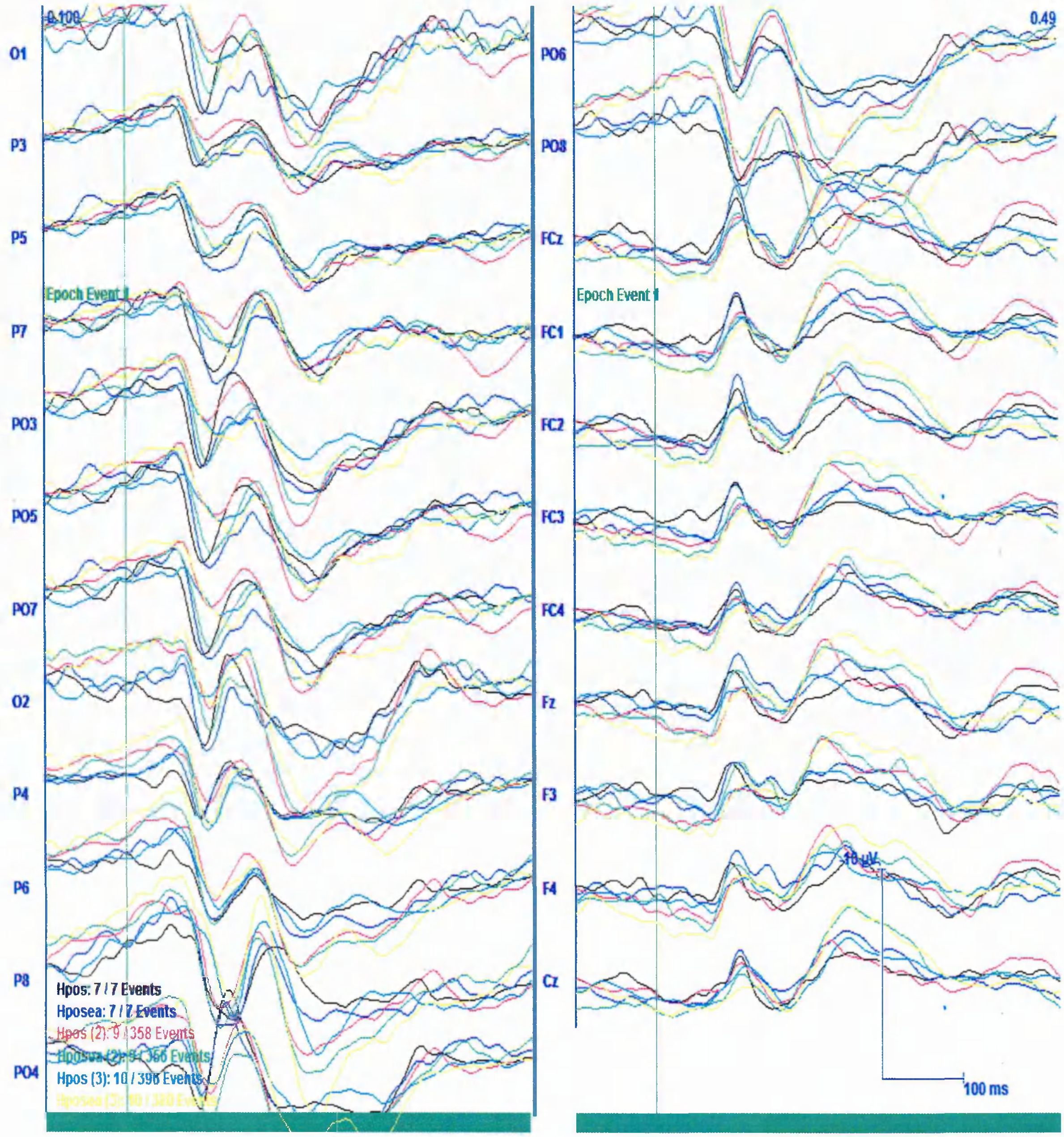

Figure 31: *Comparing CU trait group responses to positive human stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.*

Negative Non-Human Scene Stimuli

Pairwise analysis of the ERP waveform responses to negative emotional stimuli depicting non-human scenes reveals no significant differences in the low, high and control CU trait groups' responses to negative scenes in the attention and emotional attention conditions in the P2, N1 or N2 components.

Between groups analysis reveals that, as for human negative stimuli, the negative scene stimuli presented between group differences only in the non-emotional attention condition. The P2 over the right OP electrodes was significantly different in mean amplitude between the groups ($F(2,23) = 4.18$, $p = .028$, $\eta p^2 = .27$); The high CU trait group was significantly larger in mean amplitude ($X = 6.10$, $SD = 3.49$) than the control group ($X = 2.17$, $SD = 2.94$) ($t(14) = 2.39$, $p = .031$, $d = 1.22$) and the low group ($X = 2.85$, $SD = 2.54$) ($t(17) = 2.34$, $p = .032$, $d = 1.06$). No significant differences were observed between the controls and low CU trait group ($t(15) = .52$, $p = .613$, $d = .25$). Once the attention of the experimental groups was draw to the emotional content of the stimuli no significant differences were observed between the components of their ERP waveforms.

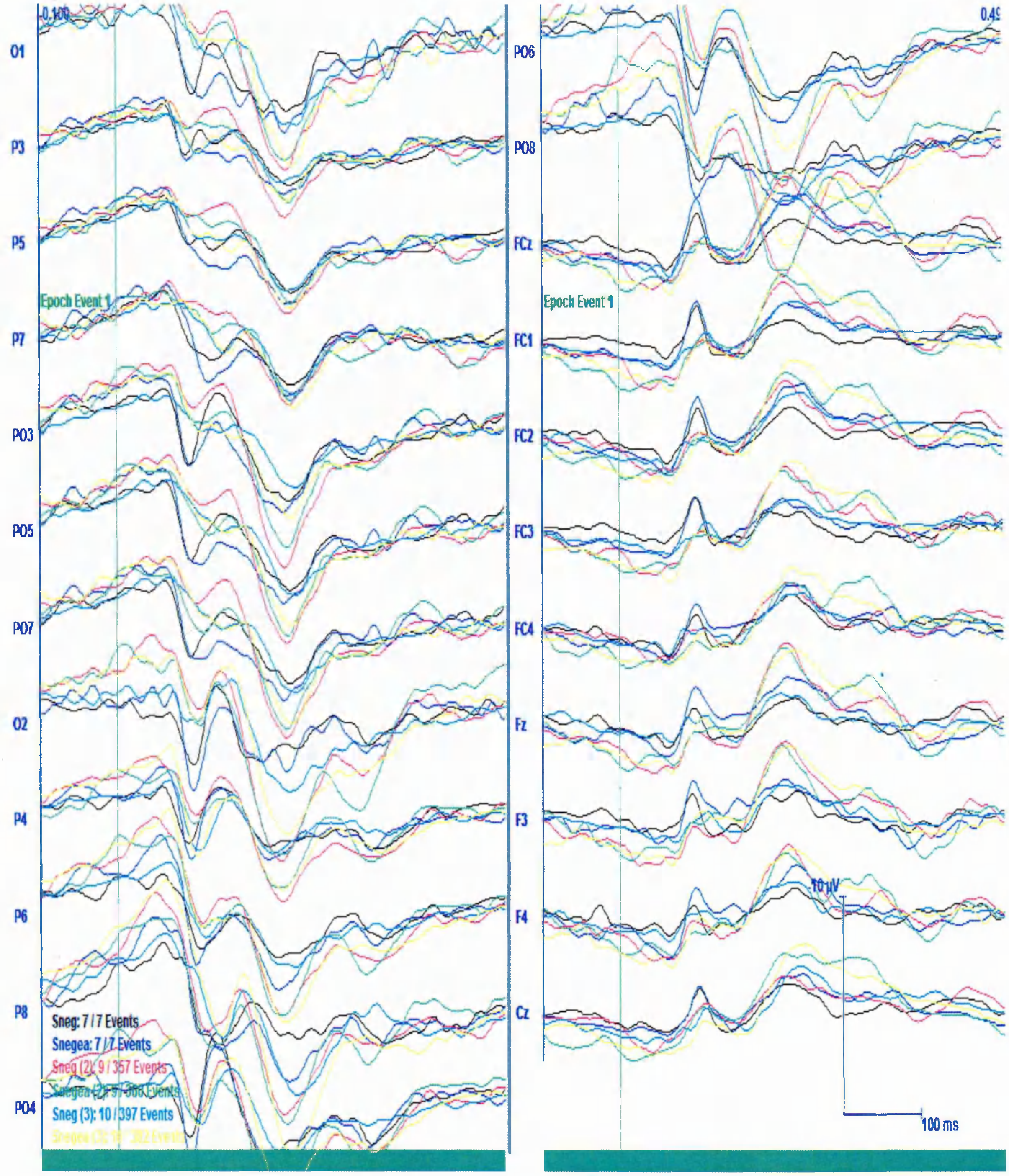

Figure 32: *Comparing CU trait group responses to negative, non-human scene stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.*

Neutral Non-Human Scene Stimuli

Pairwise, within groups analysis reveals that the control group demonstrated significant increases in the mean amplitude of the N1 over the FC in the emotional attention condition (X = -.95, SD = 1.43) when compare to the attention condition (*X* = -.04, *SD* = 1.19) (t(6) = 3.11, p = .021, *d* = .69). The high groups showed similar, but more pervasive, adaptation of their responses in their ERP waveforms to controls, when considering the emotional content of neutral stimuli containing non-human scenes. Increases in mean amplitude were observed in both the N1 and N2 over the FC for the emotional attention condition when compared to the attention only condition (see *table 33*).

Table 33:

Modulations of mean amplitude in the high CU trait groups responses to neutral scenes.

Component		N1 FC	N2 FC
Attention	Mean	-.11	-2.36
	SD	1.17	2.08
Emotional Attention	Mean	-1.10	-3.49
	SD	1.46	1.93
Comparison		t(8) = 4.72 p = .001 *d* = .75	t(8)= 3.78 p= .005 *d* = .56

The low groups also presented with increases in the mean amplitude in the N1 over the FC, the right OP P2 and the N2 over the FC electrodes, when the attention of the participants was drawn to the emotional content of the stimuli (see *table 34):*

Table 34:

Modulations of mean amplitude in the low CU trait groups responses to neutral scenes.

Component		N1 FC	P2 OPR	N2 FC
Attention	Mean	.02	2.30	-1.08
	SD	.74	1.91	1.49
Emotional Attention	Mean	-.74	6.33	-3.50
	SD	1.21	4.91	3.17
Comparison		t(9) = 2.51 p= .034 *d* = .76	t(9) = 2.54 p= .032 *d* = 1.08	t(9)= 2.45 p= .037 *d* = .98

These findings suggest similar responses across the groups to neutral stimuli; however, the high CU trait group shows the most pervasive modulation of their response between the attention and emotional attention stimuli presentation conditions. The greater prevalence of increased responses to the emotional attention condition maybe due to some difficulty discerning the emotional content of neutral, non-human stimuli.

Between groups analysis reveals significant differences in the mean amplitude right OP P2 ($F(2,23) = 5.20$, $p= .014$, $\eta p^2 = .31$) components in the non-emotional attention condition. The right OP P2 was significantly increased in mean amplitude for the high CU trait group (*X* = 6.13, *SD* =3.86) by comparison to the control (*X* = 2.14, *SD* =2.76) and low CU trait participants (*X* = 2.30, *SD* =1.91) (t(14) = 2.31, p = .037, *d* = 1.19; t(17) = 2.79, p = .013, *d* = 1.26 respectively). There was, however, no significant difference between the control and low (t(15) = .14, p = .894, *d* = .07). Only the difference between the high and low CU trait experimental groups is significant at a Bonferroni corrected alpha level of .017. There were no significant differences in the experimental CU trait groups ERP responses to neutral stimuli when their attention is draw to the potential emotional content of the non-human scene stimuli.

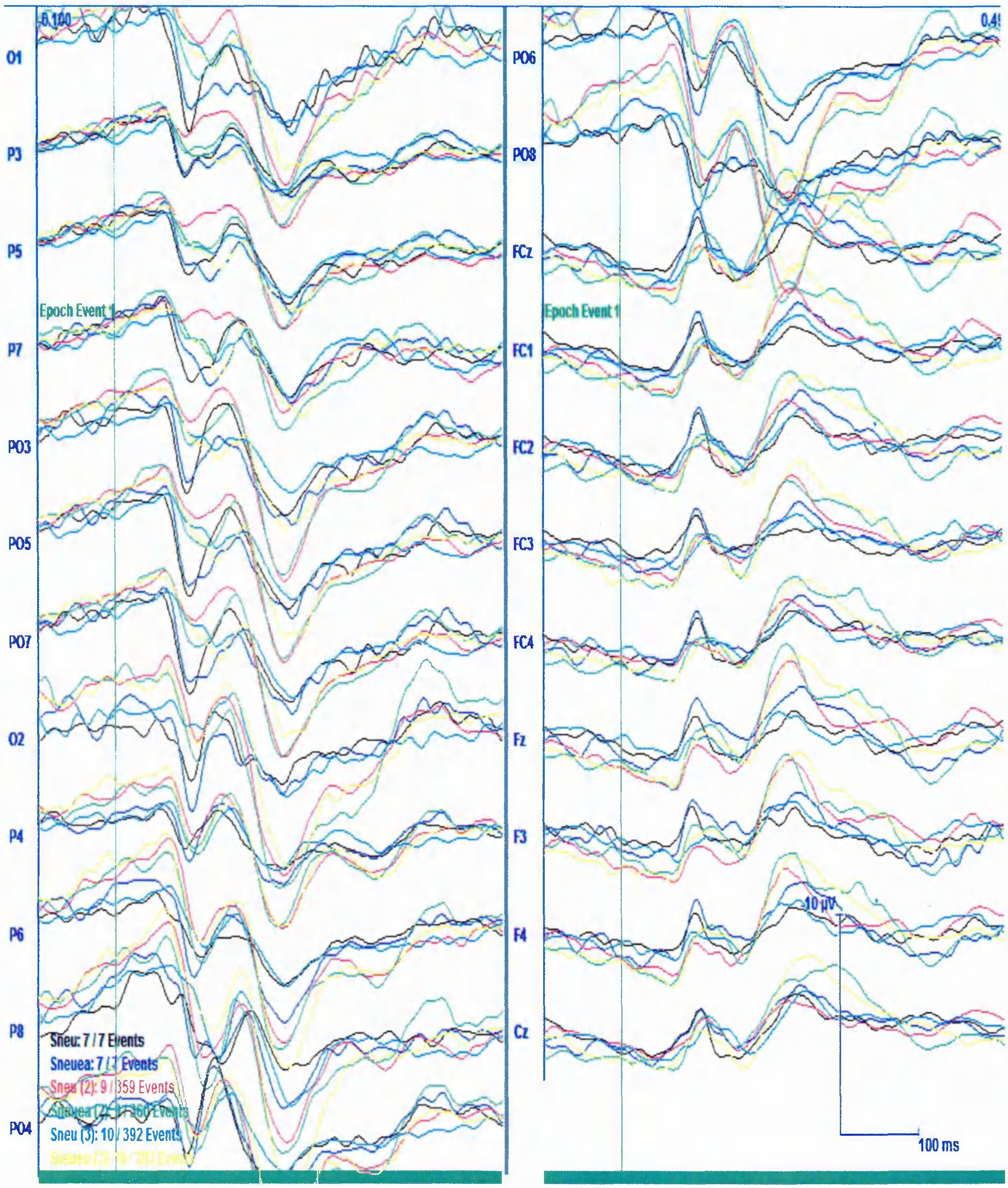

Figure 33*: Comparing CU trait group responses to neutral, non-human scene stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.)*

Positive Non-Human Scene Stimuli

Pairwise analysis between the non-emotional and emotional attention condition responses to positive non-human scenes revealed no modulations in response by the control participants. However, both the high and low groups adapted their ERP waveform responses to the positive non-human stimuli. The high CU trait group presented with decreases in right OP P2 mean amplitude when their attention is drawn to the positive stimuli (X = 3.90, SD =3.07) by comparison to the attention only condition (X = 5.53, SD =4.43) ($t(8) = 2.63$, $p = .030$, $d = .43$). By comparison, the low groups exhibited increases in the FC N1 and N2 components mean amplitude (see *table 35*). Different ERP responses are therefore exhibited by the high and low CU trait groups to positive stimuli in the attention and emotional attention conditions, whereas, no modulation is observed in the control group.

Table 35:

Modulations of mean amplitude in the low CU trait groups responses to positive scenes

Component		**N1 FC**	**N2 FC**
Attention	Mean SD	.19 1.12	-1.16 1.86
Emotional Attention	Mean SD	-.74 1.24	-3.50 2.64
Comparison		t(9) = 3.66 p= .005 *d* = .79	t(9)= 2.43 p= .038 *d* = 1.02

A similar pattern emerges in the between groups analysis as previously; the CU trait groups show difference in response over the right OP electrodes P2 component ($F(2,23) = 6.19$, $p= .007$, $\eta p^2 = .35$) in the non-emotional attention condition, but no differences are observed in the emotional attention condition. Post hoc analysis of the P2 component suggests a significantly larger mean amplitude in the high CU trait group ($X = 7.33$, $SD = 4.18$) than the low CU trait group ($X = 2.78$, $SD = 2.27$) and controls ($X = 2.48$, $SD = 2.99$) ($t(17) = 3.00$, $p= .008$, $d = 1.35$; $t(14) = 2.59$, $p = .021$, $d = 1.33$ respectively). However, again there were no differences in amplitude between the control and low CU trait group ($t(15) = .237$, $p= .816$, $d = .11$).

In conclusion, these findings therefore suggest that, when attending to the emotion of the stimuli, the high CU trait group respond by producing ERP waveforms similar to the control and low CU trait group's, but respond in a different neural manner when not specifically attending to emotional content. This difference is seen to manifest in the P2 component of the right OP electrodes; the P2 is larger over this cortical area when attention is not drawn to emotional content but normalises to control and low CU trait groups when the participants are instructed to attend to emotional content. These differences were observed in human negative and positive stimuli, but similar waveforms were observed in the human neutral stimuli across the CU trait groups in both attentional conditions. Few differences were observed between the low and control CU trait group.

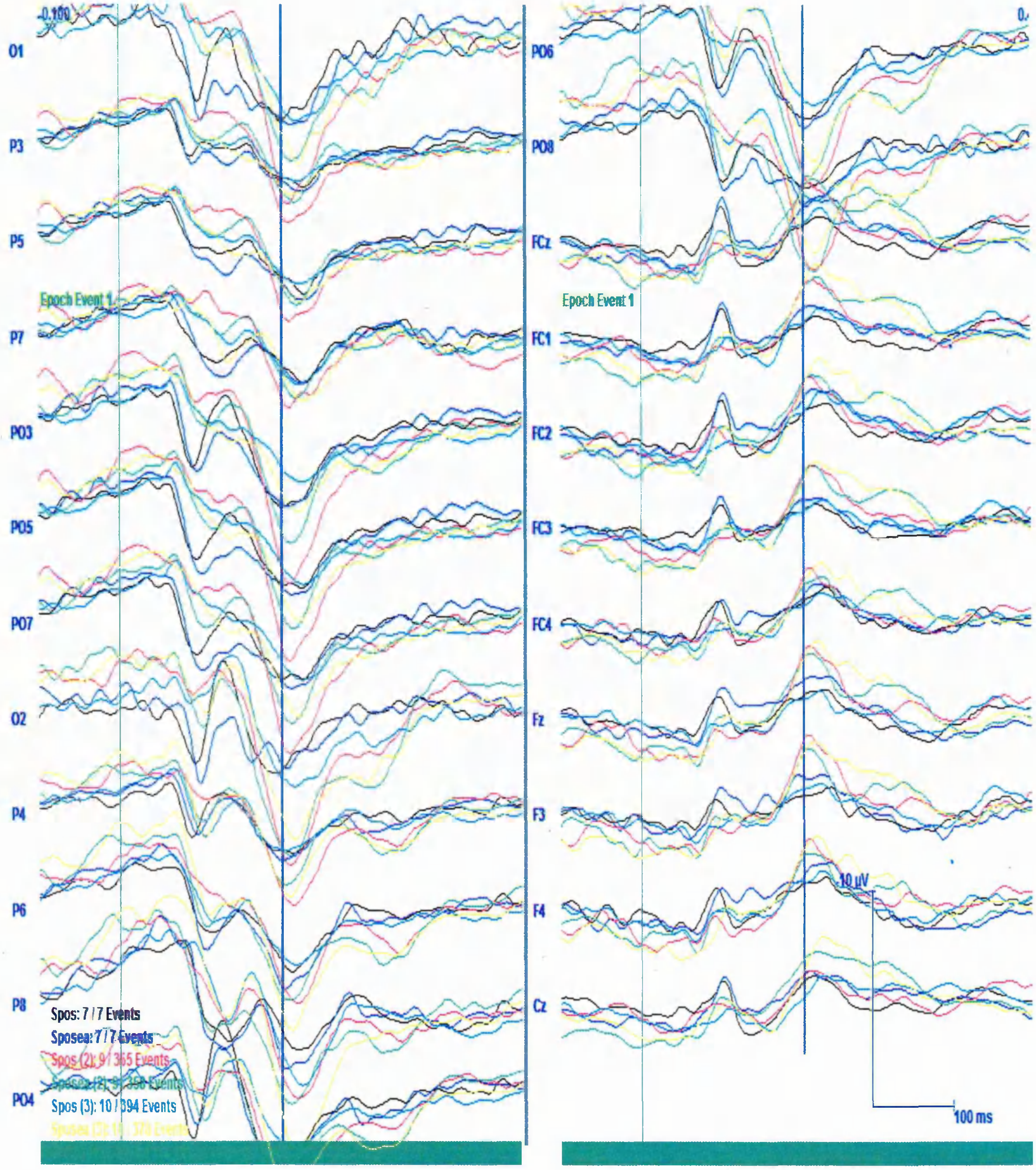

Figure 34: *Comparing CU trait group responses to positive, non-human scene stimuli in the attention and emotional-attention scenes. Control group – black: attention stimuli, blue: emotional-attention stimuli. High group – red: attention stimuli, green: emotional-attention. Low group – light blue: attention stimuli, yellow: emotional-attention stimuli.*

8.4 Discussion

Analyses of ERPs, conducted on the basis of mean amplitude (µV) and latency (ms) for each ERP waveform component's time parameters across the three experimental groups, presented three core ERP components in the left and right occipital-parietal areas; P1, N170 and P2. Furthermore, N1, P170 and N2 components were detected in the fronto-central electrodes sights. These components were modulated both by the presentation conditions (whether the participants were directed towards the emotional content of the stimuli or not) and the experimental group.

Pairwise comparison of the attention and emotional-attention conditions revealed that only the high CU trait group adapt their neural response between the conditions in response to negative human stimuli. The high group exhibited an increase in the P1 waveform component over the left OP area to negative human stimuli when the participants' attention was drawn to the emotional content of the stimuli. These findings suggest that there is increased P1 ERP response of the left OP area to negative affective images when the high CU trait participant's attention is directed to the emotional content; this increase in ERP amplitude response is observed to both human and non-human images. By comparison, the control and low CU trait experimental groups showed no such increased modulation of their response between the attention conditions for negative stimuli suggesting that their attention and valence does not change for the negative human stimuli with regards to their presentation. This may be because control and low CU trait individuals automatically attend to the emotional content of negative stimuli.

Between groups analysis revealed that in response to both the human and non-human scenes with negative affect the high CU trait group was significantly different in their neural response only within the attention condition. Mean amplitude of the right OP was higher than that of the control and low group in response to both the human and non-human scene stimuli in the attention only condition. However, the high CU trait group's ERP response is not significantly different from that of control or low CU trait participants' once their attention is specifically directed towards the affective content of the stimuli. Therefore, it appears that the high CU trait group's response normalises to a neurotypical response and is not discernible from that of those at the low end of the CU trait distribution or the controls, when they attend to the emotion of photographic stimuli. Previously, Anderson and Stanford (2012) also observed that psychopathic individual's emotion-sensitive late positive potential (LPP) was similar to controls at 200-900ms though only when their attention is drawn to emotional components of stimuli. However, LPP was not observed; instead the difference between groups seemed to manifest in the right OP P2, another established emotion-sensitive ERP component that has been associated with affective valence processing (Carretie et al., 2004; Delplanque et al., 2004). This normalisation of high CU trait neural responses, when attention to emotion is directed rather than voluntary, is congruent with recent fMRI research on clinical populations (Larson et al., 2013; Meffert et al., 2013).

Human neutral stimuli presented with adaptation only in the high CU trait group between the non-emotional and emotion directed conditions; increases in the N1 and N2 FC electrodes' mean amplitudes were observed in response to directing the attention of the participants to the emotion content of neutral stimuli. This finding suggests that a more cognitive top-down consideration of neutral stimuli once attention is drawn to the emotional content of the stimuli. Again, no adaptation of response was induced by the conditions in the control and low CU trait groups. Furthermore, no difference was observed in between group analysis for either condition, suggesting the neutral presence of humans is not associated with differences in the electroneurological responses of participants differing in their manifestation of CU traits. The dysfunction of the high CU trait group's attention, manifesting in the larger right OP P2 response, seems to therefore, be specifically a function of the interaction between affective valence and attention, and not a function of attention alone.

Neutral non-human scenes were unexpectedly associated with modulations in all three CU trait groups' ERP waveforms. Increases in the mean amplitude of the N1 components were common to all three experimental groups. This may be due to the increased cognitive effort needed to infer emotional content judgement in non-emotional scenes of non-human objects. Another explanation may be that, despite great effort to ensure equal valence of the stimuli in each condition using the IAPS valence scores, those in emotional attention directed condition may have differed in some way which invoked increased electrophysiological responses in the ERP components. Between groups analysis once again revealed increased right OP P2 mean amplitude in the high CU trait groups in the non-emotional attention condition, but no significant difference in the emotional attention conditions; again, suggesting normalisation of the high CU trait ERP waveforms to that of controls and low CU trait participants when attention to emotion is specifically required.

Positive stimuli containing humans evoked adaptation across the two attentional conditions in the two experimental groups, but not the controls suggesting a more pervasive difference in the response to human positivity when attending to the emotional content of presented scenes. The ERP components in which the adaption manifested varied between the groups, however, all exhibit an increase in mean amplitude in the component differences. Non-human positive scenes, by contrast, presented with differences in ERP waveforms in the attention conditions again for high and low CU trait participants, but the high CU trait group presented with reduced ERP amplitude in the OP P2 and lows increases in the N1 and N2. Such pervasive adaptation of response within the groups between the attention conditions suggests that electroneurological ERP responses to positive stimuli, particularly those with human content, are more sensitive to the attention required by the condition and/or cognitive task. This may be important when considering future neurological emotion research methodology.

Between groups analysis again revealed that, in response to both the human and non-human scenes with positive affect, the high CU trait group was significantly different in their ERP response only within the attention condition. In reflection of the negative, the mean amplitude of the right OP was higher than that of the control and low group in response to both the human and non-human scene positive stimuli in the attention only condition. ERP responses were, however, not significantly different from that of control or low CU trait participants' once their attention was directed towards the emotional content of the stimuli. The high CU trait group's ERP waveform response again normalises to a neurotypical response, not significantly different from that of those at the low end of the CU trait distribution or the controls, when they attend to the emotion of photographic stimuli. Therefore, the high CU trait group persistently present with an increased P2 amplitude over the right OP in the non-emotional attention conditions to all but the neutral human stimuli; this P2 component may therefore be a correlate of high CU trait emotional processing dysfunction. Hyperactivity of the parietal area has been previously associated with psychopathic responses to emotional stimuli (Muller et al., 2003). It is also demonstrable that the normalisation of the response in the emotionally directed attention condition, supported by previous research findings, is present to positive, as well as negative, stimuli (Larson et al., 2013; Meffert et al., 2013; Anderson & Stanford, 2012). These are both points that could be further researched into the effect of affective valence and attention on the neural responses of those with varying levels of CU trait manifestation.

It is also worth noting that the control and low CU trait groups ERP responses are very rarely distinguishable from each other in regards to their responses to emotional stimuli. Only small differences were observed in the modulations between non-emotional and emotional attention conditions for positive emotional stimuli of human and non-human scenes and neutral non-human scenes. Between groups analysis exhibit no waveform differences between the two groups. Further research could be done to see whether more extremely low CU trait individuals with high empathy, perhaps those with Mirror Touch Synaesthesia, are distinguishable from controls in their ERP responses to affective stimuli.

There are two core limitations of the recruited methodology. Firstly, the task, by the nature of this study, had to vary between the attentional conditions; the differences in required motor response in the task could have affected the resulting ERP waveforms and, potentially, confounded the effect of attention. However, there is no pattern of consistent differences between the condition observed, particularly in the control and low CU trait groups, which allows postulation that any differences are due to the groups adaptation of emotional valence processing, where observed. Secondly, to ensure that there was no contamination of the non-emotional attention task with the demand characteristics of the emotional attention task, and to ensure that voluntary attendance to emotional content was ensured in the attention only task, the attention only task was always run first. There is the potential for order effects, such as fatigue, in such a design, though should such an effect have occurred a pattern of response across the conditions for all groups would have been observed and none is present, again suggesting that the findings are due only to the attention to emotional content.

To conclude, there are two key findings revealed by this ERP research into the effect of attention on emotional valence processing in participants with varying levels of CU traits. Firstly, the high CU trait group displays most modulation of their ERP response both within the attentional conditions and between the groups in the non-emotional attention condition. Between the groups the high CU trait group presented with a consistently larger Right OP P2 component in response to both negative and positive stimuli. This result was consistent for both human and non-human scenes, suggesting that emotional content is the core factor. By comparison the low and control CU trait groups exhibited no significant differences in their responses to the various affect presentations. The second core observation provided is that the detected difference in the high CU trait group's ERP response to positive and negative emotional stimuli, by comparison to the control and low CU trait individuals, disappears when the attention of the participants is directed towards the emotional content of the images. The findings may suggest a normalisation to a neurotypical ERP response modulated by attention to specific cues of affect; furthermore, the affective valence deficits in high CU trait individuals may be indicative of dysfunctional attention to emotional information rather than an inability to respond in a neurotypical manner. Without voluntary and prioritised awareness of the emotional content of situations, appropriate and expected empathy responses could not be generated, even if the required neural facilities are available for such a response to occur. This postulation aligns with similar findings in research into both clinical psychopathic samples and those using fMRI imaging techniques (Larson et al., 2013; Meffert et al., 2013; Anderson & Stanford, 2012).

CHAPTER 9:

GENERAL DISCUSSION

The purpose of this thesis was to explore the relationship between CU traits and empathy with regards to both the psychological and neural correlates of any present associations. Study 1 explored the manifestation of CU traits using psychometric measures and behavioural measures to investigate the relationship between CU traits and empathy-processing abilities. This preliminary study also informed the methodological paradigms of the electrophysiological research and provided participants for the investigation into the electrophysiological correlates of empathy processing with regards to CU traits. The electrophysiological research focused on three key empathy processing constructs and their neural correlates with regards to CU traits; these constructs were: responses to facial expressions of emotion - a component of emotional empathy, EEG reactions to abstract painful and non-painful scenarios requiring the use of the cognitive elements of empathy processing and, finally, the affective valence response.

There were six fundamental questions that were addressed through this thesis:

1. What is the distribution of empathic processing ability and callous-unemotional (CU) traits? The proposed research aims to examine these constructs within a general population using a constellation of established self-report measures.

2. The second objective is to examine the relationship between empathy and CU traits. Do measures of CU trait severity correlate negatively with measures of empathy-processing, emotion recognition and affective valences as would be predicted from clinically-diagnosed populations?

3. Are cognitive empathy and emotional empathy dissociable within CU traits? The self-report data will simultaneously investigate the possible fractionation of empathic abilities in CU traits.

4. How are the neurological correlates of emotional empathic ability, measured by expression recognition, as identified using topographic electroencephalographic (EEG) recording and event related potential (ERP) analyses modulated by CU traits?

5. How are the ERP waveforms of cognitive empathy, measured by reactions to abstract painful and non-painful scenarios, modulated by CU traits?

6. How are the electroneurological correlates of affective valence modulated by CU traits and attention?

The research provided outcomes in all of these areas, providing both insights into the relationship between CU traits, empathy processing and affective valence in the general population, and actionable outcomes which generate future research possibilities. These research results and continuation possibilities will be discussed subsequently.

9.1 Research exploring the psychological manifestation of Callous-Unemotional Traits and their Relationship with Empathy

Study one aimed to address the first three research questions. To recapitulate, exploration of the influence of Callous and Unemotional traits on empathy and emotional processing was facilitated by the recruitment of the Inventory of Callous–Unemotional Traits (Frick, 2004) and The Antisocial Process Screening Device (Frick & Hare, 2001). Furthermore, two self-report measures of empathy, the Interpersonal Reactivity Index (Davis, 1983) and the Empathy Quotient (Baron-Cohen & Wheelwright, 2004) were recruited to examine the cognitive and emotional empathy of the participant. The dual measures of empathy were employed to provide an assimilated score of emotional and cognitive empathy that would help negate the effect of subjective definitions of the empathy construct within empathy measuring psychometrics (Reniers et al., 2011). The inclusion of measures of both cognitive and emotional empathy allowed the analysis of the potential disassociations between these distinct forms of empathy; furthermore, the prevalence and distribution of CU traits in the sample general population could also be investigated. A direct measure of facial emotion recognition and indirect measures of affective valence were included to explore empathetic response of the participants.

The findings of this research are discussed in relation to the questions to research was designed to answer.

9.1.2 Research Question 1 - What is the distribution of empathic processing ability and callous-unemotional (CU) traits?

Reflection on the results of Inventory of Callous –Unemotional Traits suggests that CU traits and empathy processing manifest in a normal, continuous distribution throughout the general population. This finding suggests a dimensional, rather than categorical or discrete, manifestation of CU traits; an outcome in agreement with recent findings suggesting a dimensional manifestation of similar constructs, such as psychopathy and conduct disorder (Hare & Neumann, 2008; Marcus et al., 2004; Skeem et al., 2003). The undertaken research suggested a pervasive manifestation of CU traits, core personality traits of these disorders, exist on a normal distribution continuum within the population, and those patients of psychopathy and conduct disorder may lie at the extreme high end of this distribution (Edens et al., 2006; Lynam, 2002; Lilienfeld, 1994). The conclusion of these finding when combined with those of previous literature is that CU traits are continuously distributed personality traits in a subclinical population.

9.1.3 Research Question 2 - Do measures of CU trait severity correlate negatively with measures of empathy-processing, emotion recognition and affective valences as would be predicted from clinically-diagnosed populations?

Emotional empathy was tested through the participants' responses to psychometrics, the ability to correctly identify facial expression stimuli, the self-reported emotional valence response to these expressions and, finally, the participant's report affective valence (see chapter 4). A strong negative correlation is observed in between the psychometric measures of CU traits and emotional empathy which mirrors previous explorations of clinical, and the limited subclinical, CU trait manifestation (Dadds et al., 2009; Hastings et al., 2008; Marsh & Blair, 2008; Blair, 2005).

The assimilated cognitive empathy measure was also observed to negatively correlate with the psychometric CU trait measure. The clinical disorders of Conduct Disorder, Antisocial Personality Disorder and Psychopathy reliably report emotional empathy to be dysfunctional within high CU traits clinical patients, however, cognitive empathy is usually reported intact (e.g. Blair, 2008; Marsh & Blair, 2008; Blair, 2005). However, a significant negative correlation was observed between CU traits and reported cognitive empathy (see chapter 4).

Of the six basic expressions of emotion explored, the preliminary research showed that only fear recognition associated negatively with callous and unemotional trait manifestation. This lower accuracy of fear recognition demonstrated patterns of response congruent with clinical research, which has established a reliable dysfunction in the ability of those with high CU trait conditions to recognise fearful facial expressions (Fairchild et al., 2010; Fairchild et al., 2009; Hastings et al., 2008; Marsh & Blair, 2008; Blair, 2005). Despite evidence of reduced recognition of fearful expression, no further dysfunction in recognition was observed for the other expressions, which might have been expected given research into high CU trait disorders which often evidences reduction in the recognition of other expressions (Dawel et al., 2012; Fairchild et al., 2010; Hastings et al., 2008; Blair, 2005). However, fear recognition reduction is the most reliably reported within the research on clinical and subclinical populations, possibly due to the, usually, larger effect size (Dawel et al., 2012; Fairchild et al., 2010; Hastings et al., 2008; Blair, 2005). It is possible that different samples and stimuli influence whether these results are significant, the exact effect of these potential confounding factors would need to be determined through further investigation.

It is worth noting that the specific reduction in fear recognition ability observed agrees strongly with research which looks specifically at CU trait manifestation, rather than psychopathic traits, ASPD and CD (Leist & Dadds, 2009; Muñoz, 2009). Therefore, CU traits may be specifically sensitive to fearful expressions with regards to reported recognition deficits. However, recent papers contest this conclusion suggesting that either a more pervasive dysfunction or even a positive association with fear recognition (e.g. Prado et al., 2015; Del Gaizo & Falkenbach., 2008). Again, the modulating effect of CU traits on facial expression recognition is an area requiring further investigation. To conclude, the research literature portrays a tangle of results regarding the relationship between CU traits and emotion recognition.

The research presented within this thesis built on emotion recognition research by exploring the relationship between CU traits and affective valence response to facial expressions. High CU traits in individuals within both CD and psychopathic populations often present with reduced emotional valence (Ali et al., 2009; Loney et al., 2003; Lorenz & Newman, 2002; Levenston et al., 2000; Williamson et al., 1991); therefore this research extended the literature to a subclinical population. Differences were observed on both the positive-negative and intensity scales of the self-assessment manikin (SAM), used to indirectly measure emotional responding, in response to facial affect. Response to emotional expression in peers is a key psychological construct within emotional empathy. Negative facial expressions were found to initiate less negative scoring in those participant's scoring more highly in the measure of CU traits, this pattern of response is borne out over all 5 negative emotions. Interestingly, the reverse pattern is seen in the participant responses to facial expressions of happiness, with those individuals high in callous and unemotional traits giving less positive responses. When considering the intensity of the evoked emotional empathy response, those higher in CU traits reacted with less intensity to stimuli depicting anger, disgust and pain. Fear stimuli were not associated changes in intensity of response across CU trait prevalence, however, if the expressions are being misidentified it may be that the valence of one of the other expressions is more relevant.

Furthermore, the findings regarding participant's responses to emotion invoking images suggest that CU traits consistently revealed a lower level of emotional valence in response to both positive and negative affective stimuli. This result was observed over both the positive-negative and intensity scales of the SAM in the general population. These findings mirrored closely the outcomes of both clinical population's research and research in sub-clinical populations with regards to the affective responding of the participants being reduced at higher manifestations of CU traits (Loney et al., 2003; Lorenz & Newman, 2002; Levenston et al., 2000; Williamson et al., 1991); therefore, a reduction in emotional response seems to be reliably observed in those with higher CU traits across clinical and subclinical research demographics.

9.1.4 Research Question 3 - Are cognitive empathy and emotional empathy dissociable within CU traits?

Despite the substantial evidence of a dysfunction in the neural circuitry processing emotional empathy in high CU trait individuals, there is an ambiguity in the evidence considering potential deficits in cognitive empathic ability; however, typically cognitive empathy is reported as being intact (Jones et al., 2010; Richell et al., 2003; Blair et al., 1996).Despite this commonly reported empathy paradigm, the results of this research into the general population seem to suggest a more complex association, suggesting that both emotional and cognitive empathy negatively correlate with CU traits. Such a finding tentatively suggests that perhaps CU traits are indicative of a dysfunction in both emotional and cognitive empathy processing in the general population, but that the negative association with cognitive empathy is much more tenuous and may be dependent on the type of tasks employed and the statistical analyses used to examine them, whereas emotional empathy is independently, negatively associated with CU traits. The number of predictors in the analysis seems to be particularly important.

Research that concentrates specifically on CU traits and psychopathic traits in the general population, rather than high CU trait disorders, has also previously evidenced this negative association with cognitive empathy measures (Ali & Chamorro-Premuzic, 2010; Dadds et al., 2009). It is possible that reduced cognitive empathy may be specifically a feature of high CU traits in the general, non-clinical population, contrasting to the prevalence and characteristics of cognitive empathy within high CU trait clinical populations. However, there are other factors which may also explain the variability of results within the literature, and seen within the described research.

The reduction in cognitive empathy may be task dependent; the research presented in this thesis used psychometric measure whereas previous research has focused on behavioural measures of cognitive empathy e.g. the Reading the Mind in the Eyes test (Blair, 2008). Both Ali and Chamorro-Premuzic (2010) and Dadds et al (2009), papers that reported reductions in cognitive empathy, used facial recognition tasks, it maybe that these tasks are a measure more closely associated with emotional empathy, as is evidentiary in the research presented in chapter 4. Furthermore, the power of the experimental design paradigm and the form of analysis used may influence results. For example, when the data was analysed via correlation a decrease in cognitive and emotional empathy in those with higher CU trait manifestation was observed. Analysis using Steiger's Z inferential testing to compare the coefficients shows a significant difference in the size of the coefficients for cognitive and emotional empathy, the negative association with cognitive empathy being significantly weaker than for emotional empathy. However, analysis through linear regression of this same data indicates that only emotional empathy (when controlling for cognitive empathy) was predictive of CU trait scores – the opposite pattern was not significant when controlling for emotional empathy. This suggests that the latter may have a modulating effect on cognitive empathy in relation to CU traits, and may somewhat explain the mixed results in previous literature.

The outcomes of the described research suggest that a reduction in both self-reported cognitive and emotional empathy is associated with higher CU trait manifestation in a general demographic, but that the decrease in emotional empathy exhibits a significantly larger negative correlation with CU traits; thus a disassociation in the magnitude of empathy processing dysfunction is postulated, rather than the more commonly reported preservation of cognitive empathy with dysfunction of empathy processing being restricted to emotional empathy components.

For a quick read infographic summary of these findings see Figure 35.

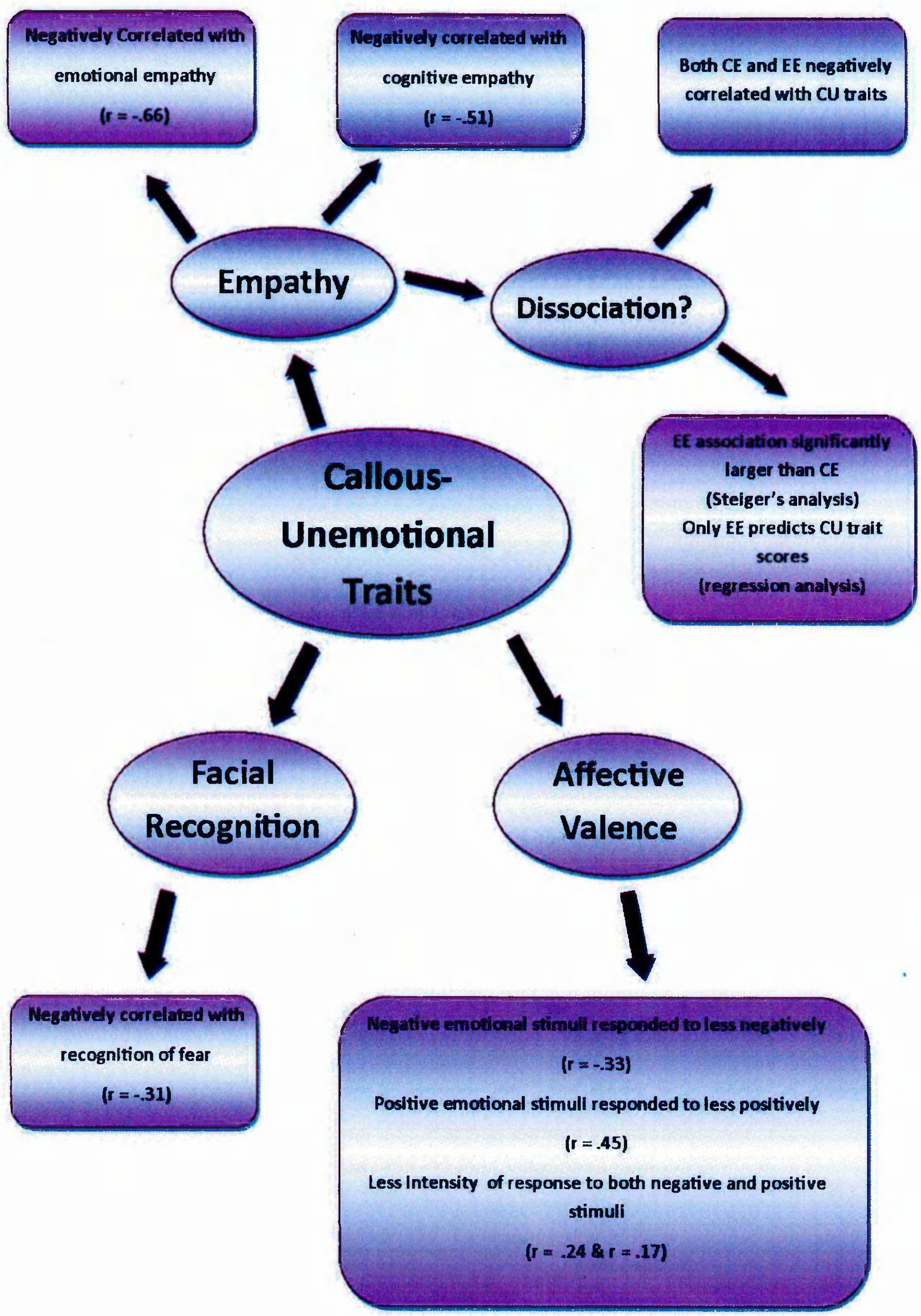

Figure 35: An infographic describing the results of research study 1.

9.1.5 Potential Research Extensions

The outcomes of this primary research study raised many questions that could be investigated through future research. One of the most intriguing was the conflicting result regarding whether emotional and cognitive empathy were disassociated in the general sample of participants studied. Future research would need to examine if a disassociation truly exists within this general demographic, or whether a universal reduction in the emotional and cognitive empathy constructs is more common within non-clinical samples, and to what extent different tasks and data analysis approaches effect the outcome of such research. Particularly, important is whether facial expression research is appropriate to be used as a method of cognitive analyses or whether such tasks activate more closely the emotional empathy pathways of the cortex. This extension in the research could be achieved through either a meta-analysis of current general demographic research exploring CU traits, or further quasi-experimental research into the mediating effect of CU traits on emotional and cognitive empathy that uses a large range of tasks designed to explore both concepts, this approach would allow the results of different tasks to be directly compared. Such research would greatly improve our understanding of how CU traits interact with the emotional and cognitive elements of empathy in the general population.

In addition to the exploration of the empathy construct disassociation, the facial expression recognition research suggests further examination of the relationship between CU traits and facial emotion recognition may prove fruitful. Useful further research could potentially determine which expression high CU trait participants from subclinical demographics mislabel expressions of fear as. This information could inform psychological research into the interpersonal responding of high CU trait individuals. Given that fear recognition reductions are not always reliably reported in the subclinical literature into CU traits, further research may be required to consider fully the relationship between CU traits and facial expression recognition in non-clinical, general demographics and to ensure the reliability of this finding. Both of these extensions could be addressed by further quasi-experimental research into facial recognition in the research demographic.

9.1.6 Discussion of the Limitations of Study 1

The sample size of study one (n=124) was smaller than some similar contemporary research (e.g. Prado et al., 2015; Bryd et al., 2013; Dadds et al., 2009), although it is consistent with other research in the area (Ali & Chamorro-Premuzic, 2010; Ali et al., 2009). Analysis with G*power 3 (Faul et al., 2007) suggests that a sample of n=124 is suitable for investigating the constructs described through correlational analysis and will provide enough power at an alpha value of <.05 to provide significance at effect sizes of > r = .28. Therefore, although smaller than some comparable research studies, the sample size obtained was appropriate for the research design and large enough to negate the potential effect of type 2 errors (Faul et al., 2007).

Gender ratios are a typical problem within psychological research, and the research described in this first study has a ratio of approximately 2:1 females to males and thus the ratio is skewed towards females. However, this ratio is congruent with, and sometimes an improvement on, similar research (Ali & Chamorro-Premuzic, 2010; Ali et al., 2009), therefore, although a ratio of 1:1 would be ideal, this limitation should not negate the reported outcomes.

There may also be limitations with regards to the validity of CU trait measures. High CU trait disorders, such as psychopathy, are reliably correlated with an increase in lying, a lack of insight and a tendency to give an overly positive report of personal qualities (Ray et al., 2013; Ziegler et al., 2012; Miller & Lynam, 2011); it is possible that such tendencies also manifest in higher CU trait individuals in the general population which would mediate the accuracy of self-report measures in higher CU trait participants. Two factors of the paradigm were included to limit the potential effect of such inaccuracies. Firstly, the use of the Inventory of Callous-Unemotional Traits (ICUT) ensures that the measure of CU traits is both widely validated and reliable (Kimonis et al., 2008; Essau et al., 2006; Frick, 2004). Furthermore, the ICUT was found to be internally reliable within the research of the presented thesis and the scores obtained were similar to those in previous research (Byrd et al., 2013; Essau et al., 2006) suggesting a stability in the research a validity of the measure. Secondly, a direct measure of emotional empathy - facial expression recognition, was included to ensure the results did not rely purely on self-report measures.

The facial stimuli, used for the facial recognition and valence task within this research, were specifically located from the internet to fulfil specific criteria, eg. close cropped, facing the camera, on a mono-coloured, pale background. Pilot research into the stimuli ensured that only those facial expression images with reliable responses were included; 70% was chosen as an appropriate level of agreement as this level has been previously employed by other facial stimuli research (e.g. Ebner et al., 2009; Tottenham et al., 2009). The decision to use a self-designed stimuli set allowed insurance that equally numbers of males and females and that a range of ethnicities were included to reduce the potential interference of 'own-group' bias (Van Bavel et al.,2013). There are limitations to such an approach. The stimuli set has only been previously validated and tested for reliability of response through pilot work. Consideration of this factor lead to the decision to use previously established stimuli for the electrophysiological research, as it was important that the stimuli used reliably produced analysable event-related potentials. Therefore, the NIMSTIM stimuli set (Tottenham et al., 2009) was recruited for further electroencephalographic research into responses to facial expression stimuli.

A similar limitation applies to the images used for emotional valence task of the primary study. The photos were chosen because other stimuli sets such as the International Affective Picture System (IAPS) (Lang et al., 2005) did not allow an appropriate level of control over the content of the images. Therefore, it was considered that to select pictures that allowed standardisation of content would allow for a better exploration of affective response and the mediating effect of CU trait manifestation. For example, selecting pictures that standardised images showing painful experiences to injections allowed a more rigorous testing of responses to such images. However, using the IAPS would have allowed the responses to be compare to a previously rated and validated stimuli set and a comparison of obtained valence scores. As the research paradigm of study one required within groups comparisons of response the independently collated stimuli was appropriate because of the greater control afford by such stimuli selection, however, in consideration of the limitations of such a stimuli set, the electroneurological study into affective valence recruited the IAPS (lang et al., 2005) which has been broadly employed in electroenchaplographic research and produces reliable ERP waveforms.

9.2 Study 2 – Research Exploring the Electroneurological Correlates of Expression of Emotion and their Modulation by Callous-Unemotional Traits

The aim of the second study was to examine potential electrophysiological correlates of facial affect response and their potential adaptation in regards to CU trait manifestation, thereby addressing research question 4. Given the research outcomes of study one, where fear recognition was negatively correlated with CU traits, it is expected that expressions of fear will invoke a different neural response in participant with high levels of CU traits by comparison to low CU trait participants and controls. Furthermore, in line with the first study's outcomes regarding valence responses to positive and negative expression stimuli differences were also potentially expected for other expressions. To recapitulate, 360 photographs were selected from the NIMSTIM facial affect stimuli set (Tottenham et al., 2009). The stimuli portrayed 5 core expressions of emotion (sadness, disgust, happiness, fear and anger) and a neutral expression (Tottenham et al., 2009), allowing a range of expressions to be investigated. 60 novel stimuli of each emotional expression were presented to the participant on a blank background using E-prime software.

9.2.1 Research Question 4 - How are the neurological correlates of emotional empathic ability, measured by expression recognition, modulated by CU traits?

Electroneurological investigation into the quasi-experimental high, low and control CU trait groups revealed subtle differences in the group's responses to facial expression stimuli. Between group comparisons of the ERP waveforms analysis of the variance revealed differences for expressions of fear, disgust and sadness, though none for expressions of neutrality, happiness or anger. Analysis of the left OP P1 and N170 components of the waveform response to fearful stimuli showed increased latencies of the peak for the low CU trait group in both instances. Differences in the P1 and N170 components may have been expected, as these have been identified as

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central to emotional expression processing (Blau et al., 2007; Eimer & Holmes, 2007; Balconi & Pozzoli, 2003); it is unclear why the low CU trait group shows an increased latency of these components. Muller et al (2003) found increased activity of the OP cortical area to negative valence images in psychopaths using fMRI. Therefore, a

responses to expressions of sadness, the P1 component of the left OP ERP waveform showed adaptation in its response across the high and low CU trait groups. Similarly, to expressions of fear the low CU trait participants were associated with a significantly longer latency of the P1 component than the high group. Three of the four negative expressions explored (fear, sadness and disgust) showed variation between the groups in the P1 and/or N170 component over the left occipito-parietal electrodes; the left OP cortical area may, therefore, be key to understanding general differences in facial expression response related to callous-unemotional trait manifestation. However, such a hypothesis would require significant further research to substantiate.

Differences in the neural electrophysiological waveforms to emotional expressions when compared to the neutral stimuli (used as a baseline) reveal further differences in response. When comparing the ERP responses to the neutral and fearful expressions in the high group, modulation was observed in the N1 and N2 components over the frontal and central cortical electrodes, with shorter latencies and larger mean amplitudes respectively observed. Therefore, differences in the response to fearful expressions seem to be manifesting primarily in the FC cortical areas in the high CU trait group. By comparison, neither the control nor low experimental groups showed differences in the FC electrodes waveforms when comparing neutral and fear expressions. However, both presented significant effects in the OP waveform P1 components. Difference in FC N1 and N2 suggests a more top-down, semantic processing of the fearful stimuli (Luck, 2005); whereas, the larger P1 over the left OP area manifested by the low CU trait group suggests larger autonomic, visual and emotional responses (Luck, 2005). These differences may underlie the different behaviour recognition responses to fearful stimuli observed in the preliminary research psychometrics.

A larger, slower N170 peak to expressions of disgust in the low CU trait group is therefore observed, suggesting a neural sensitivity to disgust within this low CU trait group. However, unfortunately there is a paucity of evidence exploring the electrophysiological responses of low CU trait individuals, who may have higher than average empathy and valence, in the literature to compare this result to.

The pair-wise comparisons for expressions of neutrality verses sadness reveal a complex pattern of results. The high and low CU trait groups showed differences over the left OP electrodes and the control participants' difference manifested over the FC. Therefore, it seems that a slower response in this OP area to expressions of sadness is common to both the more extreme personalities of high and low CU trait groups. For expressions of anger, the high CU trait group showed an increased latency of the P1 left OP component for angry expressions when compared to the neutral baseline expressions. Whereas, for expressions of happiness the high CU trait participants revealed an increased right OP P2 latency. Whereas, the N2 component in the FC of controls was significantly smaller in amplitude for happiness than the neutral comparisons. The low group exhibited no difference in their ERP responses to neutral and happy expressions. Again, as this research is novel, there is a scarcity of published research to which these results can be compared. Although research into facial expressions has previously observed fluctuations over the ERP components described (Smith et al., 2013; Batty & Taylor, 2003); however, these components have not been explored for the mediating effect of high and low CU trait personalities. The key findings of this research are summarised in the infographic below (see figure 36)

	Control Callous-Unemotional Group	High Callous-Unemotional Group	Low Callous-Unemotional Group
	No differences between the groups in their response to neutral baseline stimuli		
	Faster P1 Peak—Right OP	Faster N1 Peak—FC Larger N2 Peak - FC	Larger P1 Peak—Left OP
	Smaller N2 Peak—FC	Slower P1 Peak — Left OP	Slower P2 Peak– Left OP
	No difference between response to neutral and angry expressions	Slower P1 Peak—Left OP	No difference between response to neutral and angry expressions
	No difference between response to neutral and disgusted expres-sions	No difference between response to neutral and disgusted expressions	Larger and slower N170 Peak—Right OP
	Smaller N2 Peak—FC	Slower P2 Peak—Right OP	No difference between response to neutral and happy expressions

Figure 36: Infographic showing results of the EEG research into facial expression response in high, low and control CU trait groups - comparisons to the neutral stimuli (FC = frontal-central electrodes, OP = Occipital-parietal electrodes)

9.2.2 Potential Research Extensions

Further research which aimed to extend on these findings could focus on three areas. Firstly, a replication would be desirable due to the originality of the research. Secondly, a useful extension of the research could compare the ERP responses of high CU trait general population individuals and those with diagnosed high CU trait disorders, to explore whether responses are comparable or whether there are further differences in response to facial expression seen in clinical groups that can be measure via EEG and ERP analysis.

Finally, another potentially productive area of the research could include comparing EEG response and psychophysiological measures (e.g. heart rate and galvanic skin response) of response to expressions in high CU trait individuals from the general population and controls. This would allow consideration of whether other dysfunctional psychophysiological responses in high CU trait clinical disorders are mirrored, though more weakly, in the general population in response to facial expression stimuli, particularly those depicting fear.

9.3 Study 3 – Research Exploring Whether the Electrophysiological Correlates of Cognitive Empathy are Modulated by Callous-Unemotional Traits

CU traits were consistently associated with a less negative and less intense self-reported response to affective stimuli depicting humans and animals in pain (see chapter 4). Furthermore, Cheng et al's (2012) research investigating high CU trait offenders proposes that the N120, P300 and LPP ERP components would be most likely to be differentiated with regards to CU traits in the general sample in response to pain in others (see chapter 3). Study three aimed to develop this Cheng et al's work by looking at empathy for painful situations with regards to CU traits in a general population, an area deficient in the literature. This study should provide insight into empathy for pain as a cognitive element of the empathy construct with regards to differential ERP responses regarding CU trait manifestation in a general population, and in doing so, address research question 5.

To recapitulate, 40 pictures showing hands in painful situations and 40 matched pictures of hands in non-painful situations were used to assess empathy for pain in participants. Both male and female hands were included in the stimuli.

9.3.2 Research Question 5 - How are the ERP waveforms of cognitive empathy, measured by reactions to abstract painful and non-painful scenarios, modulated by CU traits?

As might be expected there were few differences in this more cognitive task between the high CU trait, low CU trait and control groups; however, some differences were still observed in the electroneurological responses of the experimental groups. The high CU trait group present with a reduced accuracy in discerning painful and non-painful stimuli in others, but not when imagining the stimuli are relevant to themselves. Such differences in the ability to discern painful stimuli, as relating to themselves and to others, were not observed in low CU trait participants. Additionally, high CU trait participants presented with adaptation of response to painful stimuli centring on the depletion of the 170-190ms peaks over the left OP and FC electrodes. Consideration of the non-painful stimuli was also associated with larger responses of the P170 to the stimuli considered from the perspective of occurring to oneself than another. By comparison, the low group presented with an increase in the N1 amplitude, as well as an increase in latency presented in the P170. The control group demonstrated an unexpected lack of accuracy in determining other-imagined painful and non-painful stimuli, though the p-value was within .002 of significant and, therefore, maybe subject to a loss of power due to the small experimental groups. Painful stimuli were associated with quicker N250 component in controls but no other modulations of ERP responses were observed.

The waveform components observed are comparable with those reported by Cheng et al (2012) and Li and Han (2010), who used similar pain perception research paradigms; ERP components were exhibited at latencies of 120 -130, 170-190, 250 over the occipital-parietal and frontal-central areas; this finding suggests convergent validity between the presented research and previously published research. However, it should be noted that the later peaks seen in previous research at 300ms and 360ms, as well as the LPP peaking at 600ms, were not detected in this research (Cheng et al., 2012; Li & Han, 2010). The present research found decreases in amplitude in high CU trait group's responses to painful stimuli which replicates research findings by Cheng et al (although later 170 verses 130ms). This reduced response to pain seems to manifest over the frontal and central electrodes in both studies. This finding strongly suggests a lessening in the amplitude of response to painful stimuli by comparison to non-painful ones in high CU trait participants.

High CU trait participants demonstrated modulation of their response to non-painful stimuli in the latency of the P170, which was found to be shorter for the self-imagined stimuli than the other-imagined perspective. The self-imagined, non-painful condition also evoked a larger left OP amplitude than the other-imagined. These findings suggests a smaller, slower response in the high groups to non-painful stimuli in others. However, it is interesting that self-imagined stimuli in the high group evoked no difference in waveforms between the painful and non-painful stimuli emulating the low and control group's ERP responses, suggesting less priority of response for the self in high CU trait individuals when the stimuli are painful in nature.

By comparison, the low group displayed no difficulty in discriminating between painful and non-pain stimuli when imagined as oneself or another. Painful stimuli also evoked an increase in the N1 amplitude. The N1 peak in ERP response over the frontal/central cortices has been associated with attentiveness (Coull, 1998) and emotional saliency (Pourtois & Vuilleumier, 2006). Therefore, it maybe that low CU trait individuals are cognitively more sensitive to stimuli depicting pain in addition to manifesting higher emotional empathy.

The control group show an unexpected lack of accuracy in determining other-imagined painful and non-painful stimuli although given the closeness to significance, more testing would be required to ensure this wasn't due to a type 2 error created by the lower group numbers. Painful stimuli were associated with quicker N250 component suggesting a quicker neural response to such stimuli. However, changing the imagined condition from self to other had no effect on ERP waveform response to either the control or low CU trait groups, only the high group as described previously.

9.3.3 Potential Research Extensions

These electrophysiological insights allow the positing that there are some neural differences in cognitive empathy response across high and low CU trait groups. Future research should focus on whether these research are replicable. Again, it would be interesting to extend such research to clinical samples to explore whether their electroneurological responses to cognitive empathy tasks are similar to high CU trait individuals from the general population or whether there are other factors defining these high Cu trait clinical disorders that can be measured by electroencephalography.

Another area of extension that further research into the relationship between CU traits and cognitive empathy could explore is the comparison of different forms of cognitive empathy measures. Such research may be able to discern which cognitive empathy tasks are associated with reduced cognitive empathy in high CU trait individuals and associated neural correlates, and which with preservation of both behavioural and neurological response.

9.4. Study 4 – Research Exploring the Modulating Effects of Callous-Unemotional Traits and Attention on Participants' Affective Valence

The preliminary research of this thesis observed a negative association between CU traits and emotional response. Those individuals with higher CU traits tended to score their experience of negative emotional stimuli less negatively than low CU traits individuals; furthermore, a lower valence response to positive images was also observed in higher CU trait participants. As well as differences in affective valence responses, high CU traits individuals scored themselves as experiencing less intensity of emotion when observing both positive and negative images. Anderson and Stanford (2012) observed that controls presented with an ERP positivity (200–900ms) to negative affective stimuli when compared to neutral stimuli, however, psychopathic participants only displayed this ERP waveform component when their attention was purposely directed towards the emotional content of the stimuli. The aim of this fourth study was then to build on this previous research by investigating the electrophysiological manifestation of the CU trait deficit in emotional valence and the moderating effect of attention in a general demographic. Through this study, research question six would be addressed.

Participants' neurological responses to the International Affective Picture System (IAPS) emotive stimuli set (Lang & Bradley., 2007) were measured through EEG recording and ERP analysis. The IAPS is a valence scored and validated set of emotion evoking photographs which has been recruited in many electrophysiological studies into emotional response (Sadeh & Verona, 2012; Cano et al., 2009; Codispoti et al., 2007; Olofsson & Polich, 2007; Carretie et al., 2006, 2004, 2003; Schupp et al., 2003, 2000). The negative, neutral and positive IAPS stimuli were viewed with and without attention to the emotive content to observe whether the difference in attentive response associated with psychopathic traits, reported by Anderson and Stanford (2013). It is postulated that this effect may extend to general individuals high in CU traits and may not be present in low CU trait individuals or controls.

9.4.1 Research Questions 6 – How are the Electroneurological Correlates of Affective Valence Modulated by Callous-Unemotional Traits and Attention?

Electrophysiological measurement of the interaction between affective valence and CU trait presentation revealed important findings. The high CU trait individuals exhibited most variation in their ERP response between the attentional conditions and between the groups in the non-emotional attention conditions in the positive and negative condition, although neutral stimuli containing humans did not interact with CU trait manifestation. The high CU trait group presented with a reliably larger Right

OP P2 component in response to both negative and positive stimuli. This result was consistent for both human and non-human scenes, suggesting that emotional content is the core factor, but in symmetry with behavioural findings (see chapter 4) is universal across positive and negative stimuli. However, when forced to contemplate the emotional content of affective images, and thus, attend to them, the P2 response normalises and there are no differences in the responses to emotion displayed by high, low and control CU trait individuals. By comparison the low and control CU trait groups exhibited no significant differences in their responses to the affect presentations. The findings may suggest a normalisation to a neurotypical ERP response moderated by attention to specific cues of affect in high CU trait individuals. Consequently, insufficiencies in high CU trait individuals ability to respond emotionally may be indicative of dysfunctional attention to emotional information, instead of an inability to respond in a neurotypically emotive manner. This supposition is congruent with research into both clinical psychopathic samples and those using fMRI imaging techniques (Larson et al., 2013; Meffert et al., 2013; Anderson & Stanford, 2012). See figure 37 below for a summary of these findings.

Behaviour of the Right Occipital Parietal P2 Peak in High, Low and Control CU trait Groups to Human Stimuli

	Attention Not Drawn to Stimuli	Attention Drawn to Stimuli
NEUTRAL 	No difference between groups	No difference between groups
NEGATIVE 	Larger P2 over the right occipital parietal electrodes in the high CU trait participants. No difference between the control and low CU trait individuals	No difference between groups
POSITIVE 	Larger P2 over the right occipital parietal electrodes in the high CU trait participants. No difference between the control and low CU trait individuals	No difference between groups

Figure 37: An infographic describing the behaviour of the P2 Peak in response to affective stimuli as modulated by attention and CU traits.

9.4.2 Potential Research Extensions

Due to the greater attrition of participants for this finally study due to excessive artefacts a replication of this research is particularly important to validate the research findings. Although, the pattern of the electrophysiological outcomes mirrored clinical findings with regards to the interaction between emotion, attention and CU traits, the ERP components where that difference manifested were quite different. Therefore, this effect of attention on the emotional responding of sub-clinical, high CU trait individuals would need to be accounted for within future research in this area, particularly with regards to the ERP components in which the valence differences manifest when attention is not being paid to the emotional content of the stimuli. This research should be the highest priority when extending these findings.

There is also the potential for the positive effect of attention to form the basis of a neurofeedback or emotional response programme aimed at normalising the affective response of high CU trait individuals with low affective responses. Although this valence training is currently unexplored, it is supported by both the research presented in chapter 8 and by previous published literature (Larson et al., 2013; Meffert et al., 2013; Anderson & Stanford, 2012).

9.5 Limitations of the Electrophysiological Research

There are limitations of this electrophysiological research which need to be acknowledged. Firstly, the use of a 64 electrode array is a low density EEG set up for modern research set up, however, there are advantages to using such an array. For example, it is less likely that when applying the conductive gel to the electrodes a bridge between electrodes will be created, allowing the interference of signals from difference electrode locations. The greater space between the electrodes in the 64 electrode array helps prevent such bridging. Furthermore, the shorter application time of a smaller array helps ensure that participants are still attentive and not-fatigued when they begin the experimental task. Although the 64 electrode cap provides less spatial resolution that a 128 or 256 array set up, the 64 electrode EEG has been shown to be accurate enough spatially to allow broad spatial assumption to be drawn from data obtained through use of a 64 array, given that spatial resolution is not the primary purpose of EEG investigation (Ryynanen et al., 2004).

The sample size used for the electrophysiological research were smaller than some similar studies (Smith et al., 2013; Anderson & Stanford, 2012), however, there are other studies in researching the electrophysiology of CU traits, empathy and affective valence that use group numbers are consummate with the research presented in this thesis (Suway et al., 2013; Cheng et al., 2012; Frenkel & Bar-Haim, 2011; Schupp et al., 2004). The decision to use groups of this size was based on two factors. Firstly, it was necessary to ensure that the groups were distinct with regards to CU trait manifestation. Therefore, smaller groups which represented the upper and lower quartiles of the CU trait distribution, rather than larger ones that regressed towards the mean and the control were considered advantageous in that they would be more likely to be discrete populations thus providing distinct results associated with the level of CU trait manifestation described. Secondly, further testing of these CU trait groups ensured that any confounds were removed, such rigorous participant selection would have been difficult to orchestrate within the time allowed if a larger sample was recruited.

The NIMSTIM stimuli recruited for the facial expression electrophysiological research is a commonly recruited and well validated stimuli set (Lang et al., 2005), however, the numerous presentations (e.g. different crops and colour verses black and white presentation) and accompanying behavioural task paradigms mean that facial expression literature is variable with regards to its findings; therefore, it is difficult to directly compare findings. Furthermore, colour presentation of the stimuli as utilised in study two is less usual, however, given that recent research has postulated that removing the colour from stimuli can diminish emotional response it was considered that a black and white or grayscale presentation could dampen the neural response the research wished to explore (Cano et al., 2009). This forms a potential limitation of the methodology. Furthermore, it is possible that using a task based methodology rather that a passive viewing paradigm may have invoked the later components at 300ms observed in some other research (Balconi & Pozzoli, 2003; Sato et al., 2001). Despite these limitations, the results of the research into facial expressions mirror closely the findings of Smith et al's (2013) which used an identical stimuli presentation to the one adopted in this research, therefore suggesting a validity in the generated ERP waveforms.

There were also potential limitations to the affective valence research. The task employed to ensure non-emotional attention to the target and emotional attention to the stimuli, had to differ between the attentional conditions. Therefore, the motor response in the task could have affected the resulting ERP waveforms. A potential limitation of the affective valence research paradigm. However, if the difference in motor tasks had confounded the study you would expect a consistent pattern of difference between the attention conditions. No such difference is observed in the control and low CU trait groups, nor for the neutral human stimuli in the high CU trait group, suggesting that any differences are due to the group's adaptation of emotional valence processing, rather than an effect of the task paradigm.

Finally, as the three electrophysiological stimuli were run in one session to prevent attrition of participants, there is the potential for order effects, such as fatigue and practice effect. Therefore, to ensure such effect did not limit the research the studies were run in a random order for each participant.

9.6 Conclusion

To conclude, the present work has provided insight into CU trait manifestation in a general population sample and, simultaneously, raised questions that could be addressed through future research. In many ways the findings in sub-clinical, high CU traits individuals reflect those reported in clinical samples. Particularly, the findings show a reduction in emotional empathy, a decrease in the ability in to recognise fearful expressions and the lower emotional valence. The electrophysiological response to fearful expressions and the interacting effect of attention on neural response to emotion in high CU trait participants from the general population, seem to have certain symmetry with clinical findings. This outcome, when considered in conjunction with the continuous, normal distribution observed in the measure of CU traits, suggests that it is possible that high CU trait disorder lie at the high tail end of the presentation of CU traits, rather than clinical individuals forming a psychologically and neurologically discrete population.

However, there do also seem to be distinct differences between high CU trait individuals in the general population and clinical findings regarding associated disorders. For example, the disassociation between the emotional and cognitive components of empathy does not present reliably in this and other sub-clinical samples. The presentation of cognitive empathy may be a key difference between the clinical and general sample populations, certainly one that warrants further investigation. The insights provided by the research presented within this thesis significantly improve the understanding of the psychological and neurological manifestation of callous –unemotional traits in the general, sub-clinical population.

References

Adolphs, R., Tranel, D., Hamann, S., Young, A. W., Calder, A. J., Phelps, E. A., ... & Damasio, A. R. (1999). Recognition of facial emotion in nine individuals with bilateral amygdala damage. *Neuropsychologia*, 37(10), 1111-1117.

Akitsuki, Y., & Decety, J. (2009). Social context and perceived agency affects empathy for pain: an event-related fMRI investigation. *Neuroimage*, *47*(2), 722-734.

Ali, F., Amorim, I. S., & Chamorro-Premuzic, T. (2009). Empathy deficits and trait emotional intelligence in psychopathy and Machiavellianism. *Personality and Individual Differences*, *47*(7), 758-762.

Ali, F., & Chamorro-Premuzic, T. (2010). Investigating Theory of Mind deficits in nonclinical psychopathy and Machiavellianism. *Personality and Individual Differences*, *49*(3), 169-174.

Almeida, P. R., Ferreira-Santos, F., Vieira, J. B., Moreira, P. S., Barbosa, F., & Marques-Teixeira, J. (2014). Dissociable effects of psychopathic traits on cortical and subcortical visual pathways during facial emotion processing: An ERP study on the N170. *Psychophysiology*.

American Psychiatric Association (2013). Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5).

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, *7*(4), 268-277.

Amrhein, C., Mühlberger, A., Pauli, P., & Wiedemann, G. (2004). Modulation of event-related brain potentials during affective picture processing: a complement to startle reflex and skin conductance response?. *International Journal of Psychophysiology*, *54*(3), 231-240.

Anastasi, J. S., & Rhodes, M. G. (2006). Evidence for an Own-Age Bias in Face Recognition. *North American Journal of Psychology*.

Anderson, N. E., & Stanford, M. S. (2012). Demonstrating emotional processing differences in psychopathy using affective ERP modulation.*Psychophysiology*, *49*(6), 792-806.

Aniskiewicz, A. S. (1979). Autonomic components of vicarious conditioning and psychopathy. *Journal of Clinical Psychology*, *35*(1), 60-67.

Aragno, A. (2008). The language of empathy: An analysis of its constitution, development, and role in psychoanalytic listening. *Journal of the American Psychoanalytic Association*, *56*(3), 713-740.

Avenanti, A., & Aglioti, S. M. (2006). The sensorimotor side of empathy for pain. In *Psychoanalysis and neuroscience* (pp. 235-256). Springer Milan.

Avenanti, A., Bueti, D., Galati, G., & Aglioti, S. M. (2005). Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain.*Nature neuroscience*, *8*(7), 955-960.

Avenanti, A., Paluello, I. M., Bufalari, I., & Aglioti, S. M. (2006). Stimulus-driven modulation of motor-evoked potentials during observation of others' pain.*Neuroimage*, *32*(1), 316-324.

Bagby, R. M., Taylor, G. J., & Parker, J. D. (1994). The twenty-item Toronto Alexithymia Scale—II. Convergent, discriminant, and concurrent validity.*Journal of psychosomatic research*, *38*(1), 33-40.

Balconi, M., & Pozzoli, U. (2003). Face-selective processing and the effect of pleasant and unpleasant emotional expressions on ERP correlates.*International Journal of Psychophysiology*, *49*(1), 67-74.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of autism and developmental disorders*, *34*(2), 163-175.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*(2), 241-251.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, A. T. (1997). Is there a" language of the eyes"? Evidence from normal adults, and adults with autism or Asperger syndrome. *Visual Cognition*, *4*(3), 311-331.

Barrett, L. F., & Wager, T. D. (2006). The structure of emotion evidence from neuroimaging studies. *Current Directions in Psychological Science*, *15*(2), 79-83.

Barry, C. T., Frick, P. J., DeShazo, T. M., McCoy, M., Ellis, M., & Loney, B. R. (2000). The importance of callous–unemotional traits for extending the concept of psychopathy to children. *Journal of abnormal psychology*, *109*(2), 335.

Batson, C. D. (2009). These things called empathy: eight related but distinct phenomena.

Batty, M., & Taylor, M. J. (2003). Early processing of the six basic facial emotional expressions. *Cognitive Brain Research*, *17*(3), 613-620.

Van Bavel, J. J., Xiao, Y. J., & Hackel, L. M. (2013). SOCIAL IDENTITY SHAPES SOCIAL PERCEPTION AND EVALUATION. *The neuroscience of prejudice*, 110.

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of cognitive neuroscience*, *8*(6), 551-565.

Bentin, S., & Deouell, L. Y. (2000). Structural encoding and identification in face processing: ERP evidence for separate mechanisms. *Cognitive Neuropsychology*, *17*(1-3), 35-55.

Berthoz, S., Wessa, M., Kedia, G., Wicker, B., & Grezes, J. (2008). Cross-cultural validation of the empathy quotient in a French-speaking sample.*Canadian journal of psychiatry*, *53*(7), 469-477.

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale: an updated literature review.*Journal of psychosomatic research*, *52*(2), 69-77.

Blair, J., Sellars, C., Strickland, I., Clark, F., Williams, A., Smith, M., & Jones, L. (1996). Theory of mind in the psychopath. *Journal of Forensic Psychiatry*,*7*(1), 15-25.

Blair, R.J.R., Jones, L., Clark, F., & Smith, M. (1997). The psychopathic individual: A lack of responsiveness to distress cues?. *Psychophysiology*, *34*(2), 192-198.

Blair, R. J. R., Colledge, E., Murray, L., & Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of abnormal child psychology*, *29*(6), 491-498.

Blair, R. J. R. (2003). Neurobiological basis of psychopathy. *The British Journal of Psychiatry*, *182*(1), 5-7.

Blair, R. J. R. (2005). Applying a cognitive neuroscience perspective to the disorder of psychopathy. *Development and psychopathology*, 17(03), 865-891.

Blair, R. J. R. (2005). Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and cognition*, *14*(4), 698-718.

Blair, R. J. R. (2007). Empathic dysfunction in psychopathic individuals.*Empathy in mental illness*, 3-16.

Blair, R. J. R. (2008). Fine cuts of empathy and the amygdala: dissociable deficits in psychopathy and autism. *The Quarterly Journal of Experimental Psychology*, *61*(1), 157-170.

Blair, R. J. R. (2010). Neuroimaging of psychopathy and antisocial behavior: a targeted review. *Current psychiatry reports*, *12*(1), 76-82.

Blair, R. J. R., Colledge, E., Murray, L., & Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of abnormal child psychology*, *29*(6), 491-498.

Blair, R. J. R., Mitchell, D. G. V., Leonard, A., Budhani, S., Peschardt, K. S., & Newman, C. (2004). Passive avoidance learning in individuals with psychopathy: modulation by reward but not by punishment. *Personality and Individual Differences*, *37*(6), 1179-1192.

Blair, K. S., Morton, J., Leonard, A., & Blair, R. J. R. (2006). Impaired decision-making on the basis of both reward and punishment information in individuals with psychopathy. *Personality and Individual Differences*, *41*(1), 155-165.

Blair, J., Sellars, C., Strickland, I., Clark, F., Williams, A., Smith, M., & Jones, L. (1996). Theory of mind in the psychopath. *Journal of Forensic Psychiatry*,*7*(1), 15-25.

Blau, V. C., Maurer, U., Tottenham, N., & McCandliss, B. D. (2007). The face-specific N170 component is modulated by emotional facial expression.*Behavioral and Brain Functions*, *3*(7), 1-13.

Book, A. S., Quinsey, V. L., & Langford, D. (2007). Psychopathy and the perception of affect and vulnerability. *Criminal Justice and Behavior*, *34*(4), 531-544.

Botvinick, M., Jha, A. P., Bylsma, L. M., Fabian, S. A., Solomon, P. E., & Prkachin, K. M. (2005). Viewing facial expressions of pain engages cortical areas involved in the direct experience of pain. *Neuroimage*, *25*(1), 312-319.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry*, *25*(1), 49-59.

Bradley, M. M., Hamby, S., Löw, A., & Lang, P. J. (2007). Brain potentials in perception: picture complexity and emotional arousal. *Psychophysiology*, *44*(3), 364-373.

Broca, P. (1878). *Anatomie comparee des circonvolutions cerebrales: Le grand lobe limbique et la scissure limbique dans la serie des mammiferes*.

Bufalari, I., Aprile, T., Avenanti, A., Di Russo, F., & Aglioti, S. M. (2007). Empathy for pain and touch in the human somatosensory cortex. *Cerebral Cortex*, *17*(11), 2553-2561.

Burke, J. D., Loeber, R., & Lahey, B. B. (2007). Adolescent conduct disorder and interpersonal callousness as predictors of psychopathy in young adults.*Journal of Clinical Child and Adolescent Psychology*, *36*(3), 334-346.

Byrd, A. L., Kahn, R. E., & Pardini, D. A. (2013). A validation of the Inventory of Callous-Unemotional Traits in a community sample of young adult males.*Journal of psychopathology and behavioral assessment*, *35*(1), 20-34.

Cano, M. E., Class, Q. A., & Polich, J. (2009). Affective valence, stimulus attributes, and P300: Color vs. black/white and normal vs. scrambled images.*International Journal of Psychophysiology*, *71*(1), 17-24.

Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., & Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of the national Academy of Sciences*,*100*(9), 5497-5502.

Carretié, L., Hinojosa, J. A., Albert, J., & Mercado, F. (2006). Neural response to sustained affective visual stimulation using an indirect task. *Experimental Brain Research*, *174*(4), 630-637.

Carretié, L., Hinojosa, J. A., Martín-Loeches, M., Mercado, F., & Tapia, M. (2004). Automatic attention to emotional stimuli: neural correlates. *Human brain mapping*, *22*(4), 290-299.

Carretié, L., Hinojosa, J. A., & Mercado, F. (2003). Cerebral patterns of attentional habituation to emotional visual stimuli. *Psychophysiology*, *40*(3), 381-388.

Castelli, F., Happe, F., Frith, U., & Frith, C. (2000). Movement and mind: a functional imaging study of perception and interpretation of complex intentional movement patterns. *Neuroimage*, *12*(3), 314-325.

Cheng, Y., Hung, A. Y., & Decety, J. (2012). Dissociation between affective sharing and emotion understanding in juvenile psychopaths. *Development and psychopathology*, *24*(02), 623-636.

Cleckley, H. (1976). The mask of sanity. *St. Louis, MO: Mosby*.

Codispoti, M., Ferrari, V., & Bradley, M. M. (2006). Repetitive picture processing: autonomic and cortical correlates. *Brain research*, *1068*(1), 213-220.

Cong F. (2015). Advanced Signal Processing On Brain Event-Related Potentials: Filtering Erps In Time, Frequency And Space Domains Sequentially And Simultaneously. *World Scientific Publishing Company*.

Contreras-Rodríguez, O., Pujol, J., Batalla, I., Harrison, B. J., Bosque, J., Ibern-Regàs, I., & Cardoner, N. (2014). Disrupted neural processing of emotional faces in psychopathy. *Social cognitive and affective neuroscience*,*9*(4), 505-512.

Coull, J. T. (1998). Neural correlates of attention and arousal: insights from electrophysiology, functional neuroimaging and psychopharmacology. *Progress in neurobiology*, *55*(4), 343-361.

Crawford, J. R., Deary, I. J., Starr, J., & Whalley, L. J. (2001). The NART as an index of prior intellectual functioning: a retrospective validity study covering a 66-year interval. *Psychological medicine*, *31*(03), 451-458.

Crawford, J. R., Stewart, L. E., Cochrane, R. H. B., Parker, D. M., & Besson, J. A. O. (1989). Construct validity of the National Adult Reading Test: A factor analytic study. *Personality and Individual Differences*, *10*(5), 585-587.

Cristinzio, C., Sander, D., & Vuilleumier, P. (2007). Recognition of emotional face expressions and amygdala pathology. *Epileptologie*, *24*, 130-8.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. *Biological psychology*, *52*(2), 95-111.

Dadds, M. R., Whiting, C., & Hawes, D. J. (2006). Associations among cruelty to animals, family conflict, and psychopathic traits in childhood. Journal of Interpersonal Violence, 21(3), 411-429.

Dadds, M. R., El Masry, Y., Wimalaweera, S., & Guastella, A. J. (2008). Reduced eye gaze explains "fear blindness" in childhood psychopathic traits.Journal of the American Academy of Child & Adolescent Psychiatry, 47(4), 455-463.

Dadds, M. R., Hawes, D. J., Frost, A. D., Vassallo, S., Bunn, P., Hunter, K., & Merz, S. (2009). Learning to 'talk the talk': the relationship of psychopathic traits to deficits in empathy across childhood. *Journal of Child Psychology and Psychiatry*, *50*(5), 599-606.

Dancey, C. P., & Reidy, J. (2008). *Statistics without maths for psychology*. Pearson Education.

Danford, L. A. (1991). The effect of mood and personality on cognitive and affective empathy.

Danziger, N., Prkachin, K. M., & Willer, J. C. (2006). Is pain the price of empathy? The perception of others' pain in patients with congenital insensitivity to pain. *Brain*, *129*(9), 2494-2507.

Dapretto, M., Davies, M. S., Pfeifer, J. H., Scott, A. A., Sigman, M., Bookheimer, S. Y., & Iacoboni, M. (2006). Understanding emotions in others: mirror neuron dysfunction in children with autism spectrum disorders. *Nature neuroscience*, *9*(1), 28-30.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of personality and social psychology*, *44*(1), 113-126.

Dawel, A., O'Kearney, R., McKone, E., & Palermo, R. (2012). Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy. *Neuroscience & Biobehavioral Reviews*, *36*(10), 2288-2304.

De Brito, S. A., Mechelli, A., Wilke, M., Laurens, K. R., Jones, A. P., Barker, G. J., ... & Viding, E. (2009). Size matters: Increased grey matter in boys with conduct problems and callous–unemotional traits. *Brain*, *132*(4), 843-852.

Decety, J. (2011). The neuroevolution of empathy. *Annals of the New York Academy of Sciences*, *1231*(1), 35-45.

Decety, J., Chen, C., Harenski, C., & Kiehl, K. A. (2013). An fMRI study of affective perspective taking in individuals with psychopathy: imagining another in pain does not evoke empathy. *Frontiers in human neuroscience*, *7*.

Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. *Behavioral and cognitive neuroscience reviews*, *3*(2), 71-100.

Decety, J., & Jackson, P. L. (2006). A social-neuroscience perspective on empathy. *Current directions in psychological science*, *15*(2), 54-58.

Decety, J., & Meyer, M. (2008). From emotion resonance to empathic understanding: A social developmental neuroscience account. *Development and psychopathology*, *20*(04), 1053-1080.

Decety, J., Yang, C. Y., & Cheng, Y. (2010). Physicians down-regulate their pain empathy response: an event-related brain potential study. *Neuroimage*,*50*(4), 1676-1682.

de Corte, K., Buysse, A., Verhofstadt, L. L., Roeyers, H., Ponnet, K., & Davis, M. H. (2007). Measuring empathic tendencies: Reliability and validity of the Dutch version of the Interpersonal Reactivity Index. *Psychologica Belgica*, *47*(4), 235-260.

Del Gaizo, A. L., & Falkenbach, D. M. (2008). Primary and secondary psychopathic-traits and their relationship to perception and experience of emotion. *Personality and Individual Differences*, *45*(3), 206-212.

Delplanque, S., Lavoie, M. E., Hot, P., Silvert, L., & Sequeira, H. (2004). Modulation of cognitive processing by emotional valence studied through event-related potentials in humans. *Neuroscience letters*, *356*(1), 1-4.

Delplanque, S., Silvert, L., Hot, P., & Sequeira, H. (2005). Event-related P3a and P3b in response to unpredictable emotional stimuli. *Biological Psychology*,*68*(2), 107-120.

Demenescu, L. R., Kortekaas, R., den Boer, J. A., & Aleman, A. (2010). Impaired attribution of emotion to facial expressions in anxiety and major depression. *PLoS One*, *5*(12), e15058.

Dennis, T. A., Malone, M. M., & Chen, C. C. (2009). Emotional face processing and emotion regulation in children: An ERP study. *Developmental neuropsychology*, *34*(1), 85-102.

Diedrich, O., Naumann, E., Maier, S., & Becker, G. (1997). A frontal positive slow wave in the ERP associated with emotional slides. *Journal of Psychophysiology*.

Di Russo, F., Taddei, F., Apnile, T., & Spinelli, D. (2006). Neural correlates of fast stimulus discrimination and response selection in top-level fencers.*Neuroscience letters*, *408*(2), 113-118.

Dolan, M. C., & Fullam, R. S. (2009). Psychopathy and functional magnetic resonance imaging blood oxygenation level-dependent responses to emotional faces in violent patients with schizophrenia. *Biological psychiatry*, *66*(6), 570-577.

Easter, J., McClure, E. B., Monk, C. S., Dhanani, M., Hodgdon, H., Leibenluft, E., ... & Ernst, M. (2005). Emotion recognition deficits in pediatric anxiety disorders: implications for amygdala research. *Journal of Child & Adolescent Psychopharmacology*, *15*(4), 563-570.

Eastwood, J. D., Smilek, D., & Merikle, P. M. (2003). Negative facial expression captures attention and disrupts performance. *Perception & Psychophysics*, *65*(3), 352-358.

Ebner, N. C., & Johnson, M. K. (2009). Young and older emotional faces: Are there age-group differences in expression identification and memory?. *Emotion (Washington, DC)*, *9*(3), 329.

Edens, J. F., Marcus, D. K., Lilienfeld, S. O., & Poythress Jr, N. G. (2006). Psychopathic, not psychopath: taxometric evidence for the dimensional structure of psychopathy. *Journal of abnormal psychology*, *115*(1), 131.

Eimer, M., & Holmes, A. (2002). An ERP study on the time course of emotional face processing. *Neuroreport*, *13*(4), 427-431.

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia*, *45*(1), 15-31.

Eimer, M., Holmes, A., & McGlone, F. P. (2003). The role of spatial attention in the processing of facial expression: an ERP study of rapid brain responses to six basic emotions. *Cognitive, Affective, & Behavioral Neuroscience*, *3*(2), 97-110.

Ekman, P., Friesen, W. V., & Hager, J. C. Facial action coding system. 2002.*Salt Lake City: Research Nexus eBook.*

Essau, C. A., Sasagawa, S., & Frick, P. J. (2006). Callous-unemotional traits in a community sample of adolescents. *Assessment*, *13*(4), 454-469.

Etkin, A., Klemenhagen, K. C., Dudman, J. T., Rogan, M. T., Hen, R., Kandel, E. R., & Hirsch, J. (2004). Individual differences in trait anxiety predict the response of the basolateral amygdala to unconsciously processed fearful faces. *Neuron*, *44*(6), 1043-1055.

Fairchild, G., Van Goozen, S. H., Calder, A. J., Stollery, S. J., & Goodyer, I. M. (2009). Deficits in facial expression recognition in male adolescents with early-onset or adolescence-onset conduct disorder. *Journal of Child Psychology and Psychiatry*, *50*(5), 627-636.

Fairchild, G., Stobbe, Y., Van Goozen, S. H., Calder, A. J., & Goodyer, I. M. (2010). Facial expression recognition, fear conditioning, and startle modulation in female subjects with conduct disorder. *Biological Psychiatry*, *68*(3), 272-279.

Fan, Y., & Han, S. (2008). Temporal dynamic of neural mechanisms involved in empathy for pain: an event-related brain potential study. *Neuropsychologia*,*46*(1), 160-173.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods*, *39*(2), 175-191.

Feise, R. J. (2002). Do multiple outcome measures require p-value adjustment?. *BMC Medical Research Methodology*, *2*(1), 8.

FeldmanHall, O., Dalgleish, T., & Mobbs, D. (2013). Alexithymia decreases altruism in real social decisions. *Cortex*, *49*(3), 899-904.

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

Fitzgerald, D. A., Angstadt, M., Jelsone, L. M., Nathan, P. J., & Phan, K. L. (2006). Beyond threat: amygdala reactivity across multiple expressions of facial affect. *Neuroimage*, *30*(4), 1441-1448.

Frenkel, T. I., & Bar-Haim, Y. (2011). Neural activation during the processing of ambiguous fearful facial expressions: An ERP study in anxious and nonanxious individuals. *Biological psychology*, *88*(2), 188-195.

Frick, P. J. (1998). *Conduct disorders and severe antisocial behavior*. Springer Science & Business Media.

Frick, P. J. (2004). The inventory of callous-unemotional traits. *Unpublished rating scale*.

Frick, P. J., Bodin, S. D., & Barry, C. T. (2000). Psychopathic traits and conduct problems in community and clinic-referred samples of children: further development of the psychopathy screening device. *Psychological assessment*,*12*(4), 382.

Frick, P. J., & Ellis, M. (1999). Callous-unemotional traits and subtypes of conduct disorder. *Clinical Child and Family Psychology Review*, *2*(3), 149-168.

Frick, P. J., & Hare, R. D. (2001). *Antisocial Process Screening Device: APSD*. Toronto: Multi-Health Systems.

Frick, P. J., & Moffitt, T. E. (2010). A proposal to the DSM-V childhood disorders and the ADHD and disruptive behavior disorders work groups to include a specifier to the diagnosis of conduct disorder based on the presence of callous-unemotional traits. *Washington, DC: American Psychiatric Association*, 1-36.

Frick, P. J., Ray, J. V., Thornton, L. C., & Kahn, R. E. (2014). Annual Research Review: A developmental psychopathology approach to understanding callous-unemotional traits in children and adolescents with serious conduct problems. Journal of child Psychology and Psychiatry, 55(6), 532-548.

Gallagher, H. L., & Frith, C. D. (2003). Functional imaging of 'theory of mind'.*Trends in cognitive sciences*, *7*(2), 77-83.

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

Gallese, V. (2001). The'shared manifold'hypothesis. From mirror neurons to empathy. *Journal of consciousness studies*, *8*(5-7), 33-50.

Gallese, V. (2003). The roots of empathy: the shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology*, *36*(4), 171-180.

Gazzola, V., Aziz-Zadeh, L., & Keysers, C. (2006). Empathy and the somatotopic auditory mirror system in humans. *Current biology*, *16*(18), 1824-1829.

Glass, S. J., & Newman, J. P. (2006). Recognition of facial affect in psychopathic offenders. *Journal of Abnormal Psychology*, *115*(4), 815.

Gordon, H. L., Baird, A. A., & End, A. (2004). Functional differences among those high and low on a trait measure of psychopathy. *Biological psychiatry*,*56*(7), 516-521.

Goubert, L., Craig, K. D., Vervoort, T., Morley, S., Sullivan, M. J. L., Williams, A. D. C., ... & Crombez, G. (2005). Facing others in pain: the effects of empathy. *Pain*, *118*(3), 285-288.

Guay,J., Ruscio, J., Knight, R. A., & Hare, R. D. (2007). A taxometric analysis of the latent structure of psychopathy: Evidence for dimensionality. *Journal of Abnormal Psychology*, *116*(4), 701.

Han, S., Fan, Y., & Mao, L. (2008). Gender difference in empathy for pain: an electrophysiological investigation. *Brain research*, *1196*, 85-93.

Happé, F. G. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of autism and Developmental disorders*,*24*(2), 129-154.

Hare, R. D. (1991). The psychopathy checklist-revised. *Toronto: Multi-Health Systems*, *23*.

Hare, R.D. (1993). *Without conscience: The disturbing world of the psychopaths among us. New York: Guilford Press*.

Hare, R. D. (1998). Psychopaths and their nature: Implications for the mental health and criminal justice systems. Psychopathy: Antisocial, criminal, and violent behavior, 188-212.

Hare, R. D., & Neumann, C. S. (2008). Psychopathy as a clinical and empirical construct. *Annu. Rev. Clin. Psychol.*, *4*, 217-246.

Hastings, M. E., Tangney, J. P., & Stuewig, J. (2008). Psychopathy and identification of facial expressions of emotion. *Personality and individual differences*, *44*(7), 1474-1483.

Hawes, D. J., & Dadds, M. R. (2005). The treatment of conduct problems in children with callous-unemotional traits. *Journal of Consulting and Clinical Psychology*, *73*(4), 737.

Hayes, T. L. (2013). Matthias Ziegler, Carolyn MacCann, and Richard D. Roberts.(Eds.). New Perspectives on Faking in Personality Assessment. Oxford, UK: Cambridge University Press, 2012, 364 pages, $59.95, hardcover.*Personnel Psychology*, *66*(3), 798-801.

Heider, F., & Simmel, M. (1944). An experimental study of apparent behavior.*The American Journal of Psychology*, 243-259.

Heims, H. C., Critchley, H. D., Dolan, R., Mathias, C. J., & Cipolotti, L. (2004). Social and motivational functioning is not critically dependent on feedback of autonomic responses: neuropsychological evidence from patients with pure autonomic failure. *Neuropsychologia*, *42*(14), 1979-1988.

Herpertz, S. C., Werth, U., Lukas, G., Qunaibi, M., Schuerkens, A., Kunert, H. J. & Sass, H. (2001). Emotion in criminal offenders with psychopathy and borderline personality disorder. *Archives of General Psychiatry*, *58*(8), 737.

Hill, J. (2003). Early identification of individuals at risk for antisocial personality disorder. *The British Journal of Psychiatry*, *182*(44), s11-s14.

Holmes, A., Vuilleumier, P., & Eimer, M. (2003). The processing of emotional facial expression is gated by spatial attention: evidence from event-related brain potentials. *Cognitive Brain Research*, *16*(2), 174-184.

Hoormann, J., Falkenstein, M., Schwarzenau, P., & Hohnsbein, J. (1998). Methods for the quantification and statistical testing of ERP differences across conditions. *Behavior Research Methods, Instruments, & Computers*, *30*(1), 103-109.

House, T. H., & Milligan, W. L. (1976). Autonomic responses to modelled distress in prison psychopaths. *Journal of Personality and Social Psychology*,*34*(4), 556.

Jabbi, M., Bastiaansen, J., & Keysers, C. (2008). A common anterior insula representation of disgust observation, experience and imagination shows divergent functional connectivity pathways. *PloS one*, *3*(8), e2939.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others? A window into the neural processes involved in empathy.*Neuroimage*, *24*(3), 771-779.

Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006). Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain. *Neuropsychologia*, *44*(5), 752-761.

Jackson, P. L., Rainville, P., & Decety, J. (2006). To what extent do we share the pain of others? Insight from the neural bases of pain empathy. *Pain*, *125*(1), 5-9.

Jarros, R. B., Salum, G. A., da Silva, C. T. B., Toazza, R., de Abreu Costa, M., de Salles, J. F., & Manfro, G. G. (2012). Anxiety disorders in adolescence are associated with impaired facial expression recognition to negative valence.*Journal of psychiatric research*, *46*(2), 147-151.

Jones, A. P., Happé, F. G., Gilbert, F., Burnett, S., & Viding, E. (2010). Feeling, caring, knowing: different types of empathy deficit in boys with psychopathic tendencies and autism spectrum disorder. *Journal of Child Psychology and Psychiatry*, *51*(11), 1188-1197.

Jones, A., Laurens, K., Herba, C., Barker, G., & Viding, E. (2009). Amygdala hypoactivity to fearful faces in boys with conduct problems and callous-unemotional traits. *American Journal of Psychiatry*, *166*(1), 95-102.

Kaplan, J. T., & Iacoboni, M. (2006). Getting a grip on other minds: Mirror neurons, intention understanding, and cognitive empathy. *Social neuroscience*,*1*(3-4), 175-183.

Keil, A., Bradley, M. M., Hauk, O., Rockstroh, B., Elbert, T., & Lang, P. J. (2002). Large-scale neural correlates of affective picture processing.*Psychophysiology*, *39*(5), 641-649.

Kim, H., Somerville, L. H., Johnstone, T., Alexander, A. L., & Whalen, P. J. (2003). Inverse amygdala and medial prefrontal cortex responses to surprised faces. *Neuroreport*, *14*(18), 2317-2322.

Kimonis, E. R., Frick, P. J., Skeem, J. L., Marsee, M. A., Cruise, K., Munoz, L. C., ... & Morris, A. S. (2008). Assessing callous-unemotional traits in adolescent offenders: Validation of the Inventory of Callous-Unemotional Traits.*International journal of law and psychiatry*, *31*(3), 241-252.

Klin, A., Schultz, R., & Cohen, D. (2000). Theory of mind in action: developmental perspectives on social neuroscience. *Understanding other minds: Perspectives from developmental neuroscience*, *2*, 357-388.

Kober, H., Barrett, L. F., Joseph, J., Bliss-Moreau, E., Lindquist, K., & Wager, T. D. (2008). Functional grouping and cortical–subcortical interactions in emotion: A meta-analysis of neuroimaging studies. *Neuroimage*, *42*(2), 998-1031.

Krolak-Salmon, P., Fischer, C., Vighetto, A., & Mauguiere, F. (2001). Processing of facial emotional expression: Spatio-temporal data as assessed by scalp event-related potentials. *European Journal of Neuroscience*, *13*(5), 987-994.

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *Neuroimage*, *54*(3), 2492-2502.

Lang, P., & Bradley, M. M. (2007). The International Affective Picture System (IAPS) in the study of emotion and attention. *Handbook of emotion elicitation and assessment*, *29*.

Larson, C. L., Baskin-Sommers, A. R., Stout, D. M., Balderston, N. L., Curtin, J. J., Schultz, D. H., ... & Newman, J. P. (2013). The interplay of attention and emotion: top-down attention modulates amygdala activation in psychopathy.*Cognitive, Affective, & Behavioral Neuroscience*, *13*(4), 757-770.

Lawrence, E. J., Shaw, P., Baker, D., Baron-Cohen, S., & David, A. S. (2004). Measuring empathy: reliability and validity of the Empathy Quotient.*Psychological medicine*, *34*(05), 911-920.

Leist, Tatyana, and Mark R. Dadds. (2009) "Adolescents' ability to read different emotional faces relates to their history of maltreatment and type of psychopathology." *Clinical Child Psychology and Psychiatry* 14.2: 237-250.

Leppänen, J. M., Milders, M., Bell, J. S., Terriere, E., & Hietanen, J. K. (2004). Depression biases the recognition of emotionally neutral faces. *Psychiatry research*, *128*(2), 123-133.

Levenson, M. R., Kiehl, K. A., & Fitzpatrick, C. M. (1995). Assessing psychopathic attributes in a noninstitutionalized population. *Journal of personality and social psychology*, *68*(1), 151.

Levenston, G. K., Patrick, C. J., Bradley, M. M., & Lang, P. J. (2000). The psychopath as observer: Emotion and attention in picture processing. *Journal of Abnormal Psychology*, *109*(3), 373-385.

Li, W., & Han, S. (2010). Perspective taking modulates event-related potentials to perceived pain. *Neuroscience letters*, *469*(3), 328-332.

Lilienfeld, S. O. (1994). Conceptual problems in the assessment of psychopathy. *Clinical Psychology Review*, *14*(1), 17-38.

Lindquist, K. A., Wager, T. D., Kober, H., Bliss-Moreau, E., & Barrett, L. F. (2012). The brain basis of emotion: a meta-analytic review. *Behavioral and Brain Sciences*, *35*(03), 121-143.

Lockwood, P. L., Sebastian, C. L., McCrory, E. J., Hyde, Z. H., Gu, X., De Brito, S. A., & Viding, E. (2013). Association of callous traits with reduced neural response to others' pain in children with conduct problems. *Current Biology*, *23*(10), 901-905.

Loney, B. R., Frick, P. J., Clements, C. B., Ellis, M. L., & Kerlin, K. (2003). Callous-unemotional traits, impulsivity, and emotional processing in adolescents with antisocial behavior problems. *Journal of Clinical Child and Adolescent Psychology*, *32*(1), 66-80.

Lorenz, A. R., & Newman, J. P. (2002). Deficient response modulation and emotion processing in low-anxious Caucasian psychopathic offenders: results from a lexical decision task. *Emotion*, *2*(2), 91.

Luck, S. J. (2014). *An introduction to the event-related potential technique*. MIT press.

Luck, S. J. (2005). Ten simple rules for designing ERP experiments. *Event-related potentials: A methods handbook, 262083337*.

Luo, W., Feng, W., He, W., Wang, N. Y., & Luo, Y. J. (2010). Three stages of facial expression processing: ERP study with rapid serial visual presentation.*Neuroimage*, *49*(2), 1857-1867.

Lynam, D. R. (2002). Fledgling psychopathy: A view from personality theory.

Lynam, D. R., Loeber, R., & Stouthamer-Loeber, M. (2008). The stability of psychopathy from adolescence into adulthood the search for moderators.*Criminal Justice and Behavior*, *35*(2), 228-243.

Lynam, D. R., Whiteside, S., & Jones, S. (1999). Self-reported psychopathy: A validation study. *Journal of personality assessment*, *73*(1), 110-132.

Mahmut, M. K., Homewood, J., & Stevenson, R. J. (2008). The characteristics of non-criminals with high psychopathy traits: Are they similar to criminal psychopaths?. *Journal of Research in Personality*, *42*(3), 679-692.

Manassis, K., & Young, A. (2000). Perception of emotions in anxious and learning disabled children. *Depression and anxiety*, *12*(4), 209-216.

Marcus, D. K., John, S. L., & Edens, J. F. (2004). A taxometric analysis of psychopathic personality. Journal of abnormal psychology, 113(4), 626.

Marsh, A. A., & Blair, R. J. R. (2008). Deficits in facial affect recognition among antisocial populations: A meta-analysis. *Neuroscience and biobehavioral reviews*, *32*(3), 454.

Marsh, A. A., Finger, E. C., Fowler, K. A., Adalio, C. J., Jurkowitz, I. T., Schechter, J. C., ... & Blair, R. J. R. (2013). Empathic responsiveness in amygdala and anterior cingulate cortex in youths with psychopathic traits*Journal of child psychology and psychiatry*, *54*(8), 900-910.

Marsh, A., Finger, E., Mitchell, D., Reid, M., Sims, C., Kosson, D., & Blair, R. (2008). Reduced amygdala response to fearful expressions in children and adolescents with callous-unemotional traits and disruptive behavior disorders.*American Journal of Psychiatry*, *165*(6), 712-720.

Matt, G. E., Vázquez, C., & Campbell, W. K. (1992). Mood-congruent recall of affectively toned stimuli: A meta-analytic review. *Clinical Psychology Review*,*12*(2), 227-255.

Meffert, H., Gazzola, V., Den Boer, J. A., Bartels, A. A., & Keysers, C. (2013). Reduced spontaneous but relatively normal deliberate vicarious representations in psychopathy. *Brain*, *136*(8), 2550-2562.

Miller, J. D., Jones, S. E., & Lynam, D. R. (2011). Psychopathic traits from the perspective of self and informant reports: Is there evidence for a lack of insight?. *Journal of abnormal psychology*, *120*(3), 758.

Mitchell, J. P., Banaji, M. R., & MacRae, C. N. (2005). The link between social cognition and self-referential thought in the medial prefrontal cortex. *Journal of cognitive neuroscience*, *17*(8), 1306-1315.

Montagne, B., van Honk, J., Kessels, R. P., Frigerio, E., Burt, M., van Zandvoort, M. J., ... & de Haan, E. H. (2005). Reduced efficiency in recognising fear in subjects scoring high on psychopathic personality characteristics. *Personality and Individual Differences*, *38*(1), 5-11.

Moran, P., Rowe, R., Flach, C., Briskman, J., Ford, T., Maughan, B., ... & Goodman, R. (2009). Predictive value of callous-unemotional traits in a large community sample. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*(11), 1079-1084.

Müller, J. L., Sommer, M., Wagner, V., Lange, K., Taschler, H., Röder, C. H., & Hajak, G. (2003). Abnormalities in emotion processing within cortical and subcortical regions in criminal psychopaths: evidence from a functional magnetic resonance imaging study using pictures with emotional content.*Biological psychiatry*, *54*(2), 152-162.

Mullins, D. T., & Duke, M. P. (2004). Effects of social anxiety on nonverbal accuracy and response time I: Facial expressions. *Journal of nonverbal behavior*, *28*(1), 3-33.

Muncer, S. J., & Ling, J. (2006). Psychometric analysis of the empathy quotient (EQ) scale. *Personality and Individual differences*, *40*(6), 1111-1119.

Muñoz, L. C., & Frick, P. J. (2007). The reliability, stability, and predictive utility of the self-report version of the Antisocial Process Screening Device.*Scandinavian Journal of Psychology*, *48*(4), 299-312.

Muñoz, L. C. (2009). Callous-unemotional traits are related to combined deficits in recognizing afraid faces and body poses. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*(5), 554-562.

Murphy, F. C., Nimmo-Smith, I. A. N., & Lawrence, A. D. (2003). Functional neuroanatomy of emotions: a meta-analysis. *Cognitive, Affective, & Behavioral Neuroscience*, *3*(3), 207-233.

Nelson, H. E. (1982). *National Adult Reading Test (NART): For the assessment of premorbid intelligence in patients with dementia: Test manual*. NFER-Nelson.

Nidal, K., & Malik, A. S. (Eds.). (2014). *EEG/ERP Analysis: Methods and Applications*. CRC Press.

Norman, W. H., Miller, I. W., & Dow, M. G. (1988). Characteristics of depressed patients with elevated levels of dysfunctional cognitions. *Cognitive Therapy and Research*, *12*(1), 39-51.

Nummenmaa, L., Hirvonen, J., Parkkola, R., & Hietanen, J. K. (2008). Is emotional contagion special? An fMRI study on neural systems for affective and cognitive empathy. *Neuroimage*, *43*(3), 571-580.

O'Carroll, R. E. (1987). The inter-rater reliability of the National Adult Reading Test (NART): A pilot study. *British Journal of Clinical Psychology*, *26*(3), 229-230.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: detecting the snake in the grass. *Journal of experimental psychology: general*, *130*(3), 466.

O'Keefe, D. J. (2003). Colloquy: Should Familywise Alpha Be Adjusted?.*Human Communication Research*, *29*(3), 431-447.

Olofsson, J. K., & Polich, J. (2007). Affective visual event-related potentials: arousal, repetition, and time-on-task. *Biological psychology*, *75*(1), 101-108.

O'Toole, L., & Dennis, T. A. (2012). Attention training and the threat bias: An ERP study. *Brain and cognition*, *78*(1), 63-73.

Panksepp, J. (1998). The periconscious substrates of consciousness: Affective states and the evolutionary origins of the SELF. *Journal of Consciousness Studies*, *5*(5-6), 566-582.

Peyron, R., Laurent, B., & Garcia-Larrea, L. (2000). Functional imaging of brain responses to pain. A review and meta-analysis (2000). *Neurophysiologie Clinique/Clinical Neurophysiology*, *30*(5), 263-288.

Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage*, *16*(2), 331-348.

Philippot, P., & Douilliez, C. (2005). Social phobics do not misinterpret facial expression of emotion. *Behaviour research and therapy*, *43*(5), 639-652.

Polich, J., & Kok, A. (1995). Cognitive and biological determinants of P300: an integrative review. *Biological psychology*, *41*(2), 103-146.

Pollatos, O., Gramann, K., & Schandry, R. (2007). Neural systems connecting interoceptive awareness and feelings. *Human brain mapping*, *28*(1), 9-18.

Pourtois, G., & Vuilleumier, P. (2006). Dynamics of emotional effects on spatial attention in the human visual cortex. *Progress in brain research*, *156*, 67-91.

Prado, C. E., Treeby, M. S., & Crowe, S. F. (2015). Examining relationships between facial emotion recognition, self-control, and psychopathic traits in a non-clinical sample. *Personality and Individual Differences*, *80*, 22-27.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind?. *Behavioral and brain sciences*, *1*(04), 515-526.

Preston, S. D., & De Waal, F. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and brain sciences*, *25*(01), 1-20.

Preston, S. D., Bechara, A., Damasio, H., Grabowski, T. J., Stansfield, R. B., Mehta, S., & Damasio, A. R. (2007). The neural substrates of cognitive empathy. *Social Neuroscience*, *2*(3-4), 254-275.

Pizzagalli, D., Regard, M., & Lehmann, D. (1999). Rapid emotional face processing in the human right and left brain hemispheres: an ERP study.*Neuroreport*, *10*(13), 2691-2698.

Rainville, P. (2002). Brain mechanisms of pain affect and pain modulation.*Current opinion in neurobiology*, *12*(2), 195-204.

Ray, J. V., Hall, J., Rivera-Hudson, N., Poythress, N. G., Lilienfeld, S. O., & Morano, M. (2013). The relation between self-reported psychopathic traits and distorted response styles: A meta-analytic review. *Personality disorders: Theory, research, and treatment*, *4*(1), 1.

Reniers, R. L., Corcoran, R., Drake, R., Shryane, N. M., & Völlm, B. A. (2011). The QCAE: A questionnaire of cognitive and affective empathy. *Journal of personality assessment*, *93*(1), 84-95.

Richell, R. A., Mitchell, D. G. V., Newman, C., Leonard, A., Baron-Cohen, S., & Blair, R. J. R. (2003). Theory of mind and psychopathy: can psychopathic individuals read the 'language of the eyes'?. *Neuropsychologia*, *41*(5), 523-526.

Ruby, P., & Decety, J. (2004). How would you feel versus how do you think she would feel? A neuroimaging study of perspective-taking with social emotions. *Cognitive Neuroscience, Journal of*, *16*(6), 988-999.

Ryynanen, O. R. M., Hyttinen, J. A., Laarne, P. H., & Malmivuo, J. A. (2004). Effect of electrode density and measurement noise on the spatial resolution of cortical potential distribution. *Biomedical Engineering, IEEE Transactions on*,*51*(9), 1547-1554.

Saarela, M. V., Hlushchuk, Y., Williams, A. C. D. C., Schürmann, M., Kalso, E., & Hari, R. (2007). The compassionate brain: humans detect intensity of pain from another's face. *Cerebral cortex*, *17*(1), 230-237.

Sadeh, N., & Verona, E. (2012). Visual complexity attenuates emotional processing in psychopathy: implications for fear-potentiated startle deficits.*Cognitive, Affective, & Behavioral Neuroscience*, *12*(2), 346-360.

Sato, W., Kochiyama, T., Yoshikawa, S., & Matsumura, M. (2001). Emotional expression boosts early visual processing of the face: ERP recording and its decomposition by independent component analysis. *Neuroreport*, *12*(4), 709-714.

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

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Cacioppo, J. T., Ito, T., & Lang, P. J. (2000). Affective picture processing: the late positive potential is modulated by motivational relevance. *Psychophysiology*, *37*(2), 257-261.

Schupp, H. T., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003). Attention and emotion: an ERP analysis of facilitated emotional stimulus processing.*Neuroreport*, *14*(8), 1107-1110.

Schwenck, C., Göhle, B., Hauf, J., Warnke, A., Freitag, C. M., & Schneider, W. (2014). Cognitive and emotional empathy in typically developing children: The influence of age, gender, and intelligence. *European Journal of Developmental Psychology*, *11*(1), 63-76.

Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009). Two systems for empathy: a double dissociation between emotional and cognitive empathy in inferior frontal gyrus versus ventromedial prefrontal lesions. *Brain*, *132*(3), 617-627.

Schreiter, S., Pijnenborg, G. H. M., & Aan Het Rot, M. (2013). Empathy in adults with clinical or subclinical depressive symptoms. *Journal of affective disorders*, *150*(1), 1-16.

Schulte-Rüther, M., Markowitsch, H., Fink, G., & Piefke, M. (2007). Mirror neuron and theory of mind mechanisms involved in face-to-face interactions: a functional magnetic resonance imaging approach to empathy. *Cognitive Neuroscience, Journal of*, *19*(8), 1354-1372.

Seitz, R. J., Schäfer, R., Scherfeld, D., Friederichs, S., Popp, K., Wittsack, H. J., ... & Franz, M. (2008). Valuating other people's emotional face expression: a combined functional magnetic resonance imaging and electroencephalography study. *Neuroscience*, *152*(3), 713-722.

Siegle, G. J., Steinhauer, S. R., Thase, M. E., Stenger, V. A., & Carter, C. S. (2002). Can't shake that feeling: event-related fMRI assessment of sustained amygdala activity in response to emotional information in depressed individuals. *Biological psychiatry*, *51*(9), 693-707.

Sifneos, P. E. (1973). The prevalence of'alexithymic'characteristics in psychosomatic patients. *Psychotherapy and psychosomatics*, (22), 255-62.

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

Skeem, J. L., Mulvey, E. P., & Grisso, T. (2003). Applicability of traditional and revised models of psychopathy to the Psychopathy Checklist: screening version. *Psychological assessment*, *15*(1), 41.

Smith, N. K., Cacioppo, J. T., Larsen, J. T., & Chartrand, T. L. (2003). May I have your attention, please: Electrocortical responses to positive and negative stimuli. *Neuropsychologia*, *41*(2), 171-183.

Smith, E., Weinberg, A., Moran, T., & Hajcak, G. (2013). Electrocortical responses to NIMSTIM facial expressions of emotion. *International Journal of Psychophysiology*, *88*(1), 17-25.

Soderstrom, H. (2003). Psychopathy as a disorder of empathy. *European child & adolescent psychiatry*, *12*(5), 249-252.

Sprengelmeyer, R., & Jentzsch, I. (2006). Event related potentials and the perception of intensity in facial expressions. *Neuropsychologia*, *44*(14), 2899-2906.

Stevens, D., Charman, T., & Blair, R. J. R. (2001). Recognition of emotion in facial expressions and vocal tones in children with psychopathic tendencies.*The Journal of genetic psychology*, *162*(2), 201-211.

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix.*Psychological Bulletin*, *87*(2), 245.

Streit, M., Wölwer, W., Brinkmeyer, J., Ihl, R., & Gaebel, W. (2000). Electrophysiological correlates of emotional and structural face processing in humans. *Neuroscience letters*, *278*(1), 13-16.

Suway, J. G., White, L. K., Vanderwert, R. E., Bar-Haim, Y., Pine, D. S., & Fox, N. A. (2013). Modification of threat-processing in non-anxious individuals: A preliminary behavioral and ERP study. *Journal of behavior therapy and experimental psychiatry*, *44*(3), 285-292.

Suslow, T., Junghanns, K., & Arolt, V. (2001). Detection of facial expressions of emotions in depression. *Perceptual and motor skills*, *92*(3), 857-868.

Sylvers, P., Lilienfeld, S. O., & LaPrairie, J. L. (2011). Differences between trait fear and trait anxiety: Implications for psychopathology. *Clinical psychology review*, *31*(1), 122-137.

Taroyan, N. A., & Nicolson, R. I. (2009). Reading words and pseudowords in dyslexia: ERP and behavioural tests in English-speaking adolescents.*International Journal of Psychophysiology*, *74*(3), 199-208.

Taylor, G. J., Bagby, R. M., & Parker, J. D. (2003). The 20-Item Toronto Alexithymia Scale: IV. Reliability and factorial validity in different languages and cultures. *Journal of psychosomatic research*, *55*(3), 277-283.

Tibi-Elhanany, Y., & Shamay-Tsoory, S. G. (2011). Social cognition in social anxiety: first evidence for increased empathic abilities. *Israel Journal of Psychiatry and Related Sciences*, *48*(2), 98.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., ... & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry research*, *168*(3), 242-249.

Utama, N. P., Takemoto, A., Koike, Y., & Nakamura, K. (2009). Phased processing of facial emotion: An ERP study. *Neuroscience research*, *64*(1), 30-40.

Valeriani, M., Betti, V., Le Pera, D., De Armas, L., Miliucci, R., Restuccia, D., ... & Aglioti, S. M. (2008). Seeing the pain of others while being in pain: a laser-evoked potentials study. *Neuroimage*, *40*(3), 1419-1428.

Van Bavel, J. J., Swencionis, J. K., O'Connor, R. C., & Cunningham, W. A. (2012). Motivated social memory: Belonging needs moderate the own-group bias in face recognition. *Journal of Experimental Social Psychology*, *48*(3), 707-713.

Viding, E., & McCrory, E. J. (2012). Genetic and neurocognitive contributions to the development of psychopathy. *Development and psychopathology*,*124*(Special Issue 3), 969-983.

Vitacco, M. J., Rogers, R., & Neumann, C. S. (2003). The Antisocial Process Screening Device An Examination of its Construct and Criterion-Related Validity. *Assessment*, *10*(2), 143-150.

Völlm, B. A., Taylor, A. N., Richardson, P., Corcoran, R., Stirling, J., McKie, S., ... & Elliott, R. (2006). Neuronal correlates of theory of mind and empathy: a functional magnetic resonance imaging study in a nonverbal task. *Neuroimage*,*29*(1), 90-98.

Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R. J. (2001). Effects of attention and emotion on face processing in the human brain: an event-related fMRI study. *Neuron*, *30*(3), 829-841.

Vytal, K., & Hamann, S. (2010). Neuroimaging support for discrete neural correlates of basic emotions: a voxel-based meta-analysis. *Journal of Cognitive Neuroscience*, *22*(12), 2864-2885.

Wakabayashi, A., Baron-Cohen, S., Uchiyama, T., Yoshida, Y., Kuroda, M., & Wheelwright, S. (2007). Empathizing and systemizing in adults with and without autism spectrum conditions: cross-cultural stability. *Journal of autism and developmental disorders*, *37*(10), 1823-1832.

Wenzlaff, R. M., Wegner, D. M., & Roper, D. W. (1988). Depression and mental control: the resurgence of unwanted negative thoughts. *Journal of personality and social psychology*, *55*(6), 882.

Williams, M. A., McGlone, F., Abbott, D. F., & Mattingley, J. B. (2005). Differential amygdala responses to happy and fearful facial expressions depend on selective attention. *Neuroimage*, *24*(2), 417-425.

Williamson, S., Harpur, T. J., & Hare, R. D. (1991). Abnormal processing of affective words by psychopaths. *Psychophysiology*, *28*(3), 260-273.

Wilson, K., Juodis, M., & Porter, S. (2011). Fear and loathing in psychopaths: A meta-analytic investigation of the facial affect recognition deficit. *Criminal Justice and Behavior*, *38*(7), 659-668.

Wolf, S., & Centifanti, L. C. M. (2014). Recognition of Pain as Another Deficit in Young Males with High Callous-Unemotional Traits. *Child Psychiatry & Human Development*, *45*(4), 422-432.

Woodworth, M., & Waschbusch, D. (2008). Emotional processing in children with conduct problems and callous/unemotional traits. *Child: Care, Health and Development*, *34*(2), 234-244.

Yang, T. T., Menon, V., Eliez, S., Blasey, C., White, C. D., Reid, A. J., ... & Reiss, A. L. (2002). Amygdalar activation associated with positive and negative facial expressions. *Neuroreport*, *13*(14), 1737-1741.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta psychiatrica scandinavica*, *67*(6), 361-370.

Appendix A: Participant Information Sheet 1

Project title: Empathising Processes in Relation to Personality Traits

Dear Participant,

My name is Emma Lethbridge. I am a PhD student at Sheffield Hallam University, my research investigates empathising processes with regards specific personality traits. Specifically we are investigating emotion recognition ability, emotional response, and empathy and social processing traits. The abilities and traits we are researching are present to a greater or lesser extent in everyone, they affect such aspects of your personality as, how much emotion you show and how concerned you may be about the emotions of others. The purpose of this study is to investigate the manifestation of these traits in a non-clinical, general population.

You are invited to take part in the research as part of that population. The study simply requires the completion of 4 short self-report questionnaires which measure both empathy and specific personality traits, and an emotion recognition and reaction task. Examples of statements which are included in the tasks include: "I feel bad or guilty when I do something wrong" and "I express my feelings openly", you will be required to rate how well such statements relate to your personality. Completing these measures should take no more than an hour of your time.

Please be aware that participation in this study is completely voluntary, you may leave at any time during the study and you may withdraw your data from the research for up to 7 days after your completion of the study tasks. All data will be stored and published confidentially. Participant contact details will be kept and stored separately from the data in order that your data can be effectively withdrawn if requested. The raw data will be stored with an identifier code number. In addition, your contact details and the code key will be kept separately from the raw data. Only the primary researcher and the project supervisors will have access to your data which will be stored securely under lock and key. Data extrapolated into software programs will be encrypted for protection.

As the primary researcher, I will be responsible for the protection for your data for the duration of its existence. The results of the study may be published in print and/or verbally presented, however no identifying data will be reported regarding any participants.

If you wish to withdraw your data, find out the overall results of the research or have any questions regarding my research please feel free to contact me on the details provided. When contacting me please provide your participant code which you will be provided with. Please note individual results and data analysis will not be provided.

These self-report measures will be used to identify participants for future empathy research using electroencephalography (EEG), therefore you may be contacted for recruitment into these future studies. However, you have both the right to refuse consent to be contacted regarding future studies and to refuse participation when contacted.

Please feel free to ask any questions you may have regarding the research procedure. You will be prompted to discuss the project before signing the consent form.

Many thanks,

Emma Lethbridge

Email: e.m.lethbridge@shu.ac.uk

Supervisor: Dr Paul Richardson

Email: dspr@exchange.shu.ac.uk

Appendix B: Consent Form1

Project title: Empathising Processes in Relation to Personality Traits

Primary Researcher: Emma Lethbridge

Please answer the following questions by circling your responses:

Have you read and understood the information sheet about this study?

YES / NO

Have you been able to ask questions about this study?

YES / NO

Do you feel that you have received enough information about this study? YES / NO

Do you understand that you are free to withdraw from this study:

• For up to 7 days following your completion of the research tasks?

YES / NO

• Without giving a reason for your withdrawal?

YES / NO

Do you agree to take part in this study?

YES / NO

Do you agree to be contacted by email regarding participation in future studies?

YES / NO

Your signature will certify that you have voluntarily decided to take part in this research having read and understood the information provided in the information sheet. It will

also

certify that you have had adequate opportunity to discuss the study with an

investigator and

that all questions have been answered to your satisfaction.

Signature of participant:...

Date:............................

Name (block letters):...

Signature of investigator:...

Date:............................

Participant contact details:

Email ....

Participant code ....

Please keep your copy of the information sheet. My contact email:

e.m.lethbridge@shu.ac.uk

Appendix C: Debriefing Information1

Project title: Empathising Processes in Relation to Personality Traits

Primary Researcher: Emma Lethbridge

Firstly, thank you for participating in my research. As explained previously the study you have just participated in is investigating personality traits and how they may interact with empathy processes. The purpose of this study is to investigate the manifestation of these traits and their effect, if any, on empathy processing in a non-clinical, general population.

The collected information will be assimilated with that of other participants and form the basis of unique research into the neurological correlates of empathy with regards to these personality traits using EEG technology. You may be contacted about participating in this EEG research in the future if you agreed to such on the consent form.

Please understand that you have the right to withdraw your participation for up to 7 days following the completion of this study without offering a reason for the withdrawal but that after this period withdrawal will not be possible (my contact details, and those of my supervisor, can be found below or on the participant information sheet provided earlier). Please feel free to ask any further questions you may have regarding my research.

Many thanks again for your participation,

Emma Lethbridge

My contact details:

Email: e.m.lethbridge@shu.ac.uk

Supervisor: Dr Paul Richardson

Email: dspr@exchange.shu.ac.uk

Appendix D: Participant Information Sheet 2

Project title: Empathising Processes in Relation to Personality Traits

Dear Participant,

My name is Emma Lethbridge. I am a PhD student at Sheffield Hallam University, my research investigates empathising processes with regards to personality traits. Specifically we are investigating emotion recognition ability, emotional response, and empathy and social processing traits. The abilities and traits we are researching are present to a greater or lesser extent in everyone, they affect such aspects of your personality as, how much emotion you show and how concerned you may be about the emotions of others. The purpose of this study is to investigate the manifestation of these traits in a non-clinical, general population and how these traits may affect the brain's response to certain stimuli. You have been ask to join this research as you previously completed some psychological measures for me and we are asking a cross section of the previous participants, whose data was complete and who consented to be contacted, to participate in this further electrophysiological research.

EEG requires a cap of electrodes to be placed on the scalp, this does not hurt and is non-invasive. Some conductive gel, used to improve EEG recordings, will be placed under the cap, however you will be given the opportunity to wash and dry your hair before leaving the research lab, should you wish too. The study you are about to take part in consists of 4 electroencephalographic (EEG) experiments lasting 10- 20 minutes each with a break in between. During the experiments you will be viewing a wide variety of photographic stimuli, some of which contain scenes of humans in unpleasant circumstances including moderate pain, distress and violence. However, these images are no more unpleasant than what you might see in a 15 rated movie and are only on screen for approximately 1 second each. Examples of some of the negative stimuli are included below, although not all stimuli included will be negative in nature. However, should the stimuli affect you, you are free to stop the experiment at any time without giving a reason by indicating to the experimenter that you wish to stop the experiment.

Examples of Human Negative Stimuli

Please be aware that participation in this study is completely voluntary, you may leave at any time during the study and you may withdraw your data from the research for up to 7 days after your completion of the study tasks. All data will be stored and published confidentially. Participant contact details will be kept and stored separately from the data in order that your data can be effectively withdrawn if requested. The raw data will be stored with an identifier code number. In addition, your contact details and the code key will be kept separately from the raw data. Only the primary researcher and the project supervisors will have access to your data which will be stored securely under lock and key. Data extrapolated into software programs will be encrypted for protection.

As the primary researcher, I will be responsible for the protection for your data for the duration of its existence. The results of the study may be published in print and/or verbally presented, however no identifying data will be reported regarding any participants. If you wish to withdraw your data, find out the overall results of the research or have any questions regarding my research please feel free to contact me on the details provided. When contacting me please provide your participant code which you will be provided with.

Please feel free to ask any questions you may have regarding the research procedure. You will be prompted to discuss the project before signing the consent form.

Many thanks,

Emma Lethbridge

Email: e.m.lethbridge@shu.ac.uk

Supervisor: Dr Paul Richardson

Email: p.richardson@shu.ac.uk

Appendix E: Consent Form 2

Project title: Empathising Processes in Relation to Personality Traits

Primary Researcher: Emma Lethbridge

Please answer the following questions by circling your responses:

Have you read and understood the information sheet about this study? YES / NO

Have you been able to ask questions about this study? YES / NO

Do you feel that you have received enough information about this study to give your informed consent to take part? YES / NO

Do you understand that you are free to withdraw from this study:

- During the experiment and for the 7 days following the data collection? YES / NO
- Without giving a reason for your withdrawal? YES / NO

Do you agree to take part in this study? YES / NO

Your signature will certify that you have voluntarily decided to take part in this research having read and understood the information provided in the information sheet. It will also certify that you have had adequate opportunity to discuss the study with an investigator and that all questions have been answered to your satisfaction.

Signature of participant:...

Date:............................

Name (block letters):...

Signature of investigator:...

Date:............................

Participant contact details:

Email ....

Participant code ....

Please keep your copy of the information sheet.

My contact email is: e.m.lethbridge@shu.ac.uk

Appendix F: Debriefing Information 3

Project title: Empathising Processes in Relation to Personality Traits

Primary Researcher: Emma Lethbridge

Firstly, thank you for participating in my research. As explained previously the study you have just participated in is investigating personality traits and how they may interact with empathy processes. The purpose of this study is to investigate the manifestation of these traits and their effect, if any, on empathy processing in a non-clinical, general population.

The collected information will be assimilated with that of other participants and form the basis of unique research into the neurological correlates of empathy with regards to these personality traits using EEG technology. Please understand that you have the right to withdraw your participation for up to 7 days following the completion of this study without offering a reason for the withdrawal, but that after this period, withdrawal will not be possible (my contact details, and those of my supervisor, can be found below or on the participant information sheet provided earlier).

Please feel free to ask any further questions you may have regarding my research.

Many thanks again for your participation,

Emma Lethbridge

My contact details: Email: e.m.lethbridge@shu.ac.uk

Supervisor: Dr Paul Richardson, Email: p.richardson@shu.ac.uk