POSED AND GENUINE SMILES:

AN EVOKED RESPONSE POTENTIALS STUDY

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ABSTRACT

The ability to recognise an individual's affective state from their facial expression is crucial to human social interaction. However, understanding of facial expression recognition processes is limited because mounting evidence has revealed important differences between posed and genuine facial expressions of emotion. Most previous studies of facial expression recognition have used only posed or simulated facial expressions as stimuli, but posed expressions do not reflect underlying affective state unlike genuine expressions. The current study compared behavioural responses and Evoked Response Potentials (ERPs) to neutral expressions, posed smiles and genuine smiles, during three different tasks. In the first task, no behavioural judgment was required, whereas participants were required to judge whether the person was showing happiness in the second task or feeling happiness in the third task. Behavioural results indicated that participants exhibited a high degree of sensitivity in detecting the emotional state of expressions. Genuine smiles were usually labelled as both showing and feeling happiness, but posed smiles were far less likely to be labelled as feeling happiness than as showing happiness. Analysis of P1 and N170 components, and later orbitofrontal activity, revealed differential activity levels in response to neutral expressions as compared to posed and genuine smiles. This differential activity occurred as early as 135ms at occipital locations and from 450ms at orbitofrontal locations. There were significant interactions between participant behavioural sensitivity to emotional state and P1 and N170 amplitudes. However, no significant difference in ERP activity between posed smiles and genuine smiles was observed until 850ms at orbitofrontal locations. An additional finding was greater right temporal and left orbitofrontal activation suggesting hemispheric asymmetry of facial expression processing systems.

1.0 INTRODUCTION

Recognition of facial emotional expressions has long been recognised as a vital social skill in humans and other primates (Darwin, 1872). Facial muscles are particularly highly developed and under complex systems of both volitional and non-volitional control in humans, enabling the display of different types and intensities of facial emotional expressions (Ekman, Wallace, & Hager, 2002). Emotion states are changes in multiple physiological systems that influence behaviour and response (Adolphs, 2002a; Griffiths, 1997; Prinz, 2004) and facial expressions can convey important information about the emotional state and dispositions of an individual to conspecifics (Schmidt & Cohn, 2001). It is widely agreed that there has been strong evolutionary pressure for successful production and recognition of facial expressions (Evans & Cruse, 2005; Fridlund, 1994; Plutchik, 2003; Prinz, 2004; Schmidt & Cohn, 2001). This is due to their functional value in influencing the behaviour of social group members. For example, sad or fearful expressions may recruit support and happy expressions co-operation or affiliation, while anger and disgust may be used to threaten and warn other individuals respectively (Erickson & Schulkin, 2003; Keltner, 2003; Marsh, Ambady, & Kleck, 2006). Given its central importance to human interaction, recognition of emotional state from facial expression has been the focus of extensive investigation.

Despite the proliferation of research in recent years (Eimer & Holmes, 2007; Adolphs, 2006; Parkinson, 2005; Posamentier & Abdi, 2003; Blair, 2003; Erickson & Schulkin, 2003; Adolphs, 2002a; Elfenbein & Ambady, 2002; Schmidt & Cohn, 2001), many aspects of the recognition of emotional state from facial expression remain poorly understood. Ongoing research in this field is important to increase understanding of the neural substrates that underlie human abilities and limitations. Such knowledge has diverse practical applications, from increasing understanding of the many clinical disorders where facial emotional expression processing abnormalities and consequent deficits in social interaction are evident (Kohler, Turner, Gur, & Gur, 2004; Csuklya, Czobora, Simona, & Takácsb, 2007), to aiding development of social perception applications in artificial intelligence (Fragopanagos & Taylor, 2005). For example, decreases in brain activity associated with recognition of facial expressions of happiness have been found in patients with diagnoses of depression (Surguladze et al., 2005), and decreases in brain activity associated with recognition of facial expressions of sadness have been found in patients with diagnoses of bipolar disorder (Lennox, Jacob, Calder, Lupson, & Bullmore, 2004). Understanding deficits and developing interventions will ultimately require an understanding of the normal processes underlying facial expression and emotional state recognition.

An important issue that has commonly been overlooked in the research literature is an examination of differences in response to posed and genuine facial expressions of emotion. Humans can exhibit a high degree of volitional control over their facial expression, including the capacity to pose an expression that is incongruent with their underlying emotional state (Parkinson, 2005). For example, a person who is not feeling happy may pose a smile to put someone at ease or to cover up a negative emotion (Ekman, 2001; Keating & Heltman, 1994; Ekman, Friesen, & O'Sullivan, 1988; Ekman & Friesen, 1982). In contrast, genuine facial expressions are congruent with the underlying emotional state. Thus observers are faced with the problem of detecting an individual's true emotional state from a facial expression. This factor has important consequences for facial expression research. The ability to detect an individual's emotional state from their facial expression (in addition to factors such as posture and movement patterns) is advantageous for observers because it enables more accurate prediction of the actions and intentions of the observed individual (Frith & Frith, 2006; de Vignemont & Singer, 2006; Fridlund, 2002; Keltner & Gross, 1999). As discussed in greater detail below, important distinctions exist between posed and genuine expressions. For example, posed and genuine smiles differ in the activation of facial muscles they engage, symmetry, duration, brain activation and situations where they are displayed (Ekman, Davidson, & Friesen, 1990). There are also differences in an observer's response to posed and genuine facial expressions. For example, compared with posed smiles, genuine smiles induce greater pleasure in observers (Surakka & Hietanen, 1998), observers are more likely to co-operate with individuals exhibiting genuine smiles (Miles, 2005), and posed and genuine smiles are differentially labelled by observers (Miles, 2005; Frank, Ekman, & Friesen, 1993). However, no research has yet examined the brain electrophysiological correlates that accompany different observer response patterns to posed and genuine smiles. The purpose of the current work was to investigate these correlates. Specifically the present work focused on posed and genuine smiles and the behavioural and neural responses of perceivers to these expressions. Posed and genuine smiles were selected for use in the present research as these have been the most well characterised expressions from a behavioural perspective in the research literature (Ekman, Davidson, & Friesen, 1990; Ekman, Hager, & Friesen, 1981; Frank, Ekman, & Friesen, 1993; Hager & Ekman, 1985; Miles, 2005; Miles & Johnston, 2007; Wylie & Goodale, 1988).

1.1 Posed and Genuine Smiles

The major limitation of most previous studies investigating responses to facial expressions of emotion is that they have used stimuli that have been posed or simulated. As already described, it has become increasingly evident that this methodology is problematic. Important differences between posed and genuine expressions mean that most prior work on facial expressions of emotion is potentially flawed because researchers invariably use posed or simulated facial stimuli. In particular, posed and genuine expressions such as smiles have been found to differ in several ways as outlined below.

1.1.1 Facial Muscles and Facial Action Units

The contraction of facial muscles underlying facial expressions are highly developed in humans. Ekman and colleagues' Facial Action Coding System (FACS) (Ekman et al., 2002) is a commonly used classification system to describe the muscles of the face and their movements. This system identifies which 'Action Units' (or 'AU', which may be individual muscles or groups of muscles) are active in a given expression. Posed expressions of emotion differ from genuine expressions of emotion in terms of their facial components or 'action units' and these differences may allow perceivers to differentiate between posed and genuine expressions.

Observable differences in muscle action between posed and genuine smiles were first reported by Duchenne de Bologne (Duchenne, 1862/1990). He conducted anatomical studies upon a patient with a condition of facial anaesthesia, using electrical stimulation to activate individual facial muscles. Observing the differences in appearance in the patient with anaesthesia, between a genuine smile and a smile resulting from electrical stimulation of individual muscles he concluded:

"The emotion of frank joy is expressed on the face by the combined contraction of the zygomaticus major muscle and obicularis oculi. The first obeys the will, but the second is only put into play by the sweet emotions of the soul… it is only brought into play by a true feeling, by an agreeable emotion" (p126).

In modern terms, zygomaticus major action (AU12) may occur in the absence of genuinely felt positive emotion whereas obicularis oculi action (AU6) occurs only when a person is genuinely feeling a positive emotion (Hager & Ekman, 1985; Ekman et al., 1988; Ekman et al., 1990; Williams, Senior, David, Loughland, & Gordon, 2001). The zygomaticus major muscle runs diagonally from the top of the cheek bone to the upper lip, while the obicularis oculi muscle orbits the eye. Zygomaticus major action pulls the lip corners outwards and upwards into a characteristic 'smile' expression. Contraction of the lateral part of obicularis oculi pulls the skin surrounding the eye towards centre of the eye causing characteristic wrinkles or 'crow's feet' at the outer corner of the eye, a narrowing of the eye aperture, and slight lowering of the eyebrows (Ekman et al., 2002). As shall be discussed, recent empirical evidence has brought into question how the absolute the distinction between posed and genuine smiles may be (Schmidt, Ambadar, Cohn, & Reed, 2006), but the relationship between physiognomic distinctions that do exist provide a strong basis for a perceiver to know the meaning of a smile.

1.1.2 Control of Facial Muscles

According to Damasio (1994), zygomaticus major muscles are under extensive neo-cortical control while obicularis oculi muscles are controlled by phylogenetically older subcortical pathways. In terms of neurophysiology, voluntary facial movements originate from the motor cortex and are innervated via the pyradimal tract (Gazzaniga & Smylie, 1990). In contrast, spontaneous facial movements originate in subcortical brain areas of the anterior cingulate, limbic cortices and basal ganglia (Damasio, 1994). Clinical evidence for this dissociation has been commonly observed in stroke patients. Patients with damage to the motor cortex experience asymmetrical voluntary facial movements, but symmetrical spontaneous movements. In comparison, stroke patients with damage to the anterior cingulate have asymmetrical spontaneous facial movements with impaired movement contralateral to the damaged hemisphere, but have no asymmetry in voluntary facial movements (Damasio, 1994). Recent functional magnetic resonance imaging (fMRI) evidence has confirmed these clinical observations of separate brain systems active during voluntary versus spontaneous expressions (Wild et al., 2006). Work by Ekman, Roper, and Hager, (1980) demonstrated that only around 20% of people have the ability to voluntarily contract the lateral aspect of the obicularis oculi, and it is this lateral aspect that is activated when spontaneously displaying positive affect (Ekman, Friesen, & O'Sullivan, 1988). Thus voluntary expressions such as posed smiles and spontaneous expressions such as genuine smiles have different neural substrates, though some debate continues over the nature of this difference and how absolute it is. For example, the obicularis oculi appear to receive some contralateral (though not bilateral) innervations from the primary motor cortex and zygomatic major muscles also appear to have more diverse innervations (Paradiso, Cunic, Gunraj, & Chen, 2005). Nonetheless, overall a range of evidence suggests that obicularis oculi activation may often be an important physiognomic cue available to perceivers, conveying information about the genuine affective state of an individual, as was originally proposed by Duchenne (Ekman et al., 1990; Ekman et al., 1988; Frank et al., 1993).

Recent research has demonstrated further differences between posed and genuine smiles, including symmetry and duration of expressions, patterns of brain activation during expressions, when such expressions are displayed and observer’s responses to such expressions.

1.1.3 Symmetry and Duration

There is also evidence to suggest that genuine smiles tend to be more symmetrical than posed smiles (Ekman et al., 1981; Hager & Ekman, 1985), at least in right handed females, though asymmetry with greater movement of left sided zygomatic muscles has been reported in spontaneous smiles in left handed females and males (Wylie & Goodale, 1988). Also genuine smiles tend to be smoother in patterns of muscular contraction throughout the expression than posed smiles (Frank et al., 1993; Rinn, 1984). There is also evidence of differences in duration including less variability for a genuine smile (Frank et al., 1993; Hess & Kleck, 1990; Schmidt, Cohn, & Tian, 2003). Thus in addition to obicularis oculi action other physiognomic cues of symmetry and duration are available to perceivers. Factors such as expression duration cannot be considered in research that uses only static images (including the current research). However, evidence suggests that such dynamic factors may not be as crucial to making distinctions between smile types as information already present in static images. Miles (2005) found no difference in accuracy judgments of the emotional state of posed and genuine smiles, between smiles presented as static images and smiles presented as dynamic images. Thus genuine expressions are generally more symmetrical, have smoother patterns of muscular contraction and are more consistent in duration than posed expressions.

1.1.4 Brain Activation

Differential patterns of brain activation have also been found between posed and genuine expressions. In an electrophysiological study (a study measuring electrical patterns of brain activation as described later in this work), Ekman et al. (1990) found greater left anterior temporal and parietal activation for participants whose smiles included obicularis oculi action, compared to participants showing smiles without this action. The reasons for this differential activity are unclear, although the authors speculated that it might reflect increased verbal cognitive activity during genuine smiles.

1.1.5 When Expressions are Displayed and Observer Response

Smiles with obicularis oculi action are more likely to occur when individuals are experiencing positive emotions and this finding has been reported across a range of contexts. Examples include: children succeeding at a game compared to children failing at a game (Schneider, 1987), happily married compared to non-happily married couples (Levenson, 1989), and winners in Olympic competition compared to runner ups (Matsumoto & Willingham, 2006). Smiles with obicularis oculi action are less common in individuals with depression (Berenbaum & Oltmanns, 1992; Katsikitis & Pilowsky, 1991), grief due to death of a romantic partner (Bonanno & Keltner, 1997), schizophrenia (Berenbaum & Oltmanns, 1992; Keltner & Kring, 1998), and among children who have experienced sexual abuse (Bonanno et al., 2002).

Research also indicates that posed and genuine smiles evoke differential responses in observers. Targets displaying genuine as compared to posed smiles are more likely to be perceived as feeling happiness (McLellan, 2008; Miles, 2005; Miles & Johnston, 2007; Scherer & Ceschi, 2000). Participants have also been shown to classify posed and genuine smiles as ‘social smiles’ and ‘enjoyment smiles’ respectively, and evaluate those showing genuine smiles more positively (Frank et al., 1993). Both older children and adults have demonstrated an ability to use facial information to judge whether emotion is genuine or not (Gosselin, Perron, Legault, & Campanella, 2002). Research by Surakka and Hietanen (1998) showed that genuine but not posed smiles induce the experience of pleasure in observers.

They also found that observer facial electromyography (measurement of the electrical activity of facial muscles) discriminated between viewing of genuine smiles and neutral expressions, but not between viewing of posed smiles and neutral expressions. Peace, Miles and Johnston (2006) found that T-shirts were evaluated more positively if they were worn by a person with a genuine smile than by the same person displaying a neutral expression or posed smile, suggesting that a carryover positive evaluation effect occurs. Thus it seems that genuine smiles are responded to differently compared to both posed smiles and neutral expressions, in a variety of ways.

Miles (2005) and Miles and Johnston (2007) examined detection rates of happiness in a two task experimental paradigm. In the 'show' task, participants classified neutral expressions, posed smiles, and genuine smiles as 'showing happiness' or 'not showing happiness'. In the 'feel' task, participants classed those same expressions as 'feeling happiness' or 'not feeling happiness'. Using a signal detection analysis it was found that participants exhibited a high degree of sensitivity to the emotional state of the target, and more so when judging emotion felt than when judging emotion shown. As described by Miles (2005), the distinction in tasks between judging whether or not someone is 'showing' happiness as opposed to whether someone is 'feeling' happiness was an attempt to vary the decision criterion used by participants. In other words, people are likely to have a stricter criterion for believing someone is really feeling an emotion, as opposed to just showing it on their face. Thus, response bias towards labelling an individual as happy was correctly predicted to be less in the feel as compared to the show condition. In addition, this approach (happy or not happy), as opposed to categorisation of expressions as 'social' or 'enjoyment' (e.g. Frank et al., 1993) or 'posed' and 'genuine', was used for a number of reasons. Firstly, knowledge about the underlying emotional state of an individual is of primary importance in terms of opportunities for interaction, not the structural properties of the expression itself. Furthermore using a simple direct categorisation of 'happy' or 'not happy' minimises potential for misunderstanding that could occur with more theoretical accounts involving constructs of social display rules and deception. In addition labelling a person as intentionally deceptive is counter to generally positive biases reported in initial interpersonal impression formation (Miller & Felicio, 1990). Thus it was considered that this simpler affective judgment task ('happy' or 'not happy') was a more ecologically valid task than the categorisation tasks used in previous research on posed and genuine expressions.

Recent empirical research using a game theory 'Prisoners Dilemma'[1] experiment (Miles, 2005) has also supported theoretical proposals (Owren & Bachorowski, 2001) that genuine, but not posed smiles, elicit co-operative behaviour from interaction partners. According to Owren and Bachorowski's (2001) 'selfish gene' account of smiling and laughter, Duchenne variants of smiling evolved as a form of honest signalling, displaying the signaller's genuine positive emotional state in the presence of the receiver. Receivers benefit from being sensitive to the information conveyed by the signal, as the potential for co-operative interaction is likely to be greater with an individual in a positive emotional state. Evidence suggests that co-operative behaviors are evolutionarily advantageous strategies in many types of social interaction, despite ultimately selfish competition at a genetic level (Dawkins, 1976; Nowak, 2006; Santos & Pacheco, 2006). Research also supports the idea that motivation for altruistic co-operative behaviour and for punishment of co-operative defectors is innate and adaptive in humans and other primates (Hauser, 2006; Vogel, 2004). In a study examining the neural correlates of such processes, co-operative behaviour was found to activate reward

[1] The Prisoners Dilemma is a well researched experimental paradigm where two individuals interact (Kollock, 1998) Both parties have incentive to act selfishly but if both parties do so then a less optimal outcome occurs than if both parties co-operate.

related neural circuits in the human brain, as did detection and punishment of defectors (Fehr & Rockenbach, 2004). However, from an evolutionary perspective, systems of signalling co-operative intention are vulnerable to exploitation through cheaters. For example, individuals who signal a display advertising positive emotion to encourage other individuals to act co-operatively in absence of reciprocation will have an evolutionary advantage. Owren and Bachorowski's theory posits that there was natural selection pressure for evolution of hard to fake signals and for sensitivity to detection of these in receivers. A hard to fake signal is the inability in most people to volitionally activate the obicularis oculi muscle action present in a genuine smile. Such signals would make it difficult for cheaters to reap benefits by signalling co-operative intent in the absence of genuine positive emotion and intention to reciprocate. Thus genuine smiles are proposed to be an important adaptation for promoting and maintaining such co-operative social interactions.

1.1.6 Summary

The distinction between posed and genuine expressions is an important factor that should be examined further in emotion recognition research. The ability to discriminate between posed and genuine facial expressions depends upon the presence of reliable observable markers that enable such discriminations to be made. Research findings suggest that such markers are indeed present and particularly consistent and well studied in the case of posed and genuine smiles. At the current time there is strong evidence from behavioural studies that genuine smiles are associated with positive emotional states, while posed smiles are not. There is consistent evidence that these physiognomic cues associated with posed and genuine smiles are differentially perceived by observers and evoke different behavioural responses in social interactions. However, no research has yet investigated the brain's electrophysiological correlates of these perceptual discriminations between posed and genuine smiles. The goal of the current work was to investigate neural face recognition processes associated with the observed behavioural patterns.

1.2 Neurophysiology of Facial Expression Recognition

1.2.1 Introduction and Overview

The task faced by the human brain in perceiving, recognising, and acting adaptively based on facial expression stimuli involves a large range of brain structures (Adolphs, 2002a; Haxby, Hoffman, & Gobbini, 2000; Vuilleumier & Pourtois, 2007). In relevant situations and tasks, not only must facial expressions be correctly perceived, but information concerning identity and social salience unique to the perceived individual and situation must often be integrated. Furthermore this must happen accurately and rapidly, in response to an individual face, which is structurally very similar to many other faces.

A picture of how the brain functions to achieve these goals has been emerging in the research literature. The cortical and subcortical systems involved in facial expression processing are specific yet distributed both spatially and temporally, in a highly interactive network. An influential model of facial expression processing was developed by Adolphs (2002a), based upon a review of diverse empirical findings from neuroimaging studies, lesion studies, single cell recording studies and behavioural studies. This model incorporates previous models (Bruce & Young, 1986; Haxby et al., 2000) and proposes three general phases and a feed forward and feedback system. In an initial 'structural encoding' phase lasting until approximately 120 ms post stimulus, fast perceptual processing of highly salient stimuli occurs through a system involving the superior colliculus, thalamus, amygdala and striate cortex. During this structural encoding phase a face might be identified as a face as opposed to another class of stimulus, and perhaps registered as having generally negative or positive valence. This is followed by a ‘recognition phase’ peaking at approximately 170ms post stimulus which involves more detailed perception and emotional reaction, through a system involving the striate cortex, fusiform gyrus, superior temporal gyrus, orbitofrontal cortex, amygdala, basal ganglia, hypothalamus and brainstem. In this recognition phase it is thought that an individual’s identity and emotional expression might be categorised in detail. In a third ‘conceptual phase’ occurring after 300ms, more detailed conceptual knowledge is integrated through a system involving the fusiform gyrus, superior temporal gyrus, orbitofrontal cortex, somatosensory cortex and insula cortex. During this conceptual phase identity and emotional expression are thought to be linked to other important information, for example memories about the person and potential responses given the current situational context.

Within this distributed system, the inferior occipital gyri, fusiform gyrus and superior temporal cortex are believed to comprise the core system for facial identification and emotional expression recognition. Palermo and Rhodes (2007) stressed the important modulating effect of a cortical fronto-parietal spatial attention network upon the facial expression processing systems outlined above. This network controls task parameters such as the explicit focus of attention and involves the dorsolateral prefrontal cortex, intra-parietal sulcus, and parietal cortex (Hopfinger, Buonocore, & Mangun, 2000). Processing of information about identity, context, and social relevance are dissociable from facial expression processing, but processed in parallel, with different spatial and temporal substrates. Anterior temporal areas are important in providing identity and biographical information (Haxby et al., 2000), with emotional cueing (attaching emotional saliency to faces) via amygdala-hippocampal connections (Palermo & Rhodes, 2007). The right hemisphere of the brain is thought to be more specialised for holistic processing of faces and emotional and social processing in general (Adolphs, 2002b). Bilateral activation of all areas involved in face processing occurs during face recognition, but is stronger in the right hemisphere, and in most areas activation is greater for faces displaying emotional expressions as opposed to neutral faces (Ishai, Schmidt, & Boesiger, 2005). However despite a generally accepted greater role for the right hemisphere in processing emotion, research has also suggested that the left hemisphere may have a specific role in processing positive emotions (Root, Wong, & Kinsbourne, 2006; Krolak-Salmon et al., 2001). Thus when examining the neurophysiological substrates that underlie the psychology of facial expression recognition, interaction effects between hemisphere, attentional focus and task, and context, must all be considered as important variables in the interpretation of patterns of brain activation.

In summary, the evidence seems broadly in accordance with the idea that facial expression recognition consists of an initial rapid evaluation stage where a stimulus is checked for general emotional content, and then a more prolonged stage where more detailed evaluation of social significance occurs (for example incorporating identity information). Later conceptual planning stages involve these evaluations as part of wider cognitive processes (for example placing observations into a situational context demanding a certain range of responses). Thus facial expression processing, may be considered as an array of processes that are drawn upon differentially according to particularities of a situation (Adolphs, 2002b).

The current work uses the research technique of Evoked Response Potential recording (a form of Electroencephalography or EEG) to investigate neural activity associated with responses to posed and genuine expressions of happiness. Specifically, it sought to elucidate the temporal and spatial patterns of cortical response to posed and genuine smiles.

1.2.2 EEG and Evoked Response Potentials

Traditional research techniques using behavioural measures are complemented by a proliferating range of neuroimaging technologies including evoked response potentials (ERPs), magnetoencephalography (MEG), positron emission tomography (PET), and functional magnetic resonance imaging (fMRI). These brain imaging techniques have the advantage of providing greater information than behavioural measure techniques about the specific neural systems involved in a task, and can also do so in research paradigms where a specific behavioural response is either not required or desired. From a clinical perspective neuroimaging enables construction of more precise neuropsychological models and assessment techniques to aid in analysis of deficits and plan interventions. The neuroimaging technique of ERP recording examines patterns of electrophysiological brain activity. In particular ERP techniques can be used to investigate the pattern of brain activity associated with the onset or changes in visual stimuli, such as facial expressions.

ERP techniques take advantage of the fact that the natural electrical activity of neurons in the brain produces electrical currents spreading out from the site of activity throughout the head, and to the surface of the scalp. Electrical activity generated by a nerve cell produces a 'dipole' - an electrical field that has a positive charge in one direction relative to the neuron and a negative charge in the opposite direction.[2] The dipole produced by a single neuron is

[2] Dipole generators also produce magnetic fields which pass undistorted through the brain and skull. These magnetic fields can be measured with magnetocephalography (MEG), though this technique is considerably more expensive than ERP techniques. Some MEG research is considered in this work.

too weak to detect with current technology, but the activity of many thousands of neurons acting coherently produces a measurable signal – the electroencephalogram or EEG. This signal can be interpreted as activation of specific areas of cortex (Luck, 2005; Michel et al., 2001). Such EEG activity evoked in response to a specific event is termed an 'Evoked Response Potential' (sometimes also referred to as an Event Related Potential) or 'ERP'. Typical ERP research procedures use a series of electrodes attached to the scalp to record temporal changes in cortical bioelectrical activity in response to a discrete event - such as visual presentation of a facial stimulus.

Averaging

The ERP to a single event is usually too small to be detectable. Brain responses are typically in the order of 5 μV (microvolts), while the noise level is around 20 μV. To deal with this problem, the data are divided into time segments with a zero point defined as the onset of the stimulus of interest. Many of these time segments can be averaged together so that random noise will cancel out, revealing the signal of interest. Measuring repeated ERPs to the same event (for example, a 1000ms stimulus presented 100 times) and averaging these readings allows patterns of brain response activity specific to that stimulus to be identified. Various post-stimulus deflections from the baseline activity are often referred to in the research literature as ERP 'components'.

Components

The ERP Components are commonly labelled according to: the location of the scalp electrode, whether the polarity is a positive (P or positivity) or negative (N or negativity) deflection away from baseline brain electrical activity (positive or negative depends on alignment of underlying neurons relative to the recording equipment, i.e. P and N is location sensitive and dependent on the alignment of neurons in a given area), peak or mean amplitude of the deflection, and the latency (in ms, or ordinal number of appearance) of peak amplitude after stimulus onset. Components are sometimes also labelled as exogenous to indicate dependence on external factors (such as stimulus properties) or endogenous to indicate dependence on internal factors (such as an internally regulated task performed by the subject). Labelling components helps recognition and communication between research groups. However, much debate exists over precisely what may be inferred from particular patterns of activation (Luck, 2005; Picton et al., 2000), and what is a readily identifiable component, especially at later time periods. Activity and components thought relevant to facial expression recognition research are discussed in detail later in this work. Following common labelling conventions in the facial expression research literature, these are primarily the P1 (the first positive component occurring at approximately 120ms), the N170 (the first negativity occurring at approximately 170ms), and later more extended processing at orbitofrontal locations.

Advantages and Limitations of ERP

ERP components at a particular scalp electrode represent the summation of electrical activity at that topographical location, not a direct mapping of an underlying cortical generator. Dipoles distort as they interact with fields produced by dipoles of different polarities and as they pass through the convoluted medium of the brain and skull. In addition only dipoles of sufficiently large amplitude, which are not also cancelled by dipoles of opposite polarity, are observable. When dipoles of opposite polarity are close (i.e. locations where some clusters of neurons are aligned one way but others are aligned in the opposite direction, for example where cortical surface and cerebellum are close to each other) they cancel one another, making recording of these areas difficult or impossible. Also subcortical areas are located deep in the brain making ERP recording from these areas unfeasible in typical recording paradigms. The result of this such limitations is that accurate neuroanatomical localisation of ERP components must rely upon source localisation procedures involving complementary neuroimaging techniques and mathematical modelling (Herrmann, Ehlis, Muehlberger, & Fallgatter, 2005; Picton et al., 2000). However, despite these limitations, ERP techniques provide excellent temporal accuracy, as well as being inexpensive in terms of setup and running costs in comparison to other neuroimaging techniques. The most important advantage of ERP techniques is that they offer a level of temporal specificity unmatched by other neuroimaging techniques, for example, 1000 times more powerful temporal resolution than fMRI (Luck, 2005). This enables the study of highly detailed sequential patterns of brain activation in response to stimuli such as faces.

Research utilising ERP techniques has contributed significantly to our understanding of the neurophysiology of facial expression perception in recent years, revealing dissociable patterns of processing in diverse brain areas. The following sections consider this research in detail.

1.2.3 ERPs and Facial Expression Research

Diverse, sequential and extended patterns of electrophysiological brain activation specific to faces and facial expression have been observed. ERP research has primarily focused upon the activity of the occipital visual area and the 'P1' component (the first positive deflection occurring in response to any visual event), the temporal area and the 'N170' component (the first negative deflection in activity in response to any visual event), and more extended and distributed processing components, including frontal areas. As shall be described, differential patterns of activation in response to faces and facial expressions as compared to other classes of object have been observed in these components. These three components are thought to represent vital stages of facial expression processing among the core cortical areas involved in face processing and approximately correspond to Adolph's (2002a) 'structural encoding phase' (approx 120ms), 'recognition phase' (approx 170ms), and 'conceptual phase' (post 300ms) that have been described above (section 1.2). Feedback and feed forward processes operate between these areas and other brain areas including subcortical regions such as the amygdala are crucially involved, although such subcortical activity is unobservable with typical ERP procedures and collateral methods such as fMRI are needed to observe such activity.

Most relevant to the current thesis, no previous research has examined ERP responses for posed and genuine smile expressions. Instead previous research has used posed expressions (Ashley, Vuilleumier, & Swick, 2004; Batty & Taylor, 2003; Bobes, Martin, Olivares, & Valdes-Sosa, 2000; Eimer, Holmes, & McGlone, 2003; Herrmann et al., 2002; Krolak-Salmon, Fischer, Vighetto, & Mauguiere, 2001; Marinkovic & Halgren, 1998; Sato, Kochiyama, Yoshikawa, & Matsumura, 2001; Streit et al., 2003; Werheid, Alpay, Jentzsch, & Sommer, 2005) such as those from the Ekman "Pictures of Facial Affect' series (Ekman & Friesen, 1976), or computer morphing of posed expressions (Balconi & Lucchiari, 2005; Campanella, Quinet, Bruyer, Crommelinck, & Guerit, 2002), or schematic expressions such as line drawings (Eger, Jedynak, Iwaki, & Skrandies, 2003), or did not state whether posed or genuine expressions were used (Orozco & Ehlers, 1998). Differences in ERP activity between posed smiles and neutral expressions has been found in previous research, but it was uncertain to what extent such findings would generalise to genuine smiles. This previous research and potential differences in ERP activity between posed and genuine smiles, is discussed next with respect to the occipital P1 component, the temporal N170 component, and later orbitofrontal activity.

1.2.4 The Occipital P1 Component

The P1 component is elicited by all visual stimuli, typically starting 60-90ms post stimulus and peaking between 100-130ms. It is largest at lateral occipital sites (Luck, 2005). Using ERP mathematical modelling techniques combined with fMRI data, this component has been localised to sources within the dorsal extrastriate cortex of the middle occipital gyrus in its early stages and to the ventral extrastriate cortex of the fusiform gyrus in its later stages (Di Russo, Martinez, Sereno, Pitzalis, & Hillyard, 2002). These brain regions are thought to have important roles in visual processing, with the fusiform gyrus thought to be particularly important for face processing (Allison, Puce, Spencer, & McCarthy, 1999; Rossion, Caldara et al., 2003).

Recent ERP and MEG evidence suggests that face selective processing (differential processing occurring in response to faces as compared to other classes of visual object) starts in this initial P1 phase. In a combined ERP and MEG study Linkenkaer-Hansen et al. (1998) reported increases in peak latency and amplitude of the P1 component in response to inverted faces as compared to normal faces (an inversion effect not observed in response to inverted objects) suggesting that a degree of face specific processing may be occurring. Taylor (2002) also found that P1 ERP latency increased in response to inverted faces as compared to normal faces. Itier & Taylor (2004) found that supplemental ERP brain activity occurred for faces compared to objects as early as 120ms, and that this activity continued to the later N170 component. Liu, Harris, & Kanwisher, (2002) found that (MEG) amplitude at 100ms was correlated with successful categorization of stimuli as faces, but not with successful recognition of identity, suggesting that at 100ms stimuli are categorised as faces, but individual identity is not yet recognised. Herrmann, Ehlis, Ellgring, and Fallgatter (2005) reported differences between ERPs to faces and buildings at 107ms, and also between faces and scrambled faces in a second experiment designed to control for possible contrast differences between faces and buildings. Similarly a MEG study found differences at 120ms between 'perceived as face' stimuli and 'not perceived as face' stimuli that were otherwise identical in low-level visual properties (Kato et al., 2004). Lastly, an MEG study comparing responses to pairs of faces, pairs of objects, or pairs of abstract geometric patterns, found that amplitudes at 30-60ms to the first image in a pair of faces were significantly larger than the responses to the second face of the pair or to individual faces, and differences within pairs were less for objects and absent for abstract patterns (Braeutigam, Bailey, & Swithenby, 2001). The early responses observed in these studies are consistent with evidence from priming research, where faces are presented below conscious awareness for brief intervals (for example 30ms), yet still induce differential subcortical activation as measured by fMRI, and influence behaviour subconsciously (Palermo & Rhodes, 2007). Thus taking into account the available evidence, it would appear that some face specific processing starts early in the brain during the P1 component.

In addition to an early selectivity for faces several recent studies have reported effects of facial expression upon the P1 component. A global effect of emotional expression on P1 ERP amplitude was found by Batty and Taylor (2003), with smallest amplitudes for neutral and surprised expressions as compared to sad, fearful, angry and happy expressions. However, post-hoc analysis in this study failed to reveal significant differences between any two emotions thus these results must be interpreted with caution. MEG studies have found a global effect of emotional expression as compared to neutral expression on P1 amplitude (Streit et al., 2003) and that responses to happy and sad faces differed from responses to neutral faces at 110ms at a midline occipital source (Halgren, Raij, Marinkovic, Jousmaeki, & Hari, 2000). In a study using schematic faces and scrambled schematic faces as stimuli, and global field power (GFP)[3] measures, early differential activity (80-90ms) occurred for negative as compared to positive and neutral faces (Eger et al., 2003). Increased P1 amplitudes in response to fearful face expressions have also been reported in several ERP studies (Pizzagalli, Greischar, & Davidson, 2003; Pourtois, Grandjean, Sander, & Vuilleumier, 2004; Pourtois, Thut, Grave de Peralta, Michel, & Vuilleumier, 2005; Pourtois & Vuilleumier, 2006), indicating that at least some facial expressions may influence P1 amplitude. Personal affective judgements of faces (face stimuli assessed as liked or disliked by individual ratings after ERP recording was completed) have also been found to significantly modulate early ERP responses (80-116ms for right hemisphere, 104-160ms left hemisphere) (Pizzagalli, Regard, & Lehmann, 1999) and 160ms in a second study (Pizzagalli et al., 2002), with increased amplitudes associated with liked faces.

In summary, evidence indicates that modulation of P1 activity by faces and facial expression occurs, though it is currently uncertain to what extent this modulatory activity occurs in response to posed and genuine smile expressions. In addition to early coarse perceptual discrimination, such modulation may represent recruitment of extrastriate cortex resources by frontoparietal attentional networks and/or subcortical structures such as the amygdala (Vuilleumier & Pourtois, 2007), especially in response to 'threat' stimuli such as fearful facial expressions. Exogenous rather than endogenous attention is thought to dominate P1 component modulation (Adolphs, 2002b; Vuilleumier & Pourtois, 2007). For example in a

[3] A measure using the standard deviation of amplitude of all electrodes at a given time point (so a single quantitative value) (Lehmann & Skrandies, 1980).

study comparing effects of exogenous attention, enhanced P1 activity occurred to exogenous cues (squares appearing uncued) regardless of where endogenous attention was directed, whereas later ERP components were modulated by the endogenous attention (Hopfinger & West, 2006). However, further work will be needed to untangle the influences of attention, stimulus saliency, and task demands on the P1 component.

Given the results of previous research cited above, in the current work it was predicted that amplitudes of the P1 component would likely be greater to posed and genuine smiles than to neutral expressions and probably unmodulated by endogenous attention, such as attentional focus to task parameters. In other words there was expected to be no difference in amplitudes according to what task the person was engaged in. Based upon the weight of research studies cited above, no difference in amplitude between posed and genuine smiles would be expected either, reflecting the proposition that a relatively coarse ‘neutral expression or not’ discrimination process occurs at this structural encoding phase, with finer grained discriminations only occurring in later recognition and/or conceptual phases. Importantly however, some previous research has indicated some modulating effect of affective judgement (liked or disliked) upon the P1 component (Pizzagalli et al., 1999; Pizzagalli et al., 2002). Thus given findings of greater pleasure in observers viewing genuine as compared to posed smiles or neutral expressions (Surakka & Hietanen, 1998), as well as findings that individuals with genuine smiles are evaluated more positively (Frank et al., 1993), greater P1 amplitude for genuine smiles compared to posed smiles and neutral expressions might be observed in the current experiment.

1.2.5 The Temporal N170 Component

Visual stimuli evoke a negative potential peaking approximately 170ms post stimulus which is largest over lateral temporal sites (especially over the right hemisphere), and this response is increased for faces as compared to non-face stimuli (Bentin, Allison, Puce, & McCarthy, 1996). This N170 component is thought to reflect a detailed face perception and structural encoding process according to Bruce and Young (1986). Evidence supporting this notion includes the observation that N170 amplitude increases in response to inverted as opposed to upright faces but not for inverted objects compared to upright objects (Bentin et al., 1996) and that an increased response to faces compared to non-faces is absent in patients with prosopagnosia (an inability to recognise faces) (Bentin, Deouell, & Soroker, 1999; Eimer & McCarthy, 1999). These findings suggest that the N170 reflects face specific processing, although a possibly important qualifier to this claim is that similar patterns of modulation (inversion effects or activation of brain regions in fMRI studies) have been observed for classes of objects for which viewers have extensive expertise (Itier & Taylor, 2004a). Thus amplitude increases due to inversion effects may reflect the increased processing difficulties that occur for classes of objects viewers are experts at processing holistically (faces being a class of object that is universally important to people). However, there is nonetheless widespread agreement that the brain regions generating the N170 component have a crucial role in face processing. It has been proposed that a crucial computational role for the fusiform area may be the holistic or global integration of earlier structural encoding of specific face features (Behrmann, Avidan, Marotta, & Kimchi, 2005; Bentin, Degutis, D'Esposito, & Robertson, 2007).

Source modelling suggests that increased N170 component activity for faces compared to non-face stimuli reflects activation of supplementary face specific neural sources and not just increased activity of the same brain sources active during non-face visual processing (Itier &

Taylor, 2004b; Rousselet, Mace, & Fabre-Thorpe, 2004). The fusiform gyrus and superior temporal sulcus are thought to be the primary dipole generators of the N170 component (Bentin et al., 1996; Herrmann et al., 2005).

Most studies of the N170 have found this component to be unaffected by emotional expression (Bobes et al., 2000; Eimer & Holmes, 2002; Eimer et al., 2003; Halgren et al., 2000; Herrmann et al., 2002; Krolak-Salmon et al., 2001; Munte et al., 1998; O'Connor, Hamm, & Kirk, 2005). However, a minority of studies have found some modulation of the N170 component by emotion. Batty and Taylor (2003) used a greater number of face stimuli than most previous studies to reduce habituation effects to repeated stimuli - which have been shown to decrease N170 amplitudes (Heisz, Watter, & Shedden, 2006; Henson, Shallice, & Dolan, 2000), and related processing (Breiter et al., 1996; Feinstein, Goldin, Stein, Brown, & Paulus, 2002). Batty and Taylor, (2003) found that positive and neutral expressions elicited N170 earlier than negative emotions, and amplitude to fearful faces was increased relative to neutral and surprised expressions. A study by Ashley et al. (2004) found effects of emotional expression on N170 amplitude, however these interacted with face orientation (inversion) and no differences between expressions were significant for upright faces. One highly relevant study found that liked faces elicited stronger N170 activation than disliked faces (Pizzagalli et al., 2002), and it was suggested this may reflect enhanced attention to liked faces due to their saliency in certain contexts. Miyoshi, Katayama, and Morotomi (2004) examined processing of change in facial expression (smiles and neutral), presenting smile faces preceded by either a neutral face of the same person, a smile face of a different person or a smile face of the same person. Although responses to preceding faces did not differ in their N170 component, faces elicited larger N170 amplitude for expression change in the same face relative to change in identity or change in expression and identity, suggesting an important role for this component in expression processing. Another study using a similar experimental methodology reported similar patterns of results (Campanella et al., 2002). Context also affects processing, for example N170 amplitudes were found to increase for faces presented in fearful, as opposed to neutral scenes (Righart & de Gelder, 2006). The picture that emerges from previous research is that differential N170 processing of individual facial expression types is not measurable through ERP research, though facial expression change, context, and attentional preference, may influence amplitude of the N170 component.

Indications are that standard ERP techniques may simply have insufficient sensitivity to measure the differential processing of facial expressions occurring at the N170 component, except in terms of attentional focus and facial expression change paradigms. Complementary neuroimaging technologies have however revealed a pattern of response to facial expression not evident in most ERP research. Increased right fusiform gyrus activation at 150ms with happy faces generating greater activation than neutral faces have been reported in a study utilising MEG techniques (Lewis et al., 2003). Another study using schematic faces as stimuli found larger GFP N170 field strengths for negative as compared to neutral and positive expressions (Eger et al., 2003). An fMRI study found increased fusiform gyrus activation to variations in expression, in addition to findings of greater activation when judgments of expression were made (Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005).

Overall the evidence suggests that facial expression processing occurs at the N170 component, affected by attention, especially endogenous attention (Holmes, Vuilleumier, & Eimer, 2003; Holmes, Winston, & Eimer, 2005; Hopfinger & West, 2006), though stimulus context, novelty and saliency also appear to be important modulating factors. For example expressional change may capture attention and increase processing of this component

(Campanella et al., 2002; Miyoshi et al., 2004), and a recent study also reported significant increases in amplitude of the N170 component in response to increased intensity of emotional expression, (but no effect of emotional expression type (angry, disgusted, fearful)) (Sprengelmeyer & Jentzsch, 2006). However, in general N170 facial expression discrimination processes do not appear to be easily observable with ERP techniques.

Given the results of most previous ERP research, in the current work it was predicted that amplitudes of the N170 component would be similar between neutral expressions, posed smiles and genuine smiles. However, similar to the P1 component, previous research has indicated some modulating effect of affective judgement (liked or disliked) upon the N170 component (Pizzagalli et al., 2002). Given findings of greater pleasure in observers viewing genuine as compared to posed smiles or neutral expressions (Surakka & Hietanen, 1998) and more positive evaluation of genuine smiles (Frank et al., 1993), it was possible that this effect would be evident as greater N170 amplitude for genuine smiles compared to posed smiles and neutral expressions.

1.2.6 Later Orbitofrontal Activity

Compared with earlier ERP components like the P1 and N170, later ERP activity consists of longer lasting deflections thought to reflect more detailed and extended information processing (Luck, 2005). These extended elements of the EEG are often most usefully analysed by examining average amplitudes at time windows of specified latency (for example systematic 100ms time windows) rather than at a single latency peak point (Batty & Taylor, 2003; Eimer et al., 2003; Krolak-Salmon et al., 2001; Marinkovic & Halgren, 1998). Given its crucial role in social perception described below, yet the relatively limited amount of previous ERP research investigating facial expression processing at this location, the orbitofrontal cortex was a major region of interest in the current work.

The frontal cortex, and particularly the orbitofrontal cortex, is widely acknowledged to have a crucial role in modulating social interaction processes including facial expression processing (Adolphs, 2002b; Palermo & Rhodes, 2007; Posamentier & Abdi, 2003; Vuilleumier & Pourtois, 2007). Patients with damage to the orbitofrontal cortex often experience severe deficits in social interactions (Bechara, Damasio, & Damasio, 2000; Lezak, Howieson, & Loring, 2004) and in facial expression recognition (Hornak, Rolls, & Wade, 1996; Keane, Calder, Hodges, & Young, 2002). As measured with fMRI, bilateral orbitofrontal cortex activation has been noted when perceivers made judgements of happiness in a facial expression decision task (Gorno-Tempini et al., 2001), and increased orbitofrontal cortex activation in response to smiles as compared to neutral expressions has also been observed (O'Doherty et al., 2003). In another fMRI study significant activation of left ventral prefrontal areas was found when subjects held happy faces in mind, as compared to neutral faces in a control condition (Dolan et al., 1996). Frontal activation in facial expression decision tasks has also been recorded with MEG measures (Streit et al., 1999). Thus a range of evidence suggests that the orbitofrontal cortex is an area that should be investigated further in ERP research examining facial expressions.

Differential frontal processing of facial expression has been noted in several previous studies (Esslen, Pascual-Marqui, Hell, Kochi, & Lehmann, 2004; Batty & Taylor, 2003; Eimer et al., 2003; Streit et al., 2003; Krolak-Salmon et al., 2001; Marinkovic & Halgren, 1998; Orozco & Ehlers, 1998). Some of these studies have utilised MEG (Streit et al., 2003), topographic analysis (Esslen et al., 2004; Krolak-Salmon et al., 2001) or oddball negativity paradigms

(Orozco & Ehlers, 1998). Others have used standard ERP methods to compare frontal or fronto-central brain activity associated with viewing neutral and happy expressions and deserve further consideration in the current work. In a two choice task involving the categorisation of expressions as either emotional (for 6 basic expressions) or neutral, Eimer et al. (2003) found an enhanced frontocentral positivity to emotional expressions relative to neutral expressions. This emotional expression effect was observed from approximately 250-700ms for happy expressions relative to neutral expressions, and was not evident in a second experiment where focused attention was directed away from expression towards a perceptual discrimination task, indicating that task and attention significantly modulated this effect. Similarly, in a study by Marinkovic and Halgren (1998) a greater frontal positivity for happy expressions compared to neutral expressions was observed at 450-600ms in an emotional valence judgment task (rating valence and intensity of neutral, sad and happy expressions with a joystick), though this effect was greatly diminished when attention was directed away from expression by task, suggesting that processing at this time is less automatic and more governed by endogenous attention. Batty & Taylor (2003) found the largest differentiation in amplitude according to emotional expression from 360-390ms at fronto-central sites, with significant differences 30ms before and after. There was a frontal negativity for emotional expressions compared to neutral expressions, and especially for negative emotional expressions. As the authors noted, in this study in which an implicit task was utilised (watching facial expressions with no behavioural response required), differential activity across ERP components examined was less noticeable than in previous studies involving emotional judgement tasks.

To summarise, clinical evidence and neuroimaging implicates the orbitofrontal cortex in facial expression processing. This nature of this processing is highly dependent upon endogenous attention and task demands. This differential processing according to task fits with theoretical models of orbitofrontal function as an executive area, involved in planning and decision for adaptive action, with a special role in social interaction (Bechara et al., 2000; Ochsner & Barret, 2001). An exploratory approach, dividing this later activity into systematic time windows was taken in the current research. In tasks where emotional judgment tasks have been employed increased amplitude of deflections has been noted for smiles compared with neutral expressions (Eimer et al., 2003; Marinkovic & Halgren, 1998). The opposite effect with greater amplitude of neutral expressions compared to smiles has been observed in a task where no judgement of emotional effect was required (Batty & Taylor, 2003). In the current experiment both judgment tasks and no-judgement tasks were utilised and it was expected that facial expression would influence the amplitude of late orbitofrontal activity in these. Based on past research, in the current work it was predicted that greater activation for smiles compared to neutral expressions would be evident in the tasks where active judgement of expressions was required. Given the crucial role of the orbitofrontal cortex in social interaction, face recognition and response regulation it was also hypothesised that modulation according to genuine and posed valence of expressions may be evident at this region.

1.3 Neuroelectrophysiology of Posed and Genuine Smiles

As described above, the neurophysiological substrates of facial expression recognition have been shown to involve a widely distributed system of cortical and subcortical brain areas (Adolphs, 2002a; Palermo & Rhodes, 2007). Within this system specific occipital, temporal and frontal areas of the brain are thought to have crucial roles. However many details about functioning of this system remain uncertain, and with respect to the goals of the current work, most importantly, no previous research has examined the neurophysiological substrates underlying posed and genuine expression recognition. Therefore the aim of this work was to examine the neurophysiological processes associated with discrimination of posed and genuine expressions, specifically posed and genuine smiles given that these have been the most studied in behavioural research. Evidence suggests that attention and task modulates facial affect processing and therefore a task with no behavioural judgement required and two tasks with behavioural judgements were employed. In general it was expected that greater differential brain activation between expressions would be expected in the behavioural judgement tasks (Eimer et al., 2003; Marinkovic & Halgren, 1998). Neuroelectrophysiological examination utilising ERP techniques was made throughout these tasks to assess occipital and temporal and orbitofrontal activity.

For reasons described earlier, it was considered that a simple affective judgment task ('happy' or 'not happy') (Miles, 2005; Miles & Johnston, 2007) would be a more ecologically valid task than the categorisation tasks widely used in previous research on posed and genuine expressions (e.g. 'social smile' or 'enjoyment smile'; Frank et al., 1993), and therefore such methodology was used in the current experiment. Some methodological differences compared to previous behavioural research by Miles (2005) were necessitated by the requirements of the neuroelectrophysiological techniques employed. Facial stimuli were smaller and shown for a fixed display time of 1000ms, in order to reduce eye movements that might cause problematic interference in the ERP recordings. Smaller stimuli, and fixed duration as opposed to participant choice of display time might be expected to increase task difficulty. Thus it was predicted that although similar behavioural results to Miles (2005) would be observed, sensitivity rates in detecting emotional state might be diminished as a reflection of this increased difficulty. Additionally previous research has shown that participants are more likely to judge open mouth smiles as happy as compared to closed mouth smiles (Miles, 2005; Otta, Folladore Abrosio, & Hoshino, 1996). Care was taken to control for this variable within genuine and posed pairs selected in the current study, by excluding pairs of posed and genuine smiles which were not either both closed smiles or both open mouth smiles.

The ERP technique meant an initial task with no behavioural judgment could be added prior to the two behavioural judgment tasks. In this no-judgment 'watch' task participants were instructed to simply observe facial expression stimuli without making any behavioural response or judgment, while ERP recordings were made. ERP recordings from this watch task would serve as a baseline for comparison of neurophysiological data in the two judgment tasks where attention was explicitly directed towards the certain task parameters. Thus neuroelectrophysiological activity could be compared between behavioural judgement tasks and non-behavioural judgment tasks to help elucidate differential activity associated with task related attentional focus.

While dynamic facial expressions might offer greater ecological validity to contexts such as interpersonal interactions, it was argued that for research purposes static photographs preserve a suitable level of generalisability to real world situations where only a brief view of another person's face is required to know their emotional state (Esteves & Ohman, 1993). Miles (2005) examined categorisation rates of expressions using both dynamic and static displays, and showed no difference between them in terms of participant sensitivity to felt happiness. Therefore using static displays was judged acceptable in the current research.

To increase statistical power in this initial investigation, only female participants were used. Previous evidence suggests that women appear to be more accurate and sensitive decoders of facial expression than men (Schmidt & Cohn, 2001) and faster at recognising facial expressions (Hampson, van Anders, & Mullin, 2006). Slightly greater discrimination in perception of facial expressions by women has also been found (Otta, Folladore Abrosio, & Hoshino, 1996). Furthermore in previous ERP research, compared to men, women have been found to have increased amplitude and longer latency ERP components for happy expressions (Orozco & Ehlers, 1998).

In ERP research, early occipital processing is indexed by the first positive deflection in neuroelectrophysiological activity, the P1 component. Based upon previous research it was predicted that greater amplitude for smiles as compared to neutral expressions might be evident in this component. Though this has not been a universal finding in past research it was hoped that a greater number of unique facial stimuli utilised relative to many past studies, might reduce habituation effects that would otherwise diminish observable differences.

In addition it was hypothesised that posed and genuine smiles might modulate amplitude of P1 and N170 components according to their saliency. Given research indicating that genuine expressions are perceived as more liked than neutral or posed expressions then this might be reflected by increased P1 and N170 amplitude to genuine smiles as compared to posed smiles or neutral expressions. Changes in later orbitofrontal activity reflect more detailed processing and evaluation in planning for adaptive action, adjusted by endogenous attention. It was predicted that greater activation for smiles compared to neutral expressions would be evident in active behavioural judgment tasks. It was expected that differential activation between posed and genuine smiles might be more evident in the feel rather than show condition, given the behavioural differentiation observed in previous research.

Also relevant to the current study, an interesting finding reported by a recent fMRI study using a Prisoners Dilemma scenario, was that faces of co-operators (as distinguished by identity) as compared to neutral faces produced increased activation of fusiform gyrus and superior temporal sulcus (Singer, Kiebel, Winston, Dolan, & Frith, 2004). Given that genuine smiles were reported to elicit co-operation from interaction partners in a Prisoners Dilemma game (Miles, 2005), increased activation of fusiform and superior temporal sulcus regions might be expected in response to genuine smiles in such tasks. Such increased activation may be limited to interaction contexts where explicit need to co-operate or compete is integral to the task – such as in a Prisoners Dilemma game. However, it may also be the case that genuine smiles signal a co-operative partner in a more general sense (Schmidt & Cohn, 2001). The human brain evolved in environments where the only source of a human face making eye contact would have been another human in an interaction context, where according to Owren & Bachorowski (2001) genuine smiles evolved to recruit co-operative behaviour. Given that photographs are a very recent technological invention, it is likely that lower perceptual levels of evolved neural facial recognition systems are unable to distinguish between the interaction and non-interaction contexts, of a real person and a computer image resembling a person, because the visual properties of both are so similar. Evidence supporting this notion comes from similar patterns of face specific N170 processing of static two dimensional facial photos, including greyscale as well as colour images, and even schematic faces to a lesser extent (Halgren et al., 2000), in comparison to images of other objects. It is possible that early structural encoding processes may simply register a 'co-operative face' which is only later distinguished by higher brain functions as belonging to a real person or a photograph. If so, then in the current study increased activation of fusiform and superior temporal sulcus areas may be expected in response to genuine smiles (if indeed these brain areas respond to these genuine smiles as a co-operative signal) as compared to neutral expressions. Such activation may be evident as differential modulation of the P1 and N170 components which are thought to reflect fusiform and superior temporal sulcus activity.

In conclusion it was hoped that the present experiment would shed light on a previously uninvestigated phenomenon, the ERP activity associated with differential behavioural responses between posed and genuine smiles. In addition to examining this issue, it was also expected that this research would help clarify understanding of processing differences between smiles and neutral expressions in general. Issues that were considered included lateralisation of processing (left versus right hemisphere), timing and spatial location of processing, exogenous versus endogenous characteristics of processing, and patterns of activity associated with behavioural sensitivity measures.

2.0 METHOD

2.1 Participants

For this research 27 young adult females (25 right-handed) aged between 18 and 40 years (mean 25.3 years old; SD 5.5 years), volunteered to participate in response to poster advertisements (appendix A) at the University of Canterbury. An information letter (appendix B) was sent to all potential participants and written signed consent obtained (appendix C). All participants self-reported normal or corrected to normal vision and no diagnosed neurological or psychiatric disorders. Handedness was assessed using the Edinburgh Handedness Inventory (appendix D) and all but two participants were classified as right handed. In accordance with national ethics guidelines, ethnicity of participants was recorded. Self reported ethnicity of participants was 17 New Zealand European, 3 Chinese, 2 New Zealand European/Maori, 1 Samoan, 1 Japanese, 1 American, 1 French, 1 German. Participants received a $20.00 gift voucher as compensation for time and travel costs. Three additional participants were recruited but their data were excluded from analysis, due to subsequent diagnosis of a psychiatric disorder 1 week post testing (1 case), or due to technical problems with data recording (2 cases).

2.2 Materials

Facial expression stimuli were selected from those already generated in previous research at the University of Canterbury, courtesy of McLellan (2008), Miles (2005), and Miles and Johnston (2007). Stimulus size was smaller and exposure time shorter than used elsewhere to be compatible with the ERP methodology. The procedure used by Miles and McLellan to elicit these facial expressions and final characteristics of the stimuli used in the current work is summarised below.

2.2.1 Procedure for Generation of Facial Display Stimuli

A 5 phase procedure was used to elicit posed smiles, genuine smiles and neutral expressions, from participants. This procedure involved presenting a range of materials to participants while their faces were recorded. Participants generating the facial display stimuli were aware that their facial expressions would be recorded, but they were unaware that the specific purpose of the procedure was to elicit posed and genuine smiles (Miles, 2005; Miles & Johnston, 2007). All materials were presented to participants on a standard 17 inch colour computer monitor and video recordings were made using a Canon XM2 3CCD digital video camera mounted above the monitor. Videos were taken with standard lighting, background and camera position. Each recording was standardized for brightness and contrast and compressed using an MPEG4v2 codec. Only videos without hair or glasses obscuring vital areas of the participant's face were used and all participants removed jewellery, make-up, and wore a standard white lab coat. Prior to each of the phases (45 minutes in total; see below) participants made ratings of their mood on an analogue scale which was labelled with 'very positive' and a positive expression emoticon (e.g. ☺) at one end, 'neutral' in the middle, and 'very negative' and a negative expression emoticon (e.g. ☹) at the other end. The 5 phases in order were:

1. Neutral Expression: Participants were asked to relax and look into the camera with a neutral expression for approximately 10 seconds.

2. Posed Smile: Participants were asked to look into the camera and smile for approximately 10 seconds. This instruction was repeated 5 times, each time accompanied by a contextual

description of a common situation where a posed smile might be expected (e.g. "please smile as you would for a family portrait").

3. Positive Mood Induction: Participants listened to a few minutes of classical music that has previously been shown to induce a positive emotional state (Halberstadt & Niedenthal, 1997). Participants were invited to relax, concentrate on the music, and think about any positive events that had happened to them recently.

4. Genuine Smiles from Sounds: Participants were instructed that they would hear a series of short clips of sounds they might encounter in everyday life and that they should concentrate on the sounds and try to imagine a situation in which that sound might occur. These clips (each 10 sec presentation, e.g. baby laughing, rock and roll) were chosen from the International Affective Digitised Sounds database (IAD; Bradley & Lang, 1999). IADS is a set of 120 emotionally evocative sound clips that have established male and female norms for ratings of valence, arousal, and dominance associated with each clip. Twenty clips with the highest valence ratings (i.e. those rated as most positive), were selected for male and for female participants respectively. From each set of 20 clips, 11 were selected to play to the participants on the basis of adequate arousal (>5 on a 9 point scale).

5. Genuine Smiles from Photographs: Participants were instructed to watch and think about a series of photographs. These photographs (each 15 second presentation, e.g. kitten, baby) were selected from the International Affective Picture System database (IAPS; Lang, Bradley, & Cuthbert, 2001)). IAPS is a set of approximately 700 emotionally evocative photographs that have established male and female norms for ratings of valence, arousal, and dominance associated with each image. Thirty images with the highest valence ratings (i.e.

those rated as most positive), were selected for male and for female participants respectively. From each set of 30 images, 20 were selected to show to the participants on the basis of adequate arousal (>5 on a 9 point scale).

McLellan (2008) used similar procedures and stimuli from the IADS and IAPS databases to generate facial expressions. However some minor differences in procedure (such as using a greater range of affective stimuli) were made in her research to enable a greater range of facial expression types to be generated from each participant (sad, fearful, and disgusted facial expressions in addition to posed and genuine smiles and neutral expressions). Only the neutral expressions, posed smiles and genuine smiles from that work were used in the current research. See Appendices G and H for a list of the specific stimuli used in the Miles and McLellan studies.

2.2.2 Coding of Facial Display Stimuli

Video recordings were divided into segments corresponding to each discrete phase of the procedure (i.e. posed smile instructions, IADS sounds, IAPS photographs). Each smile induction segment was inspected for any form of smiling which was coded according to FACS (Ekman et al., 2002) criteria for AU12 (zygomatic major) and AU6 (obicularis oculi). Static displays were chosen sourced from these segments of video recordings to ensure that the apex or onsets of facial expressions were not missed. Miles, (2005) and McLellan (2008) used a number of criteria to ensure stimuli were ecologically valid posed smiles and genuine smiles, and neutral expressions. The selection criteria used by Miles and McLellan for inclusion of participants in the study were:

1. Three expression types from each individual: Humans show wide variation in the structural features of the face, and it has been reported that certain features such as physical attractiveness, symmetry and eye size influence perceptions of honesty and thus overall attractiveness of an individual (Zebrowitz, Hall, Murphy, & Rhodes, 2002). Potential influences of structural features upon social perception were controlled for by ensuring that one expression of each type (neutral expression, posed smile and genuine smile) was used from each individual. In addition, faces from 25 different people (20 female) were recorded (as opposed to just a couple of individuals) in an attempt to ensure that results would be more generalisable to a wider population and to decrease EEG habituation effects.

2. Gaze Direction: Only videos where the participant was looking directly into the camera were used, in accordance with the proposition that eye contact indicates greater likelihood of interaction and thus may make stimuli more salient (Adams & Kleck, 2003).

The selection criteria used by Miles and McLellan for classifying expressions as posed smiles, genuine smiles or neutral expressions were:

1. Underlying Affective state: A self report procedure was used to ensure that all participants videotaped for the stimulus pictures reported increased positive mood during generation of genuine smiles, as compared to during the generation of the neutral expressions and posed smiles.

2. Physiognomic distinctions: As described earlier, whereas all smiles show zygomatic major action, only genuine smiles show obicularis oculi action. Thus as coded with FACS (Ekman et al., 2002) all smile facial displays showed evidence of recruitment of zygomatic major

action (AU12). All genuine smiles also showed evidence of contraction of obicularis oculi (AU6), while posed smiles did not. Neutral expressions showed no AU action. Available facial displays were also matched as closely as possible in terms of intensity within posed and genuine smiles pairs (i.e., for each target) according to AU12 contraction.

Modifications to Criteria in Previous Research

In addition to the generation and selection criteria used by Miles and McLellan a further criterion was added in the current study to match posed and genuine smiles in terms of mouth action, by excluding pairs of posed and genuine smiles which were not either both closed smiles or both open mouth smiles. All images were cropped (Adobe Photoshop Elements ®) to exclude details beyond the immediate dimensions of the face (hairline at top of forehead, bottom of chin, sides of head excluding ears) and bounded within a standard 120 pixels by 180 pixels frame. This size of stimuli was chosen to eliminate the need for participants to make eye movements in order to view the images which can occur with larger stimulus pictures and cause interference in ERP recordings (a factor relevant for the experiments described here).

In summary, the stimulus set used in the current research fulfilled requirements for valid posed and genuine smiles. When all criteria had been satisfied, 18 female and 2 male facial display sets (each of a neutral expression, posed smile, and genuine smile - so 60 photos in total), were available for use in the current thesis. An example of a stimulus set is shown in Figure 1. Only the female displays were used for experimental trials; the 2 male displays were used for practice trials.

Figure 1: A Facial Expression Stimulus Set
A neutral expression (left), a posed smile (middle) and a genuine smile (right).

2.3 Procedure

Participants were tested individually. The participant was seated facing a computer monitor approximately 60cm away. On the screen the stimuli facial expression photographs measured 5.28cm x 7.92 cm, subtending a horizontal visual angle of approximately 5.0° and a vertical visual angle of 7.5° (a head restraint was not used). To avoid potential distractions a curtain separated the participants from the EEG recording equipment and the rest of the room.

The experiment consisted of three tasks. The first task was one where no behavioural judgement was required (Watch Task) to record facial expression ERPs in absence of behavioural responses. In this task (54 trials each, 18 of each expression, with stimuli repeated across but not within blocks, and stimuli presented in random order within blocks) two blocks of trials were presented with 1000ms fixation cross followed by a 1000ms facial expression stimulus presentation. The participant was instructed to watch the fixation cross and faces that appeared on screen; no behavioural response required. No further information was provided as to the nature of the experiment at this stage.

At the end of the Watch Task, the participant was presented with an information screen describing the difference between 'showing happiness' and 'feeling happiness' (see Appendix E) and instructions for the next two tasks. The information screen described how it is possible to show emotion without experiencing it (for example smiling politely at someone you do not particularly like), as opposed to smiling and actually feeling happy at the same time. The information screen then posed the question – "is it possible to tell the difference when somebody is smiling because they are feeling happy or because they are being polite?" and the second and third tasks were behavioural judgment tasks designed to answer this question.

The second task was an active behavioural judgment task (Show Task). Two blocks of trials (54 trials each, 18 of each expression, with stimuli repeated across but not within blocks, and stimuli presented in random order within blocks) were presented with a 1000ms fixation cross, a 1000ms facial expression stimulus presentation, and an indefinite response screen (see Figure 2). Participants were instructed to watch the fixation cross and faces that appeared on screen. At the response screen participants answered the question 'Was this person SHOWING Happiness?' by pressing the '1' key for 'yes' and '2' key for 'no'. A response began the next trial.

The third task was the same as the second task, except now participants answered the question 'Was this person FEELING Happiness?' (Feel Task). Six practice trials preceded the second task, with the same format as the experiment itself but using six novel facial stimulus pictures (male faces) not used elsewhere in this study. The second and third tasks were not counterbalanced because previous evidence (Miles, 2005) suggested that judgement in the feeling task had a higher sensitivity when the show task preceded the feel task. It was decided to use this format to try and maximise the possibility of detecting any neuroelectrophysiological differences that might be present.

Fixation Cross (1000ms) Stimulus (1000ms) Response Screen (no time limit)

Figure 2: Task Procedure
(1) fixation cross (left), (2) stimulus presentation (middle), (3) response screen (right and only presented during Show and Feel tasks - example is from the Show task).

2.4 EEG Recording

EEG recordings were conducted per recent guidelines (Picton et al., 2000). Continuous electroencephalogram (EEG) was recorded using 17 free Ag/Ag-Cl electrodes, and amplified using Synamps 2 (Neuro Scan Labs ®). Nine of the electrodes (Fz, F3, F4, Cz, Pz, T5, T6, O1, O2) were attached in accordance with the international 10-20 system (Jasper, 1958), and two frontocentral electrodes (FP1, FP2) were also added. The standard centreline electrodes (Fz, Cz, Pz) and dorsolateral electrodes (F3, F4) were employed to enable quick visual inspection of typicality of waveforms obtained, while other electrode locations were the regions of interest in the current study (O1-O2 for the occipital P1 component, T5-T6 for the temporal N170 component, and FP1-FP2 for the orbitofrontal activity). Electro-oculogram was recorded from the supraorbital ridge and outer canthus of the right eye; an electrode midway between Cz and Pz was used as reference during recording, and recordings were re-

referenced to linked mastoids offline. The ground was located in the mediofrontal area. Impedances were kept to <5 kΩ. Data were recorded continuously with a 500Hz sampling rate, through a bandpass of 0.3-70Hz. A standard Neuro Scan 4.3 algorithm (Neuro Scan Labs ®) that automatically subtracted the average eyeblink pattern from the EEG whenever eyeblinks occurred (>200μv spikes) was used offline to correct data contaminated by eyeblinks. Other epochs containing artefacts >100μv were also rejected. EEG epochs were acquired beginning 100ms prior to stimulus onset and continuing for 1100ms. A baseline correction was performed automatically by subtracting the average of the prestimulus recording from the 100ms preceding the stimulus onset. Codes synchronised to stimulus delivery were used to selectively average the different stimulus responses offline. Overall, 95.37 % of trials were retained and included in averages following artefact correction procedures.

2.5 ERP Component Analysis

Across participants (grand-averaged) mean ERPs to all face expressions (Neutral, Posed Smile, Genuine Smile) for each task (Watch, Show, Feel) were computed. Early components were recorded at occipital (P1) and temporal (N170) electrodes where they are most prominent. P1 was measured at electrodes O1 and O2 using a peak detection routine that located the maximal amplitude between 80ms and 140ms. N170 was measured at electrodes T5 and T6 using a peak detection routine that located the minimal amplitude between 140ms and 230ms. To assess later orbitofrontal activity mean amplitudes were measured in seven sequential 100ms time windows starting at 250ms, at electrodes FP1 and FP2. Stepwise testing of this whole time period over the analysis of selected later components was favoured for two main reasons. Firstly, given the lack of previous research, this systematic way of analysing the time period in 100-ms steps corresponded to this initial exploration of orbitofrontal activity associated with posed and genuine smiles. Secondly, in the research literature there is debate over what may constitute clearly recognised and identifiable ‘components’ at later time periods, and the word component is used in a variety of ways (Luck, 2005; Picton et al., 2000). For the purpose of this work the later element of the EEG represented by the 250-950ms window is referred to as ‘orbitofrontal activity’. This systematic division of later activity into brief time windows is consistent with approaches in previous facial expression research examining frontal activity (Batty & Taylor, 2003; Eimer et al., 2003; Krolak-Salmon et al., 2001; Marinkovic & Halgren, 1998). ERP data were subjected to repeated measures ANOVA analyses. Type 1 errors associated with inhomogeneity of variance were corrected using the Greenhouse-Geisser epsilon where appropriate and effect sizes reported using partial eta squared. Significant effects were examined with post-hoc Bonferroni tests.

3.0 RESULTS

3.1 Behavioural Findings

Participants made behavioural judgements of facial expressions in two tasks, in the first judging whether or not the person making the facial expression was showing happiness, and in the second judging whether or not the person was feeling happiness. Average percentages of expressions categorised as ‘happy’ in each task are shown in Table 1. There were virtually no ‘happy’ categorisations of neutral expressions or variance in these results so this obvious difference was not included in the statistical analysis. A 2 (Facial Expression: Posed Smile vs Genuine Smile) x 2 (Task: Show vs Feel) repeated measures ANOVA confirmed that judging whether the expression was happy occurred more frequently for genuine expressions than for posed expressions $F\ (1,26) = 165.24$, $p < 0.001$. A significant effect of task $F\ (1,26) = 27.97$, $p < 0.001$ indicated that participants were more likely to register “happy” for the show task than for the feel task. The more important finding however, was reflected by an expression by task interaction F (1,26) = 18.80, $p < 0.001$. This interaction reflected the fact that participants were far less likely to endorse a posed smile as feeling happy than endorse a posed smile as showing happiness.

Facial Expression	*Judgement Task*	
	Show (% Happy) / Standard Dev	*Feel (% Happy)/ Standard Dev*
Neutral Expression	2 % / 2.8	1 % / 1.5
Posed Smile	78 % / 26.0	45 % / 20.4
Genuine Smile	94 % / 8.9	82 % / 8.9

Table 1: Categorisation of Facial Displays
Percentages of facial displays categorised as happy by facial expression and judgment task.

3.1.1 Signal Detection Analysis

A signal detection analysis was used to provide information concerning sensitivity to a "genuine" happiness categorisation and response bias towards making a "happy" categorisation. This was accomplished by characterising responses made to generate four possible 'classic' response-consequence outcomes: (i) genuine smile that the participant identified as an expression of happiness (correct perception or 'hit'), (ii) a genuine smile that the participant does not identify as a an expression of happiness (incorrect perception or 'miss'), (iii) a posed smile or neutral expression that the participant identifies as an expression of happiness (incorrect perception or 'false alarm'), and (iv) a posed smile or neutral expression that the perceiver correctly identifies as not indicating happiness (correct perception or 'a correct rejection'). Miss rates and correct rejection rates are redundant as miss rate = 1 - hit rate, and correct rejection rate = 1 - false alarm rate. Response data was collated in this fashion separately for each judgement task (show task and feel task). Participants sensitivity in differentiating between targets that were genuinely happy (genuine smile) and those that were not (posed smile or neutral expression), and their bias response for this distinction was evaluated using the correction recommended by Snodgrass & Corwin (1988) (see appendix F for the formulae).

In terms of the present research, if participants showed no ability to correctly identify whether or not a target was happy, based on information provided in facial expressions (i.e., zero sensitivity), then hit rate ≈ false alarm rate and A’ would approach 0, while total accuracy (perfect hit rate and no false alarms), would imply an infinite A’ (though many researchers consider it to have an effective ceiling value of 4.65 corresponding to a hit rate of 0.99 and false alarm rate of 0.01; Macmillan & Creelman, 1991). With chance responding A’ = 0.5. Response bias statistics measure how much participants are simply more willing to choose one option over the other, by combining false alarm and miss rates. If no bias is evident then B” = 0; when B” < 0 there is a negative bias (tendency to choose happy) and when B” is > 0 there is a positive bias (tendency to choose not happy). The value of B” provides an indication of the magnitude of the bias (with -2.33 to 2.33 representing lower and upper limits in practice). Table 2 shows the Hit and False Alarm rates and estimates of sensitivity (A’) and bias (B”) by judgment task.

Judgement task	*Hit rate / Standard Dev*	*False alarm rate / Standard Dev*	*Sensitivity (A’) / Standard Dev*	*Bias (B”) / Standard Dev*
Show	0.93 / 0.08	0.41 / 0.13	0.87 / 0.02	-0.63 / 0.39
Feel	0.85 / 0.23	0.23 / 0.10	0.89 / 0.03	-0.17 / 0.40

Table 2: Behavioural Judgments
Mean hit and false alarm rates and estimates of sensitivity to happiness (A’) and bias (B”) by judgement task:

3.1.2 Sensitivity

As can be seen in Table 2, Sensitivity (*A’*) was high in both judgement tasks (0.87 in the show task and 0.89 in the feel task). As expected, single sample one tailed t-tests revealed that A' was significantly different from 0.5 (chance) indicating participants were highly sensitive to happiness as specified by facial expression in both the show task, t (1, 26) = 102.64, $p < 0.001$, and the feel task, t (1,26) = 60.17, $p < 0.001$, and thus could reliably detect happiness from facial expression. Indeed for all participants A' was > 0.8 in both tasks. A one tailed paired t-test (judgement task: show / feel) revealed that sensitivity was higher in the feel as compared to the show task, t (1,26) = 2.65, $p < 0.02$. Thus participants were sensitive to the presence of happiness and more so when judging emotion felt as opposed to judging emotion shown.

3.1.3 Bias

As can be seen in Table 2, Bias (*B"*) differed markedly between judgement tasks. Single sample one tailed t-tests were used to compare the values of *B"* with 0 (representing no response bias). These tests revealed that *B"* was significantly below 0, indicating participants were biased in choosing happy as a response in the show task, t (1, 26) = -8.35, $p < 0.001$, and the feel task, t (1,26) = -2.24, $p < 0.05$. A one tailed paired t-test (judgement task: show / feel) confirmed that this bias was clearly more extreme in the show as compared to the feel task, t (1,26) = 4.00, $p < 0.001$. Thus participants showed only a weak, albeit a significant, response bias towards judging expressions as happy when judging whether the target was feeling happy, whereas a strong response bias was evident when judging the target as showing happiness.

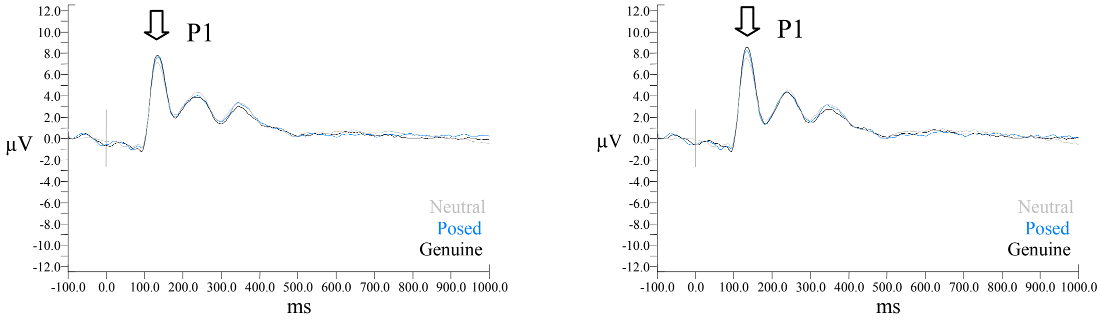
3.2 ERP Findings

Figures 3a (P1 component), 4a (N170 component), and 5a (later orbitofrontal activity) show the grand averaged ERPs obtained for response to neutral expressions, posed smiles, and genuine smiles. The P1 component and N170 component are clearly evident and a sustained positivity is observable at orbitofrontal locations. Comparison of amplitudes across expression, task, and hemisphere is shown for the P1 component (Figure 3b), N170 component (Figure 4b), and the seven time windows of the orbitofrontal activity (Figures 5b-5h).

The average latency of the P1 component peak was 135ms and the N170 component peak 186ms. A 3 (Facial Expression: Neutral vs Posed Smile vs Genuine Smile) x 3 (Task: Watch vs Show vs Feel) x 2 (Hemisphere: left hemisphere vs right hemisphere) repeated measures ANOVA analysis revealed that there were no significant effects of any independent variables upon the P1 and N170 latencies (all F values < 2.95, $p > 0.06$). Analysis of the amplitude data is discussed below.

Figure 3: The P1 Occipital Component

(Figure 3a) (left) left occipital cortex electrode O1 grand mean amplitude, and (right) right occipital cortex electrode O2 grand mean amplitude. The P1 component peak is indicated by the arrow.



(Figure 3b) P1 component grand mean peak amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.

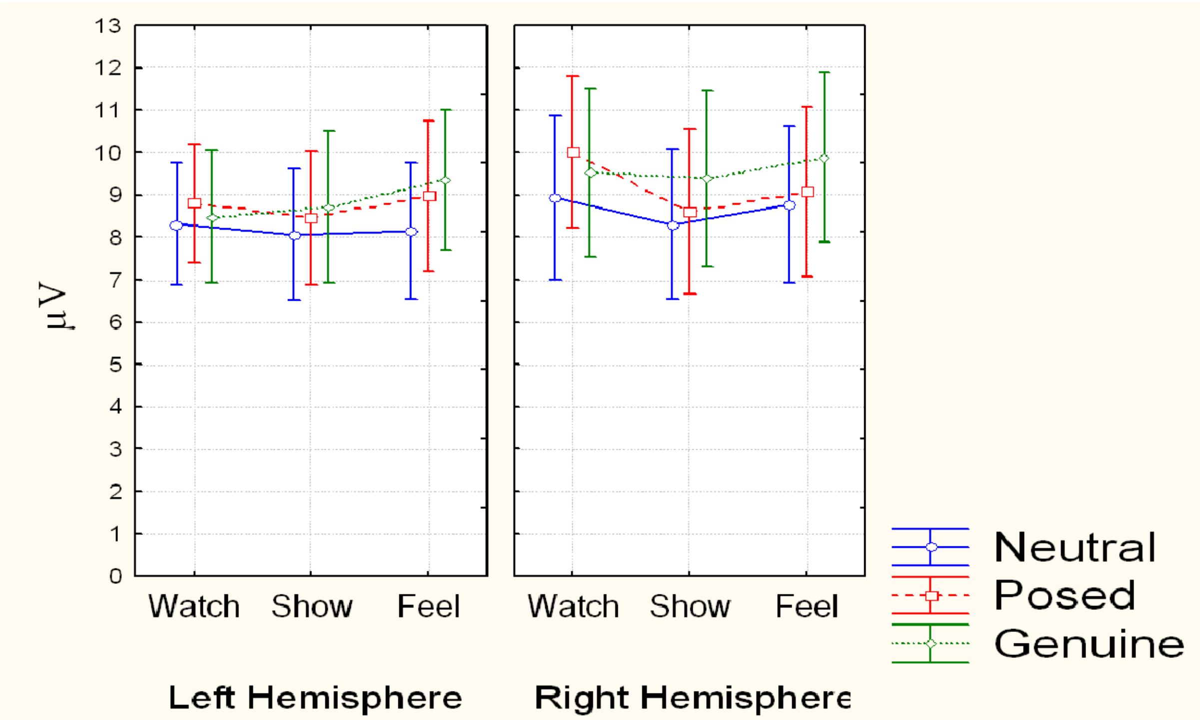
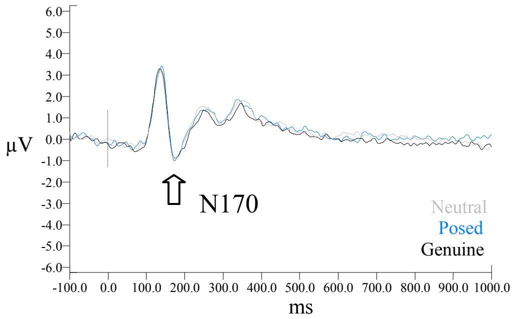
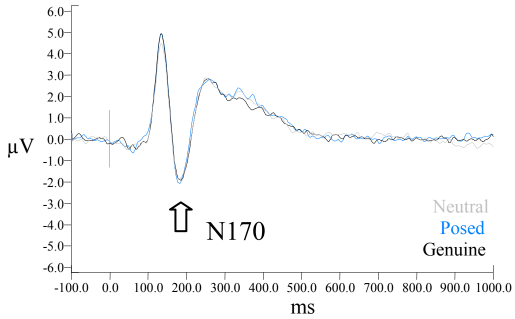


Figure 4: The N170 Temporal Component

(Figure 4a) (left) left temporal cortex electrode T5 grand mean amplitude, and (right) right temporal cortex electrode T6 grand mean amplitude. The N170 component peak is indicated by the arrow.





(Figure 4b) N170 component, grand mean peak amplitude Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.

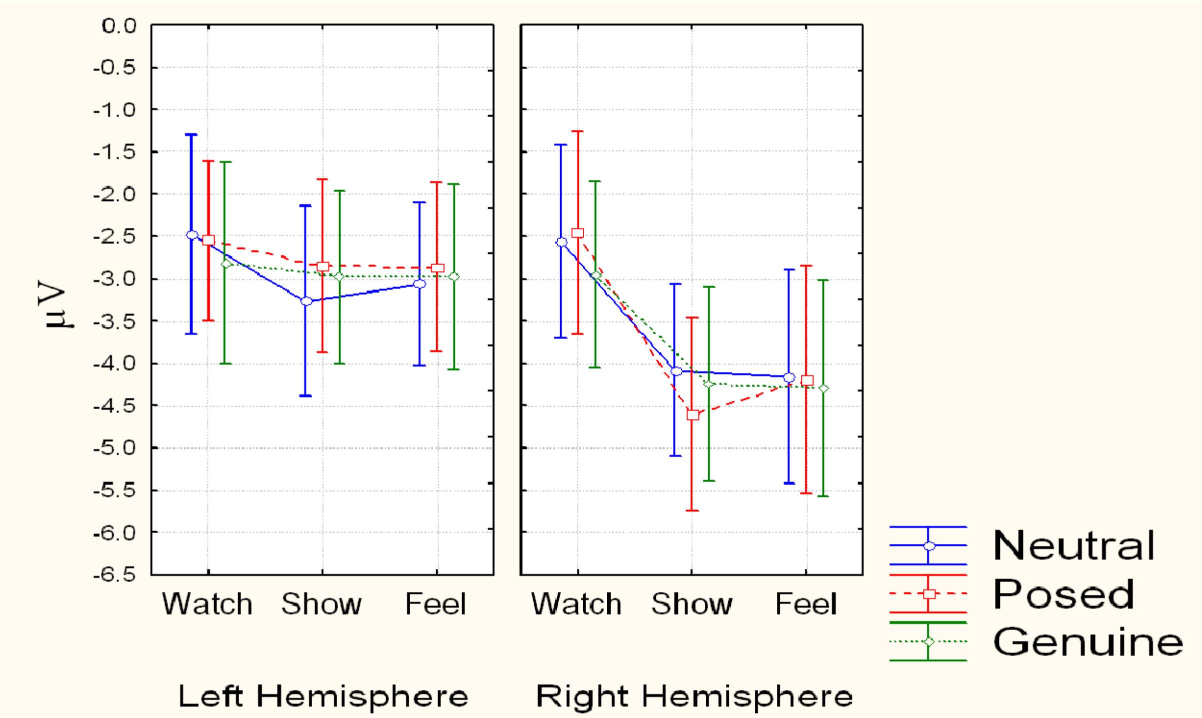
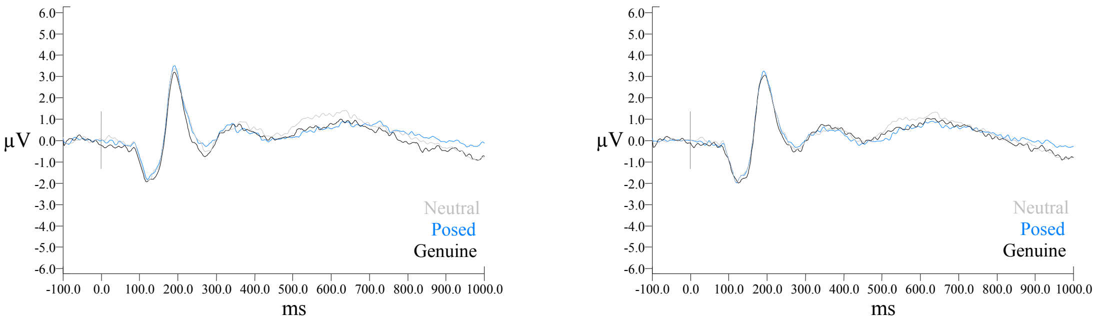
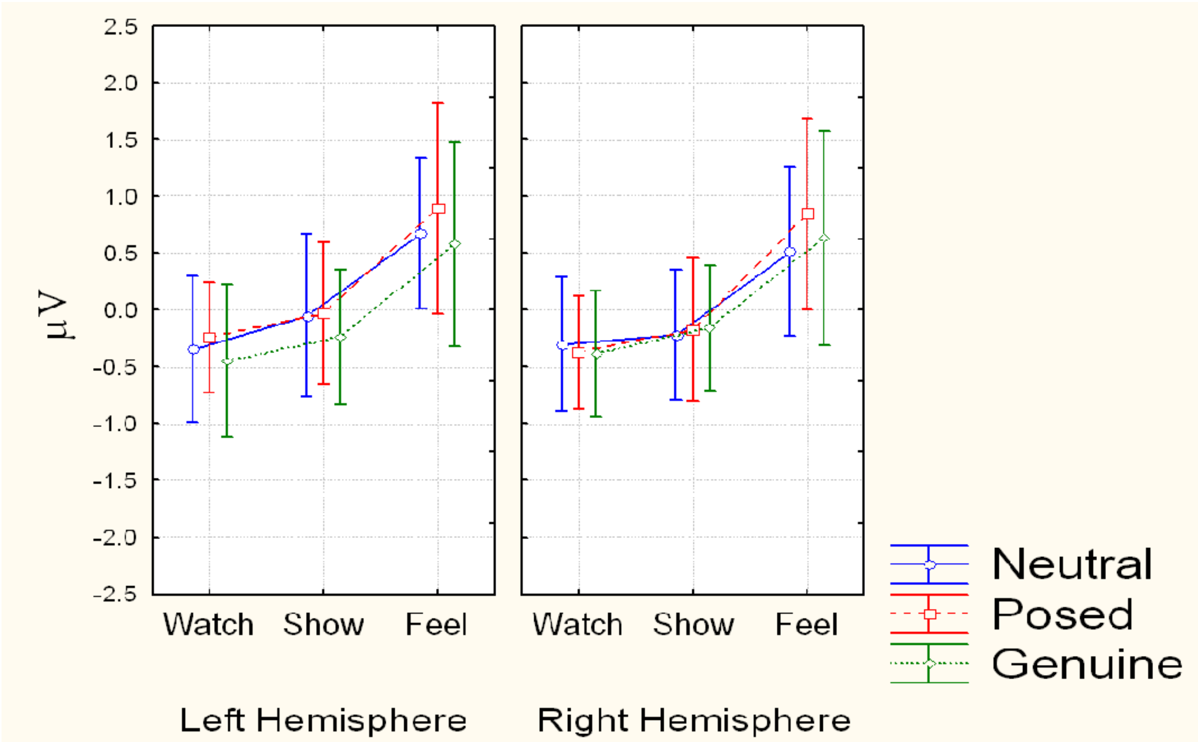


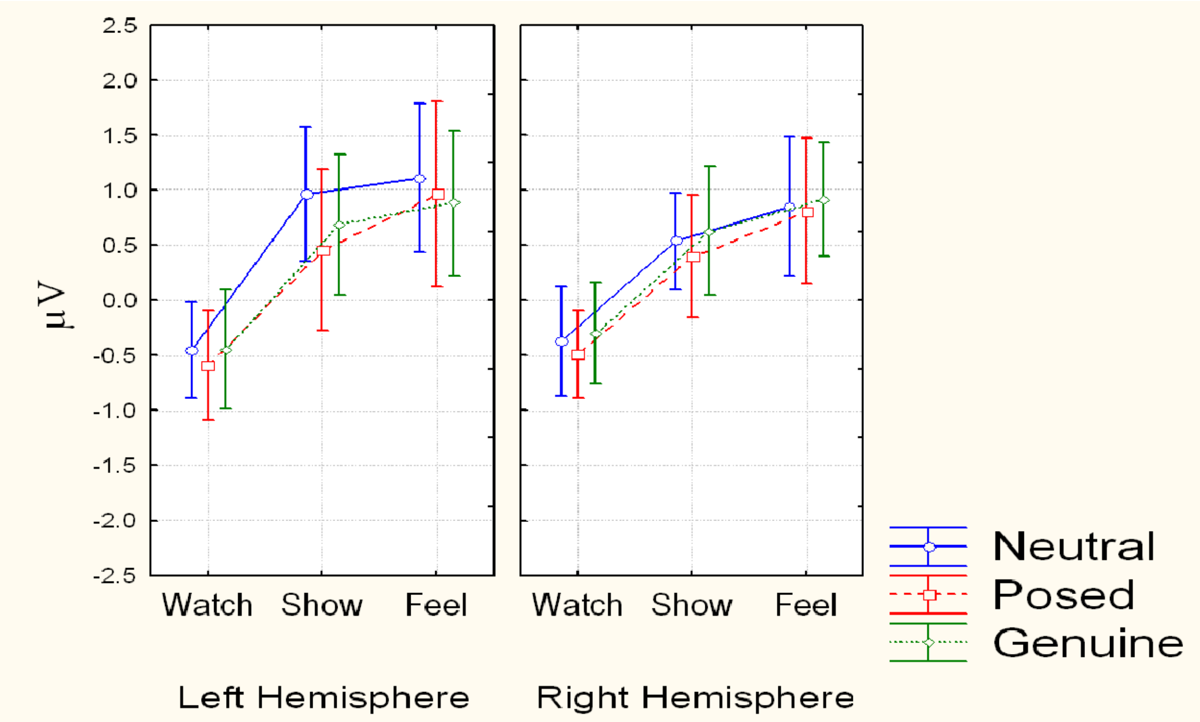
Figure 5: Later Orbitofrontal Activity
(Figure 5a) (left) left orbitofrontal cortex electrode FP1 grand mean amplitude, and (right) right orbitofrontal cortex electrode FP2 grand mean amplitude.



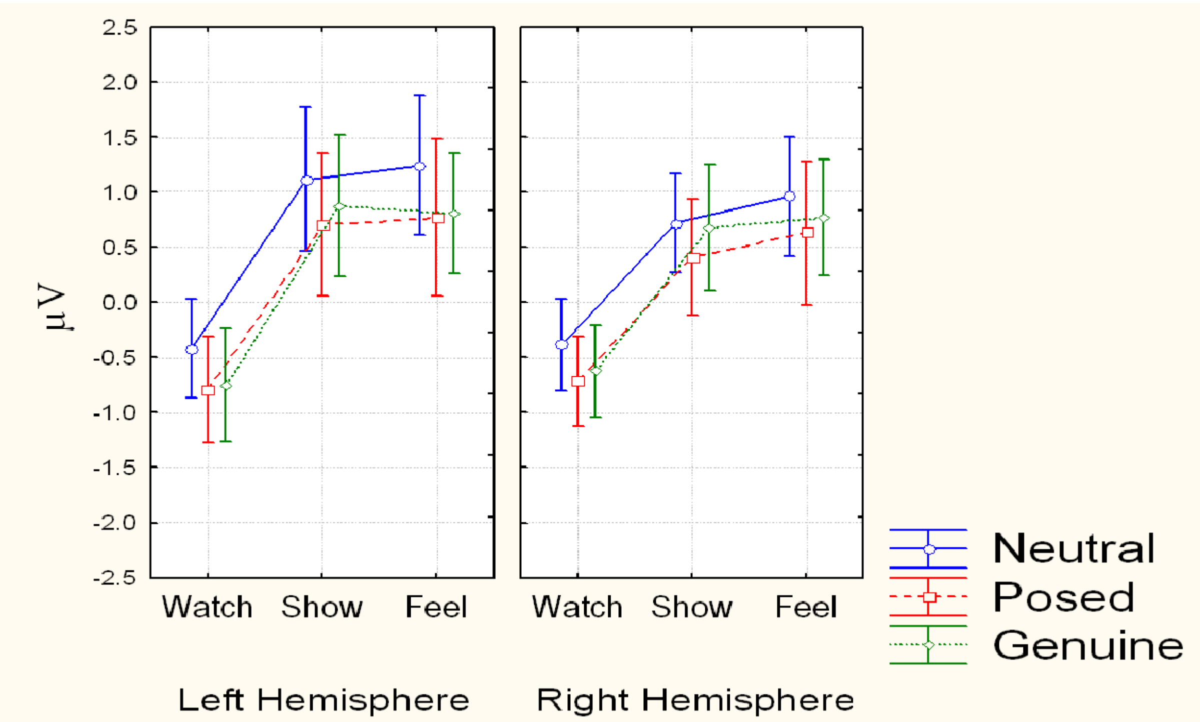
(Figure 5b) 250-350ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



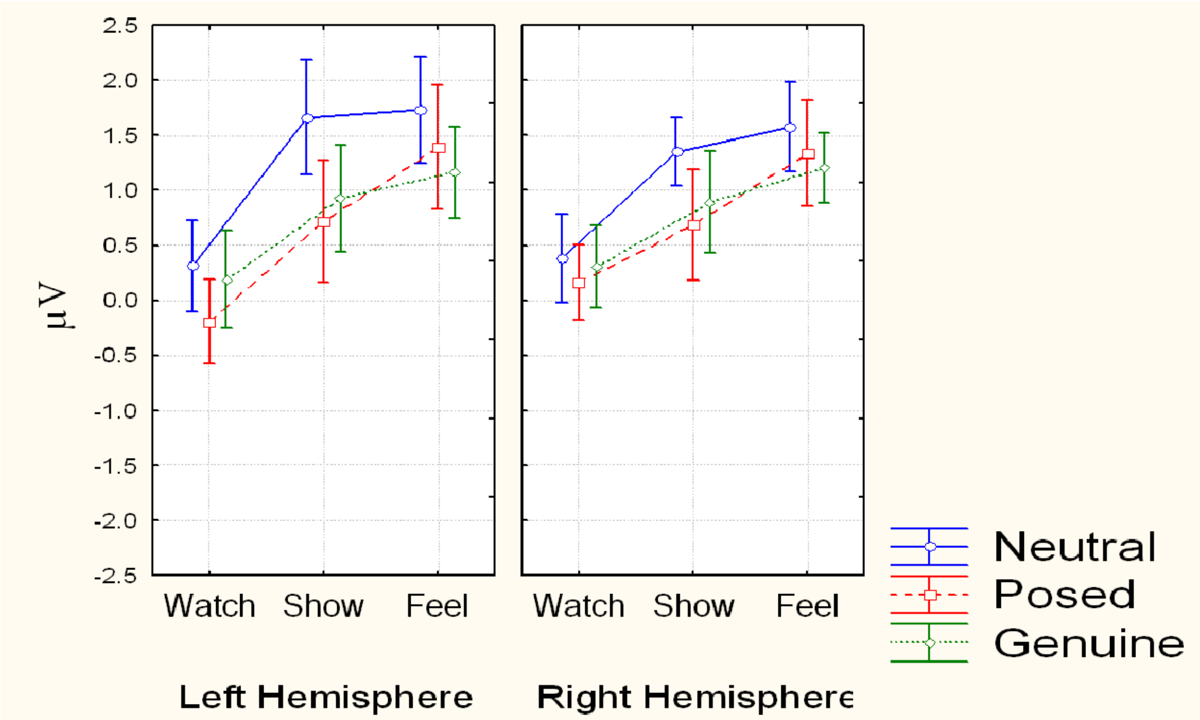
(Figure 5c) 350-450ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



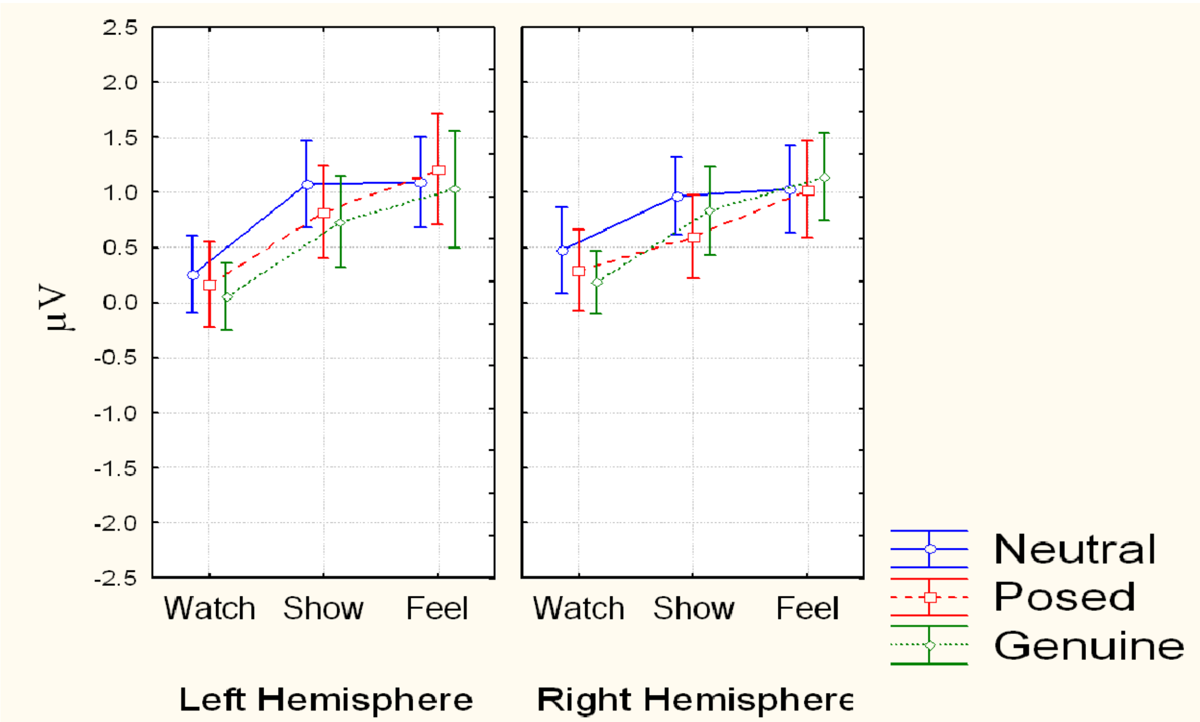
(Figure 5d) 450-550ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



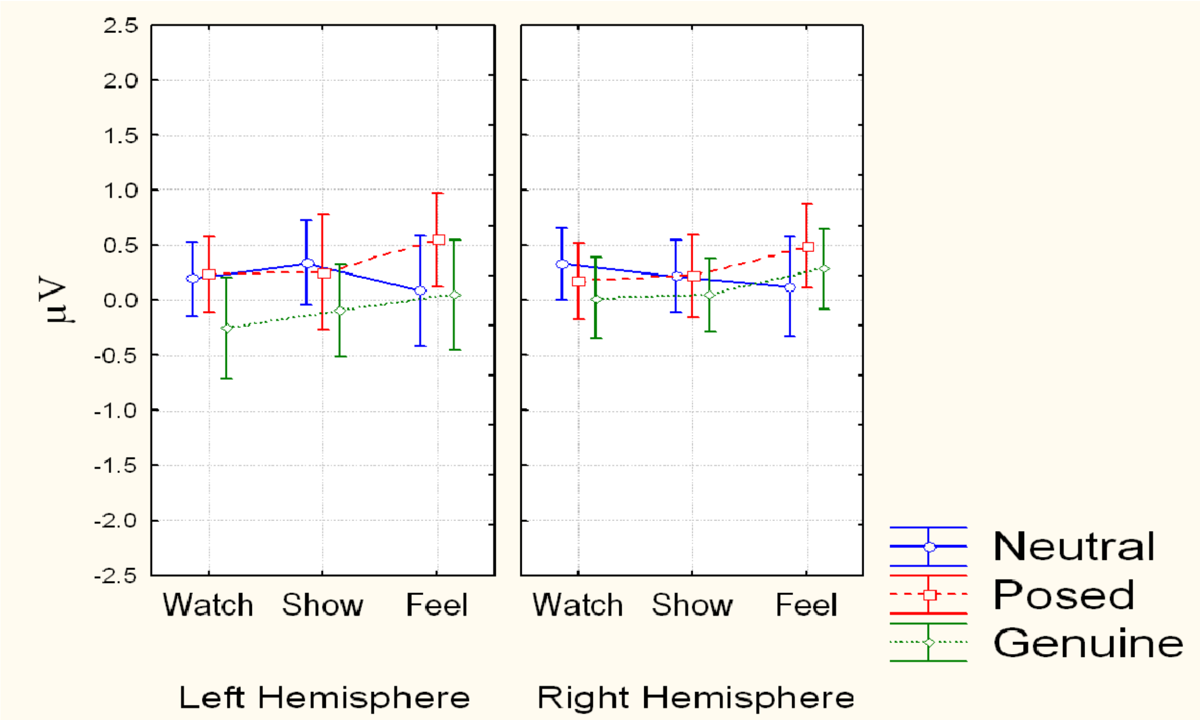
(Figure 5e) 550-650ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



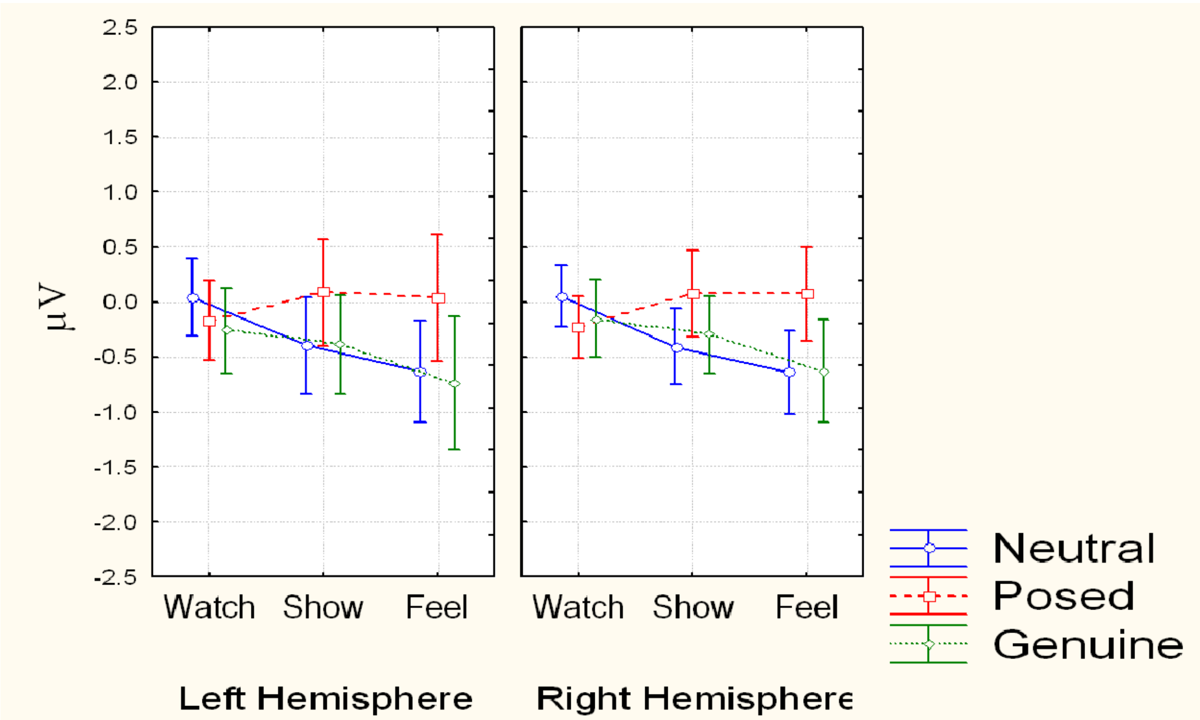
(Figure 5f) 650-750ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



(Figure 5g) 750-850ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



(Figure 5h) 850-950ms Orbitofrontal Activity, Grand Mean Amplitude. Task type is shown on the x axis for both left and right hemispheres. Vertical bars denote 95% confidence intervals.



3.2.1 The P1 Occipital Component

Visual inspection of the P1 component at the occipital cortex electrode revealed that across tasks grand mean peak amplitudes of posed smile and genuine smile expressions were elevated compared to neutral expressions (Figure 3). A 3 (Facial Expression: Neutral vs Posed Smile vs Genuine Smile) x 3 (Task: Watch vs Show vs Feel) x 2 (Hemisphere: left hemisphere vs right hemisphere) repeated measures ANOVA showed that a significant main effect of expression was present F (2,52) = 9.37, $p < 0.01$, $ES = 0.27$, with both posed smiles (m = 8.99 μV) and genuine smiles (m = 9.22 μV) having significantly greater amplitude ($p = 0.01$, and $p < 0.01$, respectively) than neutral expressions (m = 8.42 μV). There was no significant difference between posed and genuine smiles ($p = 0.66$). There were no significant main effects of task or hemisphere, and there were no significant interaction effects.

3.2.2 The N170 Temporal Component.

On visual inspection of the N170 component (Figure 4) grand mean peak amplitude appeared to be unaffected by emotional expression in both hemispheres. A 3 (Facial Expression: Neutral vs Posed Smile vs Genuine Smile) x 3 (Task: Watch vs Show / Feel) x 2 (Hemisphere: left hemisphere vs right hemisphere) repeated measures ANOVA confirmed that there was no significant main effect of expression. There was also no significant main effect of hemisphere. However there was a significant effect of task F (2,52) = 8.86, $p < 0.001$, $ES = 0.25$, and a significant task x hemisphere interaction F (2,52) = 13.13, $p < 0.001$, $ES = 0.34$. Post hoc comparisons showed no significant difference between tasks in the left hemisphere ($p > 0.20$), but significant differences between tasks in the right hemisphere (Watch vs Show $p < 0.001$; Watch vs Feel $p < 0.001$; Show vs Feel $p > 0.20$). There were significant differences between left and right hemispheres for the show and feel tasks but not for the watch task (Watch $p > 0.20$; Show $p < 0.001$; Feel $p < 0.001$). In other words there was an increased negative deflection in the right hemisphere when active behavioural judgment of facial expression was required, irrespective of whether this was a show or feel judgment, and irrespective of facial expression type (neutral expression, posed smile or genuine smile).

3.2.3 Later Orbitofrontal Activity

Later orbitofrontal activity was examined from 250-950ms and on visual inspection (Figure 5) a greater positivity for neutral expressions compared to smiles (both posed and genuine) was evident from around 450ms, and a greater negativity for genuine smiles and neutral expressions compared to posed smiles was evident around 850ms. In a systematic exploratory approach, 3 (Facial Expression: Neutral vs Posed Smile vs Genuine Smile) x 3 (Task: Watch vs Show vs Feel) x 2 (Hemisphere: left hemisphere vs right hemisphere) repeated measures ANOVA analyses were computed for each 100ms time window.

250-350ms

There were no significant main effects of expression in the 250-350ms time window (figure 5b). There was a significant main effect of task $F(2, 52) = 8.25$, $p < 0.001$, $ES = 0.24$, with a greater positivity was observed for the feel as compared to the watch task ($p = 0.001$), and for the feel as compared to the show task ($p < 0.01$), but not for the watch as compared to the show task ($p > 0.20$). There were no significant effects of hemisphere in this time window.

350-450ms

There were no significant main effects of expression in the 350 to 450ms time window (figure 5c). There was a significant effect of task F (2, 52) = 18.56, $p < 0.001$, ES = 0.42, with greater positivity observed in the show and feel tasks as compared to the watch task. There were no significant effects of hemisphere in this time window.

450-550ms

A significant main effect of expression was present in the 450-550ms time window (figure 5d) F (2,52) = 4.00, p = 0.02, ES = 0.13, with neutral expressions (m = 0.54 μV) having a greater positivity than posed smiles (m = 0.17 μV) (p = 0.02), but no difference between neutral expressions and genuine smiles (m = 0.29 μV) (p = 0.21) or between posed and genuine smiles ($p > 0.20$). There was a significant effect of task F (2, 52) = 20.72, $p < 0.001$, ES = 0.44, with greater positivity observed in the show and feel tasks as compared to the watch task. There was a significant task x hemisphere interaction in the 450-500ms time window (figure 5d), F (2,52) = 3.47, $p < 0.04$, ES = 0.12. However, post hoc comparisons failed to reveal individual significant differences of hemisphere in any task beyond a slight trend for greater amplitude in left hemisphere compared to the right hemisphere in the show task (watch task left vs right hemisphere $p > 0.20$, show task left vs right hemisphere p = 0.08, feel task left vs right hemisphere p = 1.0).

550-650ms

A significant main effect of expression was observed in the 550-650 time window F (2,52) = 5.68, $p < 0.01$, ES = 0.18, (figure 5e) with neutral expressions (m = 1.17 μV) having a greater positivity than both posed smiles (m = 0.68 μV) ($p < 0.01$) and genuine smiles(m = 0.78 μV) (p = 0.04), but no difference between posed and genuine smiles ($p > 0.20$). There was a significant effect of task F (2, 52) = 25.36, $p < 0.001$, ES = 0.49, with greater positivity observed in the show and feel tasks as compared to the watch task. There were no significant main effects of hemisphere in this time window.

650-750ms

There were no significant main effects of expression the 650-750ms time window (figure 5f). There was a significant effect of task F (2, 52) = 17.59, $p < 0.001$, ES = 0.40, with greater positivity observed in the show and feel tasks as compared to the watch task. There were no significant main effects of hemisphere in this time window.

750-850ms

There were no significant effects of expression, task or hemisphere in the 750-850ms time window (figure 5g).

850-950ms

There was a significant effect of expression in the 850-950ms time window (figure 5h) F (2,52) = 4.90, p = 0.01, ES = 0.16, with posed smiles (m = -0.02 µV) having greater positivity than genuine smiles (m = -0.41 µV) (p = 0.01), and a trend towards a difference between posed smiles and neutral expressions (m = -0.33 µV) (p = 0.07), but no difference between neutral expressions and genuine smiles (p > 0.20). There was also a significant task x expression interaction F (2,52) = 2.94, p = 0.02, ES = 0.10. Post hoc comparisons showed no significant differences between expressions in the watch task, or show task, but a significant effect of expression in the feel task (posed vs genuine p = 0.03; posed vs neutral p = 0.06;

genuine vs neutral $p > 0.20$). There were no significant main effects of task or hemisphere in this time window.

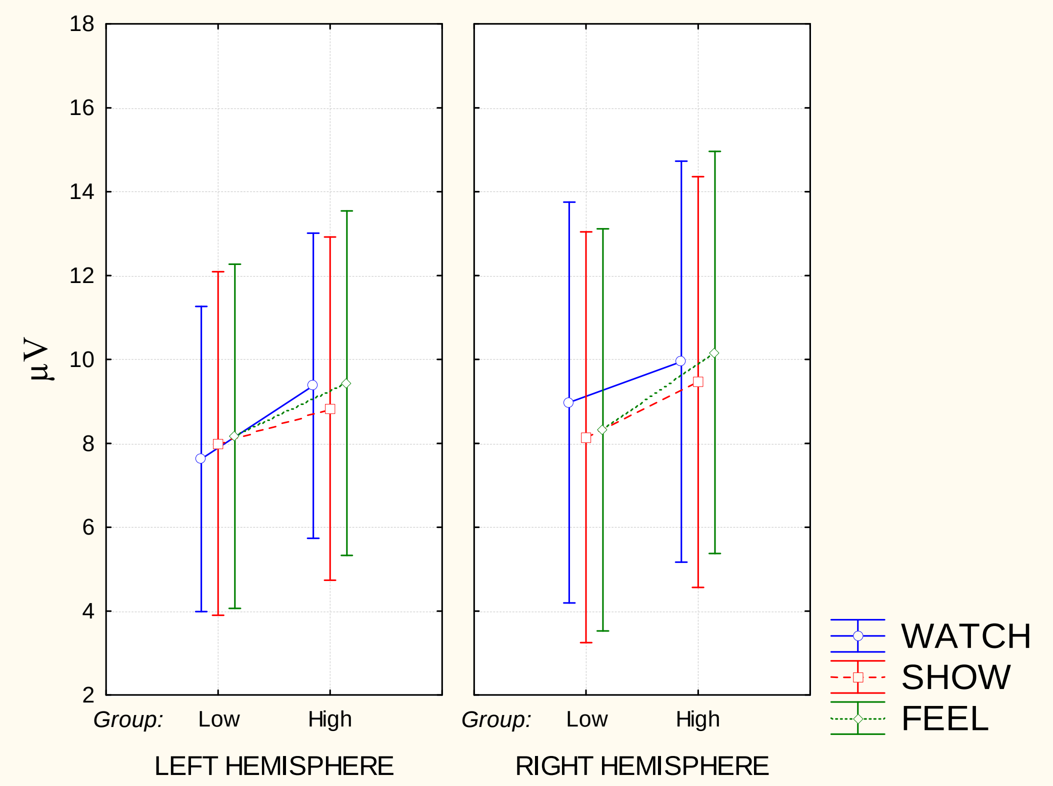
3.2.4 ERP Analysis and Behavioural Sensitivity

A further analysis was conducted on the ERP data to examine if participants' behavioural sensitivity to facial expressions might be associated with electrophysiological results. To this end a fourth between group variable named 'sensitivity' was added. A median split was used to create two groups – relatively high and relatively low sensitivity. Sensitivity scores in the feel task were chosen for this split because participants attention was explicitly directed towards emotional state in this task. ERP results from the 13 participants with the highest behavioural sensitivity measures in the feel task were grouped in the high sensitivity group, and ERP results from the 13 participants with the lowest behavioural sensitivity measures in the feel condition were grouped in the low sensitivity group.

A 3 (Expression: Neutral / Posed Smile / Genuine Smile) x 3 (Task: Watch / Show / Feel) x 2 (Hemisphere: left hemisphere / right hemisphere) x 2 (Sensitivity: High / Low) ANOVA with repeated measures on the first 3 factors was computed.

Analysis of the P1 component revealed a significant Task x Hemisphere x Sensitivity interaction for the P1 component (figure 6) F (2, 48) = 4.89, $p = 0.01$, $ES = 0.17$. While visual inspection showed increased positive deflection in the high sensitivity group compared to the low sensitivity group, post hoc tests revealed no significant difference according to sensitivity as a factor of any other condition (task, hemisphere, task x hemisphere, all $p > 0.20$). Separate task x sensitivity repeated measures ANOVA's for each hemisphere also revealed no significant results.

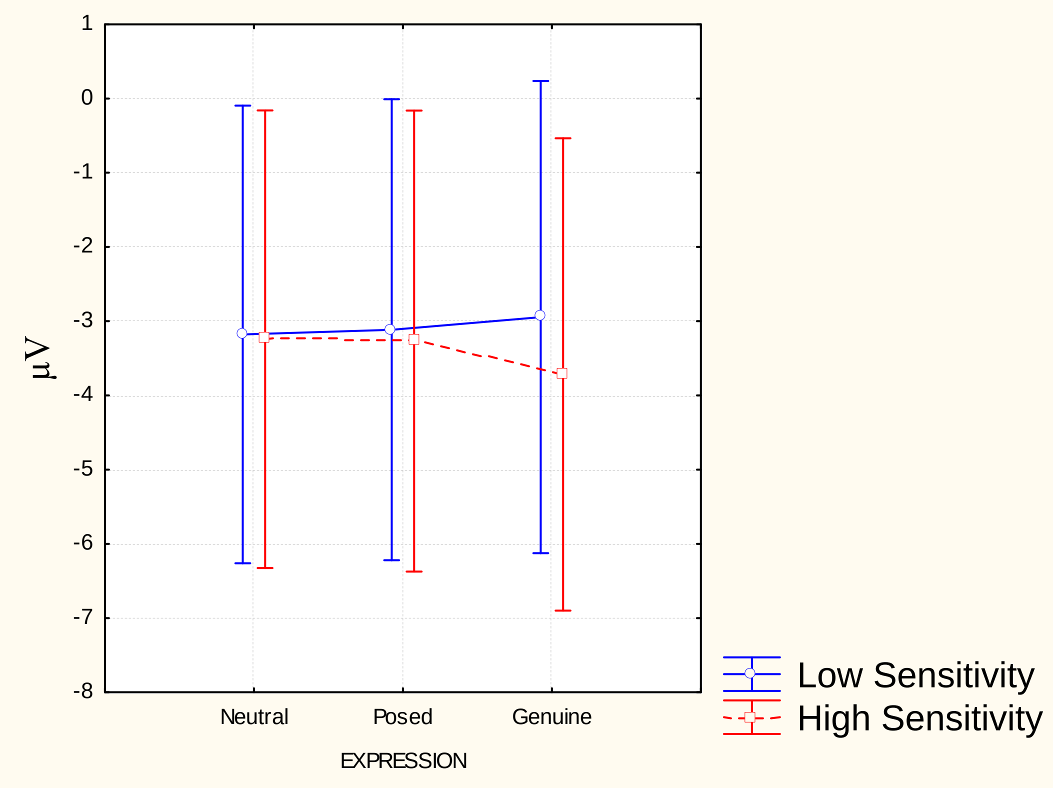
Figure 6: P1 Sensitivity x Task x Hemisphere Interaction.
Sensitivity Group (Low, High) x Task (Watch, Show, Feel), x Hemisphere (Left, Right).
Vertical bars denote 95% confidence intervals.



Analysis of the N170 component revealed no significant main effects of expression, task or hemisphere, but did reveal a sensitivity x expression interaction (figure 7) F (2, 48) = 4.62, p = 0.02, ES = 0.16, with visual inspection showing an increased deflection for genuine expressions in the high sensitivity condition. However post-hoc comparisons showed no significant differences between expressions in the low or high sensitivity conditions, nor between low and high sensitivity groups for any expressions (all $p > 0.17$).

Analysis of the later orbitofrontal activity revealed no significant main effects or interactions of sensitivity at any time window.

Figure 7: N170 Sensitivity x Expression Interaction
Sensitivity Group (Low, High) x Expression (Neutral, Posed Smile, Genuine Smile).
Vertical bars denote 95% confidence intervals.



3.2.5 Summary

The purpose of this experiment was to examine the behavioural and neurophysiological processing evoked in response to neutral expressions, posed smiles, and genuine smiles, in tasks with and without active behavioural judgment. The behavioural tasks involved participants judging whether or not a person was showing happiness (in the show task), and whether or not a person was feeling happiness (in the feel task). Behavioural results indicated that participants were sensitive to the underlying emotional state of the facial expressions, more so in the feel than in the show task being, with a greater bias towards labelling any smile as happy during the show task as compared to the feel task and far more likely to label posed smiles as showing happiness than as feeling happiness.

Examination of neurophysiological data revealed a pattern of processing that was both widely distributed and complex. Increased activation in response to posed and genuine smiles in comparison to neutral expressions was evident in activity at the early Occipital P1 component, though no difference between posed and genuine smiles was observed. Increased N170 activation in the right hemisphere was evident in the active behavioural judgement tasks. No significant effects upon P1 or N170 component latency were observed. A complex pattern of activation was evident at orbitofrontal locations at later time periods in the current study. From 450-550ms increased orbitofrontal activation to neutral expressions was evident in comparison to posed smiles, and from 550-650ms increased activation to neutral expressions was evident in comparison to both posed and genuine smiles. Differential activation between posed and genuine smiles was evident at 850-950ms with a significant interaction with task type. Analysis of this 850-950ms window revealed that difference between posed and genuine smiles and between posed smiles and neutral expressions was most evident in the active judgment tasks, and especially so for the feel as compared to the show task. Increased initial activation of the orbitofrontal cortex during the feel judgment task as compared to the show judgment and passive watching tasks was evident in the 250-350ms time window. Increased activation for both show and feel judgment tasks compared to the watch task was evident over the next 400ms (350-750ms).

When an additional sensitivity between group factor was added (high sensitivity perceivers vs low sensitivity perceivers in the feel condition) an interaction between sensitivity, task, and hemisphere was observed at the P1 component, and an interaction between sensitivity and expression was observed at the N170 component. However, no significant differences were found when P1 and N170 results were analysed with post-hoc tests. No effects of sensitivity were observed upon the later orbitofrontal activity.

4.0 DISCUSSION

No previous research has yet investigated the neural substrates subserving posed and genuine smile perception. The goal of the current work was to undertake an initial investigation of this phenomenon. To this end an experiment was designed that involved participants viewing a series of neutral expressions, posed smiles, and genuine smiles, presented in a random order, while utilising ERP recordings to enable examination of patterns of brain activation (first task). Two subsequent tasks used identical procedures to the first except that additionally participants made behavioural judgements about whether facial expressions were showing happiness (second task) or feeling happiness (third task).

As expected, behavioural measures indicated that participants were sensitive to emotional information conveyed by facial expressions and more so in the feel task than in the show task, with posed smiles significantly less likely to be labelled as happy in the feel task as compared to the show task. Differential ERP activation between neutral expressions and smiles was observed, though no unambiguous differential activity between posed smiles and genuine smiles was apparent. Early differential ERP activation between smiles and neutral expressions at occipital sites suggested a possible coarse ‘emotional expression or not’ decisional process occurs at this location peaking at around 135ms, shortly after Adolphs (2002b) hypothesised early perceptual ‘structural encoding’ phase. During the hypothesised ‘facial recognition’ phase at temporal locations, an increased right hemisphere deflection peaking at 185ms occurred during tasks where active behavioural judgements were required. Such lateralisation of activity is supportive of notions that the right hemisphere is preferentially involved in emotional judgment tasks during this activation component. Additionally participant behavioural sensitivity to differences between posed and genuine smiles was associated with differential activity for the P1 and N170 components, perhaps suggesting that more detailed processing between posed and genuine expressions than was apparent from other results, may indeed be occurring during these components. Later orbitofrontal processing is thought to represent more detailed conceptual planning, and a broad range of differential activation according to task, expression, and hemisphere was observed. Most importantly in terms of the primary goal of the current research, differential activation between posed and genuine expressions was not observed until 850ms and only during the active judgment task where participants had to judge whether or not a person was feeling happy. This late differential activation may thus reflect planning of behavioural responses, based upon earlier perceptual discrimination between genuinely happy and not happy expressions. Overall, ERP measures appeared to reflect aspects of cognitive processing likely to be associated with participants behavioural sensitivity to the emotional state of targets, and much of the activity observed was broadly consistent with predictions. The implications of these and other findings are discussed in further detail below.

4.1 Behavioural Findings

The behavioural tasks involved participants judging whether or not a person was showing happiness (in the first task), or whether or not a person was feeling happiness (in the second task). These behavioural findings replicated previous research (Frank et al., 1993; Miles, 2005; Miles & Johnston, 2007) whereby perceivers were able to detect the presence or absence of positive affect from facial expressions with a high degree of sensitivity. Participants demonstrated a high degree of sensitivity to the emotional state of the target, with posed smiles labelled as feeling happiness significantly less often than they were labelled as showing happiness. A bias towards choosing happiness as a response was evident, perhaps related to the fact that 2/3 of the expressions were smiles, and a tentatively theorised 'response readiness' to label any smile as happy (Miles, 2005). This response bias was significantly stronger when judging emotion shown as opposed to judgements about emotion felt, indicating that participants would more readily label an expression as showing happiness than they would label a smile as feeling happiness. Thus participants appear to have a stricter criterion for deciding that someone is genuinely feeling happiness as opposed to simply showing happiness. Such perception of person's emotional state enables more accurate prediction of the actions and intentions of the observed individual and planning given those contingencies (Frith & Frith, 2006; de Vignemont & Singer, 2006) and thus increases adaptive action in social interactions. The results from the current study are further evidence supporting the important differences between posed and genuine facial expressions, including the differential response of perceivers to these faces.

4.2 ERP Findings

4.2.1 The Occipital P1 Component

Increased amplitude of the occipital P1 component was evident in response to posed and genuine smiles as compared to neutral expressions. This result was consistent with recent research suggesting that discriminatory processing between emotional expressions and neutral expressions occurs even at this early time point, as measured by scalp ERP (Batty & Taylor, 2003; Pourtois et al., 2004; Pourtois et al., 2005; Pourtois & Vuilleumier, 2006), MEG (Halgren et al., 2000; Streit et al., 2003), and GFP (Eger et al., 2003). Other research has not replicated this finding (Herrmann et al., 2002; Krolak-Salmon et al., 2001; O'Connor et al., 2005; Sato et al., 2001). Such a disparity in findings may at least in part be explained by the observation that compared to happy facial expressions, negative facial expressions such as fear preferentially capture early processing resources in a manner that is likely to be more easily observable (Pourtois & Vuilleumier, 2006). Additionally, increased repetition of fewer total stimulus materials and consequent diminished observable differences due to habituation effects (Henson et al., 2000) may explain other negative findings. In terms of repetition of faces the current research used more faces and less repetition than much previous research, likely aiding the discovery of early discriminatory processing between smiles and neutral expressions.

No difference between posed and genuine smiles was observed suggesting that activity here is reflective of a simple discrimination between neutral and other expressions. Previous research has showed that greater activation has occurred for liked as opposed to disliked faces (Pizzagalli et al., 1999; Pizzagalli et al., 2002) and additionally greater pleasure in observers viewing genuine as compared to posed smiles or neutral expressions has been found (Surakka & Hietanen, 1998) and genuine smiles are evaluated more positively (Frank et al., 1993). Thus it had been hypothesised that greater activation to genuine as compared to posed smiles might be observed in the P1 component because of increased liking for genuine as compared to posed smiles. However the lack of difference observed between processing of posed and genuine smiles in the current research suggests that observable differences in amplitude of the P1 component may be confined to affective judgment tasks of liked versus disliked faces based upon factors other than facial expression, such as attractiveness independent from expression. Alternatively differences in brain activation between posed and genuine smiles at this component may simply be too subtle to be observable with current ERP methods where activation often represents summation of many distinct neural processes operating simultaneously (Luck, 2005). Notably, when the P1 amplitude data was re-examined as a dependent variable of behavioural sensitivity (low and high sensitivity groups) to different expression types, a significant interaction with task and hemisphere were observed for the P1 early occipital component. While the meaning of this interaction was ultimately unclear, it raises the possibility that more detailed structural encoding may occur here than has been generally assumed.

There was no obvious effect of task type which is consistent with theoretical notions that such early processing is dominated primarily by exogenous factors such as stimulus saliency, as opposed to endogenous factors like the intentions and goals of the observer (Palermo & Rhodes, 2007; Vuilleumier & Pourtois, 2007) such as making or not making affective judgments about facial expressions in the current experiment. Also consistent with previous research (Batty & Taylor, 2003; Eimer et al., 2003; Krolak-Salmon et al., 2001) no significant effects of any independent variables upon latency were found.

4.3.3 The Temporal N170 Component

Consistent with the majority of previous research (Bobes et al., 2000; Eimer & Holmes, 2002; Eimer et al., 2003; Halgren et al., 2000; Herrmann et al., 2002; Krolak-Salmon et al., 2001; Munte et al., 1998; O'Connor et al., 2005), no effect of facial expression was evident upon the N170 component. Differences in the N170 component have been observed in a minority of previous studies. However in comparison with the current work those studies used either: a much greater number of unique facial expression stimuli (Batty & Taylor, 2003) which has been argued to reduce habituation effects (Heisz et al., 2006; Henson et al., 2000); or an ‘expressional change’ task paradigm (Campanella et al., 2002; Miyoshi et al., 2004), rather than individually presented random facial expressions; or MEG (Lewis et al., 2003) or GFP measurements (Eger et al., 2003), as opposed to the standard ERP measurement procedures used in the current study. With respect to the issue of number of stimuli used in the experiment, it is notable that a difference was found in the earlier P1 component and as speculated above, this may have been due to an increased number of stimuli used in the current study. Perhaps therefore, N170 differences are not as observable as P1 differences. Indeed N170 modulation by facial expression has been observed in fewer comparable studies, but further research will be needed to further explore the reasons for this disparity. It appears likely that expressional change paradigms may detect a different class of cognitive activation (detection of temporal change in a face, rather than initial reaction to a face), while MEG and GFP measurement procedures typically assess a wider range of brain activation than ERP, with consequent greater power to detect minor variations. Also consistent with previous research (Ashley et al., 2004; Balconi & Lucchiari, 2005; Batty & Taylor, 2003; P. Campanella et al., 2002; Eimer et al., 2003; Halgren et al., 2000; M. J. Herrmann et al., 2002; Krolak-Salmon et al., 2001; Miyoshi et al., 2004), no significant effects of any independent variables upon latency were found for this component.

Similar to the P1 component, it had been hypothesised that a modulating effect of affect might be evident upon the N170 component (Pizzagalli et al., 2002), due to greater observer pleasure in response to genuine smiles as compared to posed smiles or neutral expressions (Surakka & Hietanen, 1998). However, like the P1, this effect was not observed, suggesting it may be confined to affective judgment tasks of liked versus disliked faces according to factors other than facial expression, or simply too subtle to be observed with current methods as discussed for the P1 component previously. Interestingly though, when participant behavioural sensitivity was added as an independent factor a significant sensitivity and expression interaction was revealed. While post hoc tests were not significant, visual trends of greater deflections for genuine expressions in the high sensitivity condition were in direction predicted by previous ERP research (Pizzagalli et al., 2002) if expressions were indeed being discriminated upon the basis of affective saliency, that is genuine smiles being preferred to posed expressions and neutral expressions. Further research using denser electrode arrays, greater number of stimuli, and complementary neuroimaging methods would be necessary to test this hypothesis further however.

Increased activation of N170 component over the right hemisphere was evident in the active behavioural judgement tasks as compared to the watch task or left hemisphere activation, suggesting a dominant role for the right hemisphere in these facial expression judgment tasks. This observation is consistent with observations of preferential right occipito-temporal activation in response to faces in general, as compared to other classes of objects (Balconi & Lucchiari, 2005; Campanella et al., 2000; Rossion, Joyce, Cottrell, & Tarr, 2003; Yovel, Levy, Grabowecky, & Paller, 2003); and with clinical observations that that prospagnosia tends to follow either right occipito-temporal or bilateral occipito-temporal lesions (Barton, 2003; Rossion, Caldara et al., 2003). Differential right temporal effects in response to facial expressions of happiness as compared to neutral expressions have been observed in previous research but only with MEG (Lewis et al., 2003). The current results are further evidence that in terms of the N170 component, the right hemisphere has a more prominent role in face and possibly facial expression processing than the left hemisphere, and also indicates that this processing can be strongly modulated by task driven endogenous attention.

4.3.4 Later Orbitofrontal Activity

A complex pattern of activation was evident at orbitofrontal locations. Differential orbitofrontal activation between posed and genuine smiles was evident at 850-950ms with a significant interaction with task type. A difference between posed smiles and genuine smiles and between posed smiles and neutral expressions was most evident in the feel judgment task, with some evidence of such an effect emerging in the show task, and no difference in the watch task. It is speculated that this differential activation between posed smiles and both neutral expressions and genuine smiles, might reflect increased difficulty in decisions regarding posed smiles, given the more mixed responses that occurred to posed expressions as compared to either neutral expressions or genuine smiles. Considering the very late occurrence of this activation difference between posed and genuine smiles and its occurrence only during the feel task, together with the orbitofrontal cortex's role in decision making and planning (Bechara et al., 2000; Ochsner & Barret, 2001), this late difference seems likely to be related to planning of behavioural responding 1000ms post-stimulus, based upon earlier simple perceptual discrimination between the two stimulus types. While there were indications of earlier activation perhaps reflective of simple perceptual discrimination between posed and genuine smiles, such differences were not definitively observed in the current study. However such activity must occur given that discriminatory behavioural responses have been shown to occur at earlier times (Eimer et al., 2003; Miles & Johnston, 2007). As noted earlier, brain activation related to such simple perceptual discrimination may be too subtle for measurement with the ERP techniques used, and/or may be primarily subserved by brain areas not observable with ERP techniques, for example subcortical structures like the amygdala.

Based on past research examining frontal activity (Batty & Taylor, 2003; Eimer et al., 2003; Marinkovic & Halgren, 1998) it had been predicted that greater activation for smiles compared to neutral expressions would be evident in the active judgment tasks. In the current research a different pattern of processing to that predicted occurred. From 450-550ms increased activation to neutral expressions was evident in comparison to posed smiles, and from 550-650ms increased activation to neutral expressions was evident in comparison to both posed and genuine smiles. Differences in methodology seem the most likely reason for the discrepancy between results of the current and previous studies. The results were perhaps most similar to Batty and Taylor (2003) where a non-face target was used during random presentation of a range of six facial expressions, together with similar ERP analysis and recording methodologies. Marinkovic & Halgren (1998) used a task where participants had to rate the valence and intensity of facial expressions with a joystick, and found the opposite pattern of results with greater activation for smiles as compared to neutral expressions. This task is superficially similar to that in the current work, however differences (rating valence and intensity of expression as compared to judging 'showing' or 'feeling' happiness), and the unusual use of a circular neck electrode as reference point rather than mastoids or earlobes makes direct comparison of results impossible. Eimer et al. (2003) also found greater amplitude for smiles as compared to neutral expressions, but only during a task where faces were rated as 'emotional or not' by participants, which again is different from the task used in the current research. Differential activity according to emotional expression was observed at later time periods (>450ms) in the current study, consistent with research by Marinkovic and Halgren (1998), but not as early as other researchers have found (Batty & Taylor, 2003; Eimer et al., 2003). Differences in tasks utilised by different research groups, and limited examination of orbitofrontal activity in research to date, make comparisons of brain activation difficult, a problem that can only be addressed through further research investigating a wider range of ERP activity in a more comprehensive range of experimental paragdigms (Vuilleumier & Pourtois, 2007). However the current study is consistent with previous research to the extent that differential frontal activation between neutral and emotional expressions was observed, highlighting the importance of further detailed investigation of the orbitofrontal region in future research if facial recognition processes are to be understood more comprehensively.

Increased initial activation of the orbitofrontal cortex during the feel judgment task as compared to the show judgment and watching tasks was evident in the first 100ms time window (250-350ms), and increased activation for both show and feel judgment tasks compared to the watching task was evident over the next 400ms (350-750ms). These results support the apparent functional importance of the orbitofrontal cortex in interpreting, synthesising information and planning adaptive goal directed action in social judgment tasks (Gorno-Tempini et al., 2001; O'Doherty et al., 2003; Ochsner & Barret, 2001). The earlier and thus greater total activation for the feel as opposed to the show judgment task might reflect the more demanding cognitive aspects of this task. For example accurate judgments about whether someone is feeling happiness require processing of information from both mouth and eye regions, while for judgments about whether someone is showing happiness processing of information from the mouth may be sufficient. Lastly there was some indication of greater activation of the left as compared to the right hemisphere at 450ms, supportive of notions that the left hemisphere may have a specific role in processing of smiles (Root et al., 2006; Krolak-Salmon et al., 2001), at least at this time point and location.

4.5 Limitations, Strengths, and Future Directions

The current research was necessarily limited in several ways due to practical considerations. Although a greater number of expression displays were available than that utilised in much previous research (Ashley et al., 2004; Balconi, 2005; Eimer & Holmes, 2002; Herrmann et al., 2002; Krolak-Salmon et al., 2001; O'Connor et al., 2005; Orozco & Ehlers, 1998; Sato et al., 2001; Streit et al., 2003), there were not as many as that utilised in some previous research (Batty & Taylor, 2003; Marinkovic & Halgren, 1998; Miyoshi et al., 2004; Munte et al., 1998). ERP component responses and thus observable differences have been shown to attenuate to repeated presentations of the same stimulus (Heisz et al., 2006; Henson et al., 2000) and thus it was considered important to have as large a range of individual facial expressions as possible. In terms of quantity the number of facial expressions utilised this study thus compared favourably with much previous research, though more stimuli would be preferable, and given resource limitations there was an absence of male expressions available for experimental use. Previous research suggests that a faster response to male as compared to female happy expressions might be expected (Orozco & Ehlers, 1998). With respect to the facial expression display stimuli used, these were created according to strict criteria to ensure that ecologically valid facial expressions were created. Specifically, these were neutral expressions, posed smiles unrelated to a positive emotional experience, and spontaneous genuine smiles that occurred as part of a positive emotional experience. The rigorous facial expression display generation procedures helped ensure that ecologically valid posed and genuine expressions were available as opposed to just posed or computer morphed facial expressions, the use of which has been criticised by commentators (Holberg, Maier, Steinhauser, & Rudzki-Janson, 2006; Russel & Fernandez_Dols, 1997). Future research could make methodological improvements by using a greater range of facial expression stimuli and including male facial displays as well as female.

The experiment in this work also used static and not dynamic facial expression displays. This was judged as acceptable given that Miles (2005) found no difference in detection sensitivity rates between static and dynamic expressions, though bias in expression judgment was somewhat reduced when using dynamic displays. Differences in duration between posed and genuine expressions have been found (Schmidt et al., 2003; Frank et al., 1993; Hess & Kleck, 1990) and while these are not regarded as being as important as other cues, it has been argued that the greater information contained in dynamic expression displays may facilitate more accurate judgment of affect (Ambadar, Schooler, & Cohn, 2005), or reduce judgment bias (Miles, 2005). Consistent with this hypothesis increased activation of amygdala and fusiform gyrus have been observed in response to dynamic as compared to static facial expression displays as measured by fMRI (LaBar, Crupain, Voyvodic, & McCarthy, 2003) and in experiments utilising PET increased activation for dynamic as compared to static happy expressions occurred in visual area V5, extrastriate cortex, and middle temporal cortex (Kilts, Egan, Gideon, Ely, & Hoffman, 2003) Furthermore females (but not males) rated intensity of dynamic happy facial expressions as being greater than that of static happy facial expressions (Biele & Grabowska, 2006) and thus might be expected to have greater N170 amplitudes to such expressions (Sprengelmeyer & Jentzsch, 2006). Further research is needed to understand differences in brain response to dynamic as compared to static facial expression displays. In relation to differences between posed and genuine expressions, it is predicted that increased brain activity would occur in response to dynamic as compared to static expressions, as has been observed previously for other dynamic expressions compared to static expressions (Kilts et al., 2003; LaBar et al., 2003). Given interactions between behavioural sensitivity and ERP amplitudes in the current experiment, it also predicted that accurate judgment and less bias in judgment might be associated with increased differential brain activity in response to dynamic as compared to static posed and genuine smile expressions.

With respect to the behavioural component of the experiment, the social interaction task was conducted in a tightly controlled laboratory environment, in a situation not typical of everyday social interaction. However, differential responses to genuine as compared to posed smiles have been found to generalise across several experimental paradigms. These generalisation effects of genuine smiles include enhanced co-operative behaviour in response to genuine smiles as compared to neutral expressions and posed smiles, in co-operation tasks (Miles, 2005); more positive evaluation of products associated with genuine smiles (Peace et al., 2006), and a trend towards faster identification of positively valenced words in a priming task (Miles & Johnston, 2007). Thus it is considered likely that observed effects are not merely artefacts of the laboratory procedures employed, and have some real world ecological validity. It is also considered that the task involved (judging whether someone is happy or not), is a degree more naturalistic than much previous research that has often involved simply classifying facial expressions themselves as opposed to the observed persons underlying emotional state. Nonetheless more research utilising ecologically naturalistic behavioural tasks is necessary to enable generalisability of neuroelectrophysiological laboratory results obtained during those tasks to real world contexts (Vuilleumier & Pourtois, 2007).

The inherent limitations of ERP techniques mean that only patterns of cortical and not subcortical brain activation were examined. Complementary neuroimaging techniques such as fMRI would be valuable to aid source localisation of ERP components, and to investigate subcortical activation patterns. For example, as measured with fMRI, smiles as compared to neutral expressions have been found to activate the amygdala differentially (Hennenlotter et al., 2005; Williams, McGlone, Abbott, & Mattingley, 2005; Liu, Ioannides, & Streit, 1999; M. Williams, Morris, McGlone, Abbott, & Mattingley, 2004; Yang et al., 2002) and it has been argued that processing by the amygdala and consequent feedback to other brain areas such as the orbitofrontal cortex is a crucial part of the facial recognition processes. However, due to the electrically shielded properties of the amygdala and its location deep inside the brain such activity is not observable with ERP techniques (Eimer et al., 2003). Thus for various reasons the present research necessarily presents analysis of only a limited range of brain activity occurring during facial expression recognition tasks. Future research utilising a complementary range of techniques would assist with identification of other brain regions intimately involved in facial expression recognition. In particular such investigations would help to answer the question raised in the current work about early discriminative processing between posed and genuine smile expressions, that is, to what extent are the substrates of this process subcortical and to what extent are they cortical.

In the interests of statistical power, this study used only young adult females. Previous research indicates that there are different patterns of brain activation in facial expression processing at different stages of the lifespan (Batty & Taylor, 2006; Taylor, Batty, & Itier, 2004) and between males and females (Campanella et al., 2004; Lee et al., 2002; Orozco & Ehlers, 1998; Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006). Recent research suggests that females may have a general superiority to males in facial expression recognition tasks, perhaps based on an evolved 'attachment role promotion' mechanism rather than domain general learning (Hampson et al., 2006). A recent fMRI study (Chakrabarti, Kent, Suckling, Bullmore, & Baron-Cohen, 2006) found that striatal reward responses to happy faces were modulated by the cannabinoid receptor 1 (CNR1) gene, indicating an effect of an individual's genotype upon responses in social interaction tasks. The effect of such genetic, and also cultural differences (Schmidt & Cohn, 2001), in facial expression neurophysiology remain to be elucidated. Further research will be needed to fully understand patterns of brain activation in different populations. Given the research cited above greater amplitude to smiles and greater differentiation in brain activity between posed and genuine smiles might be expected in females as compared to males. Additionally face specific components develop over time in children and it is expected that responses to posed and genuine smiles would modulate these early homologues of the adult brain activity according to the ability of children to discriminate posed and genuine smiles.

While acknowledging the limitations of the current work, it is believed that the current research nevertheless represents a novel contribution to this field of research, and raises questions worthy of further investigation. In terms of the primary aim of this study, while definitive differences in brain activity between posed and genuine smiles were not detected at early time periods, significant interactions between behavioural sensitivity and ERP amplitudes were observed for P1 and N70 components. Additionally the patterns of early differential activity at occipital locations, and complicated modulation of orbitofrontal activations according to expression, task and hemisphere are findings that require further explanation. More detailed examination using ERP technology with denser electrode arrays and complimentary brain imaging techniques would aid in examining this brain activation in more detail. Analyses in future work could also usefully examine EEG responses in terms of ‘hits’ and ‘false alarms’. More stimuli may also help elucidate such differential brain activation (Batty & Taylor, 2003). Such further analysis is necessary to understand more fully the complex processes of brain activation associated with facial expression recognition.

4.6 Conclusions

This work was an investigation into the neural correlates of responses to posed and genuine smiles. Participants observed neutral expressions, posed smiles, and genuine smiles in a task with no behavioural judgment required, and two tasks where behavioural judgments ('showing happiness?' and 'feeling happiness?' respectively) were required. EEG recordings were made during these tasks to assess cortical brain activity at occipital, temporal and orbitofrontal locations during critical time periods.

Behavioural results replicated previous work, with participants demonstrating a high degree of sensitivity to the emotion underlying posed and genuine smiles. In terms of neuroelectrophysiological findings no early differential activation in response to posed and genuine smiles was observed, but it was observed during behavioural judgment tasks at a late time window 850ms post stimulus at orbitofrontal locations. In contrast differential processing between neutral expressions and smiles was observed as early as 135ms post stimulus at occipital locations. Thus, the observed late difference in activation between posed and genuine smiles may reflect later differential behavioural activation according to earlier initial perceptual discrimination activity that was unobserved in the current study. This lack of definitive earlier observable processing differences suggests that early cortical discriminative processing between posed and genuine smiles may be too subtle to detect with the ERP methodology used in the current experiment, or alternatively that critical discriminative processing differences may occur at a subcortical level unobservable with ERP techniques. However, when behavioural sensitivity of observers was considered in analysing the ERP data, a significant interaction between this perceiver sensitivity and early ERP amplitudes at occipital and temporal locations was observed, suggesting that more detailed processing may be occurring at these times and locations. Future research utilising denser electrode arrays and complimentary brain imaging techniques will be needed to explore these findings further.

Additional results supported hemispheric lateralisation of emotion processing. There was increased right temporal activation during behavioural judgment tasks supporting the theory that the right hemisphere is generally and preferentially involved in emotion tasks. Indications of increased left orbitofrontal activation is also consistent with previous research suggesting that the left hemisphere may have a specialised role in processing of positive emotional expressions.

Lastly there was the novel finding of increased activation of the orbitofrontal cortex during the task of judging whether a person was feeling happiness, as compared to the task of judging whether a person was showing happiness. It was hypothesised that this extra neural activity reflected the increased neural demands of feel judgments which require successful attention to the eye and mouth regions, as compared to show judgments which only require attention to the mouth region. This observation further emphasises the important role of the orbitofrontal cortex in social perception tasks.

Overall the results of this study support the important distinction between posed and genuine smiles, replicating previous behavioural research findings and describing a detailed first ERP exploration of this behavioural phenomenon. Observations were consistent with recent theoretical models that describe neural processing of facial expressions as task dependent, complex and widely distributed spatially and temporally.

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APPENDIX A: PARTICIPANT RECRUITMENT POSTER

VAN DER VEER INSTITUTE for Parkinson's & Brain Research

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

Discrimination of Facial Expression Study

18-40 Year-Old Female Research Participants Needed!

This study is an important part of ongoing research investigating human social perception. The procedure will involve you wearing a sensor array while seated, and watching faces on a computer screen. The duration of the procedure will be approximately 45-60 minutes. This is a completely safe and harmless procedure and you may withdraw at any time. The research is to be conducted at the Van der Veer Brain Research Institute in Christchurch (16 St Asaph St).

A $20 gift voucher will be given to all participants.
If you are female aged 18-40, and have no diagnosed visual or neurological problems (except corrected vision), and are interested in helping, please contact me for an information letter by emailing XXXXXXXXXX, or phoning/texting Mark at XXXXXXXXXX

APPENDIX B: PARTICIPANT INFORMATION SHEET

Discrimination of Facial Expression Study

Project Information Sheet for Participants (V5)

Dear Potential Participant,

I would like to invite you to be involved in a research project conducted by the Van der Veer Brain Research Institute and the Department of Psychology at the University of Canterbury. The project aims to investigate brain electrophysiological activity in adults viewing facial expressions. Discriminating facial expressions is an important social skill. Knowledge acquired in this project will aid our understanding of social perception disorders, and the potential benefits for diagnostic tests and treatment interventions are wide ranging.

Overview of the Study

The experiment will involve you watching faces on a computer screen while seated and wearing a number of sensors. These sensors detect changes in your brains electrical activity which will occur in response to you viewing the faces on the computer screen. These changes in brain electrical activity are called 'evoked response potentials', or ERP's. Evoked potential studies are considered safe procedures. The tests cause little discomfort. The sensors only record activity and do not produce any sensation.

The locations for each sensor are first cleaned with a slightly abrasive paste, and then the sensors are attached with adhesive tape. The sensors use a small amount of conductive gel to improve detection of your brains electrical activity, so your hair may be slightly dampened in places. Once the test is complete, the sensors will be removed and the gel washed off. In some cases you may need to wash your hair at home to completely remove all traces of the gel. **(Important: Please ensure your hair is washed with shampoo and clean and dry the morning before the experiment, but do not use conditioner or apply any hairspray or other hair products – as these coat the scalp and interferes with the recording).**

An experimenter and technician will be on hand to observe the participant and the equipment throughout the entire procedure. Before the procedure you will have an opportunity to discuss any concerns or questions you have about the procedure, such as storage and use of data collected. Participants and/or their whanau may also carry out Karakia (blessings) before the procedure takes place. Care will be taken that you

APPENDIX B (cont): Participant Information Sheet

are not placed under any stress at any time during the procedure. If at any time you wish to discontinue, you will be removed from the study.

Duration and Location of the Study

The duration of the procedure will be approximately 20 minutes, plus approximately 20-40 minutes set-up time. It will take place at the Van der Veer Brain Research Institute, located at 16 St Asaph St, Christchurch.

Financial Reimbursement

A $20.00 gift voucher will be provided to you as reimbursement for time and travel costs.

People Involved

The Masters student who will be working on the project is Mark Carlisle Ottley. The project is being supervised by Associate Professor John Dalrymple-Alford from the Department of Psychology at the University of Canterbury, and Dr Catherine Moran from the Department of Communication Disorders at the University of Canterbury. The project has received ethical clearance from Human Ethics Committee at the University of Canterbury and the Health and Disabilities Upper South Regional Ethics Committee.

Information Collection and Usage

The results of the project will be published but no identifying information will be included in any project reports, professional papers or presentations. All data collected will be stored securely at the University of Canterbury for 5 years and then destroyed.

If you have any concerns or queries about being involved in the project, including the procedure itself, the storage and use of information collected, or anything else, please do not hesitate to contact:

Mark Ottley
Telephone: XXXXXX
Mobile: XXXXXX
Email: XXXXXX

If you are happy to participate in this project please contact me, and I will arrange a time for you to come in for the experiment.

Many thanks for your time in considering this invitation

Yours sincerely,
Mark Ottley: BSc, Gr. Dip. Sc. BA Hon.
Master of Science Student

APPENDIX C: PARTICIPANT CONSENT FORM

Discrimination of Facial Expression Study

Project Consent Form for Adult Participants

1. I have read and I understand the information sheet dated 27 July 2006 for volunteers taking part in the above study. I have had the opportunity to discuss this study. I am satisfied with the answers I have been given.
2. I understand that the information gathered from the project may be published but no identifying information will be included in any project reports, professional papers or presentations.
3. I also understand that I may withdrawal my participation in the project at any stage and any previously gathered information in regards to my participation will be withdrawn.
4. I understand that I will receive a $20.00 voucher to reimburse time and travel costs upon the completion of the procedure.

I ___________________________ give consent to be involved in the research project being carried out by Mark Ottley under the supervision of Associate Professor John Dalrymple-Alford and Dr Catherine Moran.

Signed (Participant) _________________________________ Date: ________

Signed (Investigator) ________________________________ Date: ________

APPENDIX D: HANDEDNESS AND ETHNICITY FORM

VAN DER VEER INSTITUTE for Parkinson's & Brain Research

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

Edinburgh Handedness Inventory Participant No:____ Age:____

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column*. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks*. If in any case you are really indifferent, *put a check in both columns*.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	☐ ☐	☐ ☐
2. Drawing	☐ ☐	☐ ☐
3. Throwing	☐ ☐	☐ ☐
4. Scissors	☐ ☐	☐ ☐
5. Toothbrush	☐ ☐	☐ ☐
6. Knife (without fork)	☐ ☐	☐ ☐
7. Spoon	☐ ☐	☐ ☐
8. Broom (upper hand)	☐ ☐	☐ ☐
9. Striking Match (match)	☐ ☐	☐ ☐
10. Opening box (lid)	☐ ☐	☐ ☐
TOTAL(count checks in both columns)		

Ethnicity of participant: **Which ethnic group do you belong to?** *Please tick the one(s) or enter another that applies to you.*

New Zealand European	
Maori	
Samoan	
Cook Island Maori	
Tongan	
Niuean	
Chinese	
Indian	
OTHER (Please State)	

APPENDIX E: PARTICIPANT INSTRUCTIONS FOR MAIN EXPERIMENT

<u>Instructions for Experiment 2a:</u>

“Watch the white cross in the centre of the screen and the faces that appear.

Try not to blink too much, as this causes interference in the recordings.”

<u>Introduction for Experiments 2b and 2c:</u>

“In the second and third parts of this experiment we are interested in whether or not people can tell if somebody else is actually experiencing or FEELING an emotion that they are SHOWING on their face. For example, if somebody is smiling are they actually feeling happy?

Sometimes we can display, or SHOW, an emotion without actually experiencing it. For instance if you encounter a person, say a work colleague, who you do not particularly like, often you will smile politely – that is you SHOW happiness (by smiling) even though you don’t actually FEEL happy when you see the person. So can we tell the difference between when somebody is smiling because they are feeling happy or because they are being polite?”

<u>Instructions for Experiment 2b:</u>

“As before, watch the white cross in the centre of the screen and the faces that appear.

After each face a response screen will appear, and you will be asked to choose whether the face you just saw was SHOWING happiness. Press the '1' key to answer 'no', and the '2' key to answer 'yes'.

Once again, try not to blink too much, except when the response screen is showing.”

<u>Response Screen for Experiment 2b:</u>

“Was this person SHOWING Happiness?

Yes – Press 1.
No – Press2.”

<u>Instructions and Response Screen for Experiment 2c:</u>

Wording was identical to that for Experiment 2b except that instances of the word ‘SHOWING’ were replaced by the word ‘FEELING’.

APPENDIX F: SIGNAL DETECTION ANALYSIS FORMULAS

For calculation of non-parametric indices of sensitivity (A') and response bias (B").

Sensitivity (A')

- For H≥FA: A' = 0.5+[(H-FA)(1+H-FA)]/[4H(1-FA)]
- For FA≥H: A' = 0.5+[(FA-H)(1+FA-H)]/[4FA(1-H)]

Response Bias (B")

- For H≥FA: B" = [H(1-H)- FA(1-FA)]/[(H(1-H)+FA(1-FA)]
- For FA≥H: B" = [FA(1-FA)-H(1-H)]/[(FA(1-FA)+H(1-H)]

APPENDIX G: STIMULI IN MILES STUDY (MILES, 2005)

Procedure and stimuli used for the generation of facial displays

Phase		*Description*	
Intro		Welcome and instructions *Mood scale 1*	
1	Neutral	neutral expression *Mood scale 2*	
2	Posed Smile	smile passport photo family portrait photo with PM photo for CV photo for drivers license *Mood scale 3* Instructions	
3	Mood Induction	Classical music: Allegro movements (4:05 minutes) - Mozart Divertimento #136 - Vivaldi Concerto… g major - Mozart Eine Kleine Nach Musik *Mood scale 4* Instructions	
4	Genuine Smile (IADS)	*Males* cardinal (116) rock and roll (815) erotic female (201) sport crowd (352) boy laugh (220) funk music (820) baby laugh (110) applause (351) erotic female (202) baseball (353) erotic couple (215) *Mood scale 5* Instructions	*Females* choir (812) rock and roll (815) baseball (353) boy laugh (220) erotic couple (215) funk music (820) male laugh (221) applause (351) baby laugh (110) erotic female (201) applause (401)
5	Genuine Smile (IAPS)	kitten (1460) erotic couple (4607) snow skiing (8190) baby (2050) rabbits (1750) baby (2040) dolphin soccer (1920) baby (2070) erotic female (4220) babies (2080) erotic female (4250) puppies (1710) erotic female (4210) erotic female (4232) seal (1440) erotic couple (4664) erotic couple (4652) car (8510) baby (2260) *Mood Scale 6* END	garden (5760) dolphin soccer (1920) seal (1440) kitten (1460) puppies (1710) baby (2057) rabbit (1610) rabbits (1750) baby (2040) ladies (2395) erotic couple (4607) sunset (5830) baby (2058) baby (2070) babies (2080) children (2091) snow skiing (8190) man and baby (2165 grandfather and kids (2340)

APPENDIX H: STIMULI IN MCLELLAN STUDY (MCLELLAN, 2008)

Procedure and stimuli used for the generation of facial displays

Block 1	Task	Relax	
	IADS	Clock tick (708)	
		Typewriter (322)	
	IAPS	Tumor (3261)	
		Baby (2661)	
		Sad child (2800)	
		Infant (3350)	
		Disabled child (3300)	
		Mug (7009)	
		Checkerboard (7182)	
	Task	Task Passport photo	
		ID card	
	IAPS	Attractive man (4572)	
		Erotic male (4561)	
		Women (1340)	
		Monkeys (1811)	
		Adult (2020)	
		Attack (6550)	
		Spider (1205)	
		Mutilation (3060)	
	Task	Pretend sad	
		Pretend fearful	Reaction sheet
Block 2	Task	Sing National Anthem	
		Stop	
		Permission to show tape	
		Stop	
Confederate stimuli		Fake sad reaction to blank slide	
		Fake fearful reaction to blank slide	
		Fake disgust reaction to blank slide	
	Scenario	Display sad face	
		Display frightened face	Reaction check
	Sad song	Think about sad event	Confirm reaction
Block 3	Scenario	Walking alone at night	
	IADS	Walking (722)	
		Female scream (276)	
		Puppy cry (105)	
		Baby cry (261)	
		Victim(286)	
		Car wreck (424)	
		Bike wreck (600)	
		Baby laugh (110)	
		Erotic female (201)	Reaction sheet
	Task	Relaxation	
	IADS	Clock tick (708)	
		Typewriter (322)	
	Task	Pose a sad face	
		Pose a fearful face	