DISSERTATION

EVENT-RELATED POTENTIALS FOR THE IMPLICIT AND EXPLICIT PROCESSING OF EMOTIONAL FACIAL EXPRESSIONS AS BASIC LEVEL- AND SUBORDINATE LEVEL-STIMULUS CATEGORIES

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ABSTRACT

EVENT-RELATED POTENTIALS FOR THE IMPLICIT AND EXPLICIT PROCESSING OF EMOTIONAL FACIAL EXPRESSIONS AS BASIC LEVEL- AND SUBORDINATE LEVEL-STIMULUS CATEGORIES

The two dominant models in face perception propose independent mechanisms are responsible for initial face perception (discriminating a face from an object), identity recognition (recognizing a specific face) and emotional expression perception (processing of an expression). However, Bruce and Young (1986) propose a linear model where identity recognition and expression perception operate in a parallel manner after initial face perception while Haxby, Hoffman and Gobbini (2000) propose an interactive model where all three mechanisms interact with each other within a non-linear core system. Event related potentials (ERPs) demonstrate that initial face perception is reflected by the temporal occipital P1 and N170 while identity recognition is reflected by the anterior N250. Some studies have found an expression influence on the P1 and N170 while other studies have not, providing mixed support for either model. The current study examined how facilitation of basic level and subordinate level category processing of emotional expressions may have influenced the results of previous studies. Research in stimulus category processing demonstrates that faces are typically processed at the subordinate level (e.g. my friend “Joe” as opposed to the basic level of “face”) while objects are processed at the basic level (e.g. car but not the subordinate level of “Nissan Sentra”). However, there has been little research exploring how the processing of expressions may be influenced by category processing.

Happy, neutral and sad expressions were presented in isolation for Experiment 1 to facilitate processing of expressions on the basic level (faces are all unfamiliar with the most basic changes being only in expression) while the same expressions were presented alongside cars, houses and butterflies in Experiment 2 to facilitate subordinate processing (basic level: faces vs. objects; subordinate level: happy, neutral and sad expressions and cars, houses and butterflies). Experiment 1 found P1 and N170 modulations by happy, neutral and sad expressions that were not influenced by implicit or explicit processing condition with no such modulations in Experiment 2. Additionally, there were early modulations of ERPs related to expression in both experiments in the 30-80ms range with explicit processing mediating face and object differences found in the 30-80ms range for Experiment 2.

The results of the current study support the Haxby, Hoffman, and Gobbini model where expression perception mechanisms can modulate early ERP components reflecting initial face perception and also show that this modulation depends on the presence or absence of comparison object stimuli. When comparison stimuli were not present (Experiment 1), expressions processed as a basic level stimulus category mainly influenced ERPs in the 140-400ms time range reflecting enhanced processing of the specific expression. When comparison object stimuli were present (Experiment 2), expressions processed as a subordinate stimulus category mainly influenced ERPs in the 30-140ms time range reflecting quicker categorization due to the presence of object stimuli rather than processing of the specific emotional expression.

Dedicated to Mom and Dad: For their unconditional love and support over the years.

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Introduction

Humans have the ability to not only rapidly distinguish faces from other types of objects, but the ability to also recognize thousands of individual faces with little variation between the size and configuration of distinguishing facial features. Additionally, faces facilitate the rapid exchange of social information such as emotional expression, eye gaze, age, and attractiveness. The spatial and temporal aspects of face discrimination (discrimination of faces from other objects such as houses or chairs), identity recognition (discrimination of a specific face from other faces) and emotional expression recognition have been the focus of many behavioral, clinical, and neuro-scientific investigations (e.g., see Bruce and Young (1986) and Haxby, Hoffman & Gobbini (2000) for reviews). Spatially, face discrimination, identity recognition, and emotional expression recognition have been shown to rely on both unique and overlapping cortical areas demonstrating both the independence and dependence of these three systems. Temporally, it is generally accepted that the ability to distinguish faces from objects occurs before the ability to recognize the face of a specific individual. However, the extent that emotional expression influences face processing on a temporal level is still unclear.

Event Related Potential (ERP) investigations of initial face perception have identified the P1 (Herrmann, Ehlis, Ellgring, & Fallgatter, 2005; Rossion, Joyce, Cottrell, & Tarr, 2003; Schendan, Ganis, & Kutas, 1998; Thierry, Martin, Downing, & Pegna, 2007) and N170 (Bentin, Truett, Puce, Perez, & McCarthy, 1996; Botzel, Schulze, & Stodieck, 1995; Carmel & Bentin, 2002; Eimer, 2000a, 2000b, 2000c; Henson, Goshen-Gottstein, Ganel, Otten, Quayle, & Rugg, 2003; Rousselet, Husk, Bennett, & Sekuler, 2008;) as the earliest temporal markers indicating when a face is discriminated from other types of visual stimuli such as houses and chairs. The P1 is a temporal-occipital positive going waveform occurring 80-140ms post-stimulus while the N170 is a negative going waveform also found on occipital temporal areas occurring 140-200ms post-stimulus.

ERP investigations of identity recognition have identified the temporal occipital N250 (Bentin & Duell, 2000; Gordon & Tanaka, 2011; Gosling & Eimer, 2011; Kaufman, Schweinberger, & Burton, 2009; Nasr & Esteky, 2009; Tanaka, Curran, Porterfield, & Collins, 2006) and the frontal central FN400 (Curran & Hancock, 2007; Galli & Otten, 2011; MacKenzie & Donaldson, 2009; Rugg & Curran, 2007) as the earliest markers indicating when a specific face is discriminated from other faces. The N250 is an occipital temporal negative going waveform found 200-300ms post-stimulus while the FN400 is found over frontal central areas 300-500ms post-stimulus. Therefore, there is a linear progression of face recognition processes where initial face discrimination is indexed by the P1 and N170 and precedes identity recognition as indexed by the N250 and FN400.

Emotional expressions have influenced ERP components occurring at 250ms or later in a number of studies (Batty & Taylor, 2003; Dong & Lu, 2010; Luo, Feng, Wang, & Luo, 2010; Munte, Brack, Grootheer, Wieringa,Matzke, Johannes, 1998; Rellecke, Sommer, & Schacht, 2012) with some studies finding modulation of early components in frontal regions only rather than temporal occipital regions (see Eimer & Holmes, 2002, 2003, 2007; Holmes, Winston & Eimer, 2006). However, the influence of emotional expressions on the two well-known temporal occipital ERP components related to initial face discrimination, the P1 and N170, is unclear. Although some studies demonstrated that emotional expression modulates the amplitude of the P1 (Batty & Taylor, 2003; Rellecke et al., 2012) and the N170 (Batty & Taylor, 2003; Blau, Maurer, Tottenham, & McCandliss, 2007; Rellecke et al., 2012), other studies have found no modulation of the P1 and N170 components by emotional expression (Ashley et al., 2004; Carretie & Iglesias, 1995; Eimer & Holmes, 2002, 2003, 2007; Herrmann et al., 2002; Holmes, Winston & Eimer, 2006; Tsurusawa, Goto, Mitsudome, & Tobimatsu, 2005; Munte et al., 1998). Therefore, the general temporal dynamics of face discrimination and identity recognition are better understood than the temporal dynamics of emotional expression recognition.

The purpose of the current study is to conduct two novel experiments that will examine how the presentation of emotional facial expressions influence ERPs such as the temporal-occipital P1 and N170 when presented as basic level-stimulus categories and subordinate level-stimulus categories. Experiment 1 presented emotional facial expressions as a basic level-stimulus category by using only faces as stimuli that differ along happy, neutral and sad expressions. Additionally, Experiment 1 examined if the order of task presentation influenced ERPs related to expression perception. That is, Experiment 1 examined if receiving implicit or explicit processing tasks first or second influence ERPs related to expression perception. Experiment 2 presented emotional facial expressions as a subordinate level-stimulus category by using faces and objects as the basic level-stimulus category and by using cars, houses and butterflies as subordinate objects categories and happy, neutral and sad expressions as subordinate expression categories. Additionally, Experiment 2 examined how image cropping (the practice of removing the hair, jawline, and other outer facial features to focus on the eyes, nose and mouth areas of the face) influenced the perception of faces, objects, and emotional expressions.

This paper consists of several major parts before the introduction of two novel experiments. First, a review of the face recognition literature related to the initial discrimination of faces from other objects will be followed by a discussion of the independence of initial face discrimination, identity recognition, and emotional expression recognition mechanisms. Next, a discussion of the two dominant face perception models and their relation to the literature will be followed by a discussion of the time course of initial face discrimination and why it is thought to temporally precede identity recognition. Then, the literature examining the influence of emotional expression recognition on the P1 and N170 and its relation to the two face perception models will be discussed. Finally, two novel experiments that examined how ERPs were influenced by emotional expressions processed as basic level- and subordinate level-stimulus categories are presented.

Face Recognition

The first evidence that face selective neural pathways existed in humans were psychiatric studies involving patients diagnosed with a visual condition called propsopagnosia (Bodamer, 1947; reviewed by Ellis & Florence, 1990). Bodamer coined the term Prosopagnosia by describing a patient with a bullet wound to the head who could no longer recognize his friends or family by their faces; he used other traits such as their tone of voice or gait. Recently, prosopagnosia has been diagnosed from both brain injuries (acquired prosopagnosia) and developmental abnormalities (congenial prosopagnosia) with patients exhibiting a wide range of deficits in face perception. The most common factor across cases of prosopagnosia is that individuals with both types of prosopagnosia typically exhibit impaired facial recognition ability while demonstrating preserved object recognition ability (Damasio, Damasio & Van Hoesen, 1982; Damasio, Tranel, & Damasio, 1990; Meadows, 1974; Whitely & Warrington, 1977). This neuropsychological condition was the first evidence suggesting a special neural network existed for face processing that was unique from other types of visual object processing.

With the advent of neuroscientific techniques such as subdural electrode recording, face selective cortical areas were identified within the temporal lobe of non-human primates (for a complete review see: Rolls, 2000). For example, Perrett, Rolls, and Cann (1982) recorded action potentials of single neurons within the superior temporal sulcus of alert rhesus monkeys presented with human faces, monkey faces, or simple geometric stimuli such as lines and bars or 3d stimuli of everyday objects. They found that human and monkey faces elicited neuronal responses that were at least twice as large as responses to geometric stimuli or 3d objects. These face selective neurons were unresponsive to auditory and tactile stimuli such as loud noises or touches from experimenters as well as threatening stimuli such as toy snakes or spiders. Accordingly, action potentials of neurons within the superior temporal sulcus of monkeys have demonstrated selective sensitivity to face angles (Oram & Perrett, 1992; Smith, Potter, Mistlin, Head, Milner & Jeeves, 1985; Tanaka, 2000), face features (Yamane, Kaji, & Kawano, 1988), facial identity (Rolls, Baylis, Hasselmo, & Nalwa, 1989) and facial expression (Hasselmo, Rolls, Edmund, Baylis & Gordon, 1989), and gaze direction (Heywood, Cowey, & Rolls, 1992).

Subdural EEG recordings in humans undergoing corrective surgery for epileptic seizures have also identified face selective regions within the temporal and occipital lobes. Puce, Allison, and McCarthy (1994) placed strips of subdural EEG electrodes on temporal and occipital lobes of patients undergoing neurosurgery for epileptic seizures and presented images of faces, scrambled faces, letter-strings, number strings, and various objects. They found that cortical areas within the occipital temporal cortex were activated more for faces than for the other categories of stimuli. The earliest point where increased activation for faces separated from other categories of stimuli was represented by a negative going waveform with a peak latency of 200ms (N200) mainly located bilaterally in the fusiform gyrus. Although hemispheric differences in amplitude and latency were not found, there were larger patches of face-selective cortical areas in the right hemisphere. Follow up papers described other comparisons made during the experiment and reported that the N200 was not significantly influenced by color or grayscale faces, blurred faces, line drawings of faces, or the size of faces (McCarthy, Puce, Belger, & Allison, 1999). Further, the N200 was larger for human faces than to faces of cats and dogs, larger for faces with averted eyes compared to eyes facing directly ahead, and smaller for faces with profile compared to full or three-quarter views. Finally, the N200 was not responsive to familiar faces such as Ronald Reagan or learned unfamiliar faces from the context of the experiment, violent images, semi-nude images, or landscapes (Puce, Allison, & McCarthy, 1999). Thus, this demonstrated that specialized cortical areas were dedicated to processing faces as opposed to other types of visual stimuli and confirmed early predictions of face specific pathways from clinical assessments of prosopagnosia.

As subdural electrode recordings involve highly invasive neurosurgery, the majority of face processing research is now conducted using non-invasive methods such as Positron Emission Tomography (PET), functional Magnetic Resonance Imaging (fMRI), Magnetoencephalography (MEG), and scalp-acquired ERPs. PET and fMRI offer excellent spatial resolution while MEG and ERPs offer excellent temporal resolution. These techniques have been used to demonstrate both spatial and temporal differences for face processing compared to the processing of other types of visual stimuli.

PET, fMRI, MEG, & ERP

Neuroimaging techniques with excellent spatial resolution such as PET and fMRI have identified the fusiform gyrus within the dorsal object recognition stream as being selectively responsive to faces compared to other types of visual stimuli such as houses and chairs. For example, Haxy, Grady, Horwitz, Ungerleider, Mishkin, and Carson et al. (1991) used PET to examine cortical activity correlated with face recognition and spatial recognition. Participants were presented with one image on the top of the screen of either a face or a spatial location of dots and were asked to identify which one of two images on the bottom of the screen was similar to the top image. They found that the face recognition task activated cortical areas such as the fusiform gyrus within the temporal lobes within the dorsal object identification stream while the spatial matching task activated cortical areas within the superior parietal lobes within the ventral spatial location stream. Other PET studies that have focused more specifically on face and object processing also identified unique fusiform cortical activity related to face processing (Haxby, Horwitz, Ungerleider, Maisog, Peitrini, & Grady, 1994; Sergent, Ohta, & MacDonald, 1992).

Because of the radioactive nature of the isotope used to identify cortical activity in PET, the use of fMRI in face processing studies have increased due to the use of non-harmful magnetic fields that identify increased blood flow in the brain. A host of fMRI studies have identified the fusiform gyrus within the temporal lobes as an important cortical area for face perception (Clark, Keil, Maisog, Courtney, Ungerleider, & Haxby, 1996; Hoffman & Haxby, 2000; McCarthy, Puce, Gore & Allison, 1997). For example, Kanwisher, McDermott, and Chun (1997) conducted one of the first fMRI studies to specifically examine face perception processes by first presenting faces and common objects to participants in order to identify face specific region of interests within the fusiform gyrus. Follow up tests in the fMRI scanner demonstrated that these face specific cortical regions of interest for each participant responded more to faces than scrambled faces, houses and human hands. Other fMRI studies have also found increased cortical activation in localized areas of the fusiform gyrus in response to faces compared to houses (Haxby, Ungerleider, Clark, Chouten, Hoffman, & Martin, 1999), tools (Chao, Haxby, & Martin, 1999), and chairs (Ishai, Ungerleider, Martin, Schouten, & Haxby, 1999).

MEG studies offer excellent spatial and temporal resolution by utilizing MRI scans to correlate electrical activity acquired from magnetic fields with physical locations within the brain. However, the extreme cost of using both an MRI scanner and an MEG scanner restricts availability to most researchers. Those with the means to conduct MEG studies have identified a negative going temporal-occipital waveform occurring approximately 170ms (M170) after stimulus onset that responds more to faces than to other types of visual stimuli; the M170 is thought to be the corollary of the N170 ERP. For example, Halgren, Raij, Marinkovic, Jousmaki and Hari (2000) presented participants with images of human faces, scrambled faces, animal faces and animal bodies, and random everyday objects such as houses and books. They found that electrical activity within the fusiform gyrus approximately 165ms after stimulus onset was greatest in response to the human faces compared to all other stimuli category. The finding that fusiform activation occurring approximately 170ms after stimulus presentation is largest in response to faces compared to other stimuli has been found in numerous MEG studies (Linkenkaer-Hansen, Palva, Sams, Hietanen, Aronen, & Ilmoniemi, 1998; Liu, Higushi, Marantz, & Kanwisher, 2000; Okazaki, Abrahamyan, Stevens, & Ioannides, 2008; Sams, Hietanen, Hari, Ilmoniemi, & Lounasmaa, 1997; Xu, Liu, & Kanwisher 2005).

ERPs offer excellent temporal resolution while being the most cost-effective neuro-scientific methodology reviewed in this paper. These two advantages combined with its non-invasive nature is the reason ERP experiments are a popular methodology among neuroscientists. ERP studies have identified the temporal occipital N170 as an index of initial face perception (the N170 ERP, the N200 in subdural electrode studies, and the M170 in MEG studies are all thought to represent the same underlying face processing mechanism). Perhaps the first systematic study on the N170 was conducted by Bentin et al. (1996). They presented participants with four or five types of various categories of faces and objects while asking them to keep count of a non-face target category in a passive face viewing task. They found that the N170 amplitude was larger for human faces opposed to scrambled faces, cars, scrambled cars, butterflies (Experiment 1), hands, animal faces, and furniture (Experiment 2). When facial features were presented individually (Experiment 3) or presented within a scrambled manner on the face (Experiment 5), the N170 was greatest in response to those faces that contained eyes as features. The authors argued that the N170 was the first temporal marker of face perception and represented processing of general facial features rather than identity recognition. This finding is in accordance with a large literature demonstrating that the initial perception of a face is represented by the N170 that will be reviewed below. Recently however, the P1 that is found over the same temporal-occipital scalp areas as the N170 has been implicated as an index of initial face perception. The role of the P1 and N170 in initial face perception and their relationship to emotional expression recognition will be discussed in more detail later.

Emotion Recognition

There are numerous lines of evidence from several areas of research suggesting that face perception, identity recognition, and emotional expression recognition rely on separate neural mechanisms. As the focus of the proposed study is the examination of face perception and emotional expression recognition, only studies containing emotional expression recognition tasks will be reviewed (for studies focusing on the N250 that compare face perception and identity recognition see Schweinberger, Huddy, & Burton, 2004; Schweinberger, Pickering, Burton, & Kaufman, 2002; Schweinberger, Pickering, Jentzsch, Burton, & Kaufmann, 2002; Tanaka et al., 2006). As with the convergent lines of evidence for a specialized face perception system reviewed above, there is a similar convergence of evidence from several lines of research suggesting emotional expression recognition relies on a neural network that is distinct from face perception and identity recognition.

As mentioned previously, prosopagnosics demonstrate clinical evidence of a specialized face recognition pathway. Interestingly, prosopagnosics also provide clinical evidence that identity recognition and expression recognition rely on separate neutral pathways by demonstrating preserved emotional expression recognition despite being unable to recognize faces of family members or famous individuals. For example, Duchaine, Parker, and Nakayama (2003) demonstrated that an individual with developmental prosopagnosia that scored below average in tests of face recognition performed normally in tests of object recognition and emotional expression recognition. Such findings of preserved emotional expression recognition with impaired identity recognition have been demonstrated in both lesion-induced prosopagnosia (Tranel, Damasio, & Damasio, 1988) and developmental prosopagnosia (Duchaine, Parker, & Nakayama, 2003; Lee, Duchaine, Wilson, & Nakayama, 2009). Therefore, while prosopagnosics are unable to recognize individual faces, they can still recognize emotional expressions suggesting that identity recognition and expression recognition are separate neural processes.

Behavioral studies have also been used as evidence that identity recognition and emotional expression are processed independently. Some of the first behavioral evidence for separate mechanism underlying identity and expression recognition was that reaction time and repetition priming tasks influenced identity recognition but not emotional expression recognition (Ellis, Young & Flude, 1990; Young, McWeeny, Hay, & Ellis, 1986). Additional evidence from behavioral paradigms come from memory experiments demonstrating that faces presented with emotional expressions at encoding can both enhance (D'Argembeau & Van Der Linden, 2007; D'Argembeau, Van Der Linden, Comblain, & Etienne, 2003) and harm (Nomi, Rhodes & Cleary, 2013) the recognition of those faces when displayed with neutral expressions at test compared to those test faces encoded with neutral expressions depending on the employed experimental paradigm.

Along with the previous primate studies that have measured cortical activity in the temporal lobes with subdural electrodes in response to faces, other primate studies have investigated the specialization of cells with regards to identity and emotional expression recognition within the temporal lobes. For example, Hasselmo, Rolls, and Baylis (1989) recorded the responses of single neurons within the temporal lobe of the macaque monkey while presenting them with images of three monkeys displaying three facial expressions: calm, slight threat, full threat. They found that certain neurons activated in response to the identity of a certain monkey regardless of its expression while other neurons only activated in response to expressions regardless of identity. Identity neurons were found primarily in the inferior temporal gyrus, while emotional expression neurons were found primarily in the superior temporal gyrus. This demonstrated that primate brains had specific pathways for identity and expression processing and suggested that a similar divergence between identity and expression processing existed in humans. Accordingly, Ojemann, Ojemann, and Lettich (1992) placed subdural electrodes over 13 populations of neurons in the right temporal lobe of human subjects while presenting several tasks that included facial identity matching tasks and emotional expression recognition tasks. They found that some neurons in the middle temporal gyrus were more responsive to emotional expression suggesting specialized processing of emotional expressions compared to identity and vice versa.

Non-invasive techniques such as PET and fMRI have also identified distinct cortical areas related to face perception and expression recognition. Sergent, Ohta, MacDonald, and Zuck (1994) used PET to measure participants' blood flow while performing face recognition and emotional expression recognition tasks. They found that recognition tasks increased blood flow to the ventral-temporal region of the right hemisphere while expression recognition tasks increased blood flow to the dorsal region of the temporal lobes. Using an fMRI scanner, Winston, Henson, Fine-Goulden, and Dolan (2004) presented participants with pairs of faces that matched in identity or emotional expressions. When repeating pairs matching in identity, blood flow was reduced within the fusiform gyrus and the posterior superior temporal sulcus (STS). When repeating pairs matching in emotional expression, blood flow was reduced in the anterior STS suggesting a functional dissociation between identity recognition and emotional expression recognition. They argued that reduced blood flow within cortical areas signified specialization of processing as neurons relevant for a certain process would habituate when presented with the same stimuli twice. Other neuroimaging studies have also found distinct cortical activation for identity recognition and emotional expression recognition processes (Gläscher, Tüscher, Weiller, & Büchel, 2004; Nomi et al., 2008).

Streit et al. (1999) utilized a MEG paradigm by presented participants with either human and animal faces along with random objects such as houses and cars (Experiment 1) or faces displaying six emotional expressions (Experiment 2) while asking them simply to identify the face, object, or emotional expression. They found specific cortical areas within the right superior temporal cortex that were preferentially responsive to expressions but not face identification, cortical areas activated during both tasks but more so for expression identification, and finally, cortical areas that were activated early in response to identification but later in response to expressions. Further, differences between faces and objects emerged as early as 100 ms while differences in identification and expression tasks emerged as early as 170 ms.

ERP studies have also found that empathizing with various emotional expressions has different influences on cortical activity. Esslen, Pascual-Marqui, Hell, Kochi, and Lehmann (2004) presented participants with images of six different emotional expressions while asking participants to acquire the emotion displayed in the expression. Using low resolution brain electromagnetic tomography (LORETA) they identified regions within the right superior temporal cortex that were increased in response to emotional expressions compared to neutral expressions.   This difference occurred as early as 100 ms and also involved areas within the right and left prefrontal cortex. Although this ERP study focused more on spatial information in conjunction with temporal information, a more in depth discussion of ERP studies that have focused solely on the temporal dynamics of emotional expressions will be reviewed below.

In summary, a vast amount of research from behavioral and neuroscientific investigations have identified unique neural networks related to face perception, identity recognition, and emotional expression recognition. This network is centered around inputs from superior and inferior occipital areas feeding into the fusiform gyrus for face perception processing along with dorsal and ventral areas adjacent to the fusiform gyrus. The superior and inferior occipital areas along with the fusiform gyrus are thought to represent the initial processing of low level facial features with the fusiform gyrus working in concert with areas of the superior temporal sulcus and adjacent dorsal and ventral areas for emotional expression recognition.

Models of Face Perception

There are two major models that have been used as frameworks to interpret the findings that propose different cortical mechanisms are responsible for face perception, identity recognition and expression perception: the Bruce and Young model (1986) and the Haxby, Hoffman, and Gobbini model (2000; *Figure 1*). The Bruce and Young model assumes that face perception occurs in stages with the first stage being the early detection of low level facial features or head angle or the discrimination of faces from objects. After a face is detected, separate systems process information such as emotional expression, identity, or lip movement in a parallel manner. The distinctive feature of this model is that it assumes that identity recognition and emotional expression recognition take place in distinct neural networks in a parallel fashion *after* the initial recognition of a face. Thus, there is a linear progression from the systems that process the initial perception of a face and its features to the systems responsible for perception of identity and facial expression.

The Bruce and Young model remained the dominant model of face recognition until Haxby et al. (2000) introduced a face model based on more recent neuroscientific research. In their model, a core system is responsible for three main processes: early perception of facial features, invariant aspects of faces such as identity recognition, and changeable aspects of faces such as emotional expression or eye gaze. The early perception of facial features are found in the inferior occipital lobes that project into the fusiform gyrus for invariant aspects of face perception such as identity and gender with other projections into the superior temporal sulcus for variant aspects of faces such as expression and eye gaze. The model proposes that these three mechanisms interact with each other because invariant information such as the face shape is still needed to help process variant information such as expression and gaze movements. That is, the perception of a face as a "face" is a necessary framework within which expression and gaze movements can be processed. This core system interacts with an extended system that is able to incorporate mechanisms such as attentional control, emotion, and personal information such as name or occupation of an individual. This creates an interactional approach within which initial perception of the face is processed in a core system that also overlaps with the processing of invariant aspects such as gender and identity and the processing of variant aspects such as gaze and expression.

The main similarity between the Bruce and Young Model and the model by Haxby and colleagues, is that variant and invariant aspects of faces are driven by separate mechanisms. In the Bruce and Young Model, the mechanisms for invariant and variant aspects of face processing are separate but operate in parallel. However, in the model by Haxby et al., variant and invariant aspects of faces are driven by separate mechanisms that interact with each based on the idea that invariant aspects responsible for assembling features into a human "face" is a necessary framework for interpreting variant aspects such as expression and gaze movements.

The Bruce and Young model implies that emotional expression recognition should not influence ERP components related to initial face perception but should influence those components that occur later and that are related to identity recognition. On the other hand, the model proposed by Haxby at el allow for the influence of emotional expression during the perception of face features and identity implying that emotional expression should be able to influence components during the time course related to early face perception and also those later components during the time course related to identity recognition. Although the neuroscientific literature supports separate neural systems for facial identity and emotional expression recognition as well as separate neural systems for face perception and identity recognition, the evidence for how emotional expression recognition interacts with initial face perception and identity recognition on a temporal level is less clear. The literature related to ERP processing of face discrimination and emotional expression perception will be presented before they are discussed in relation to the two previously described models of face perception.

Time Course of Face Discrimination, Identity Recognition and Expression Recognition

The ERP literature is largely in agreement on two aspects of face recognition. First, the initial encoding of a representation that can be identified in a general manner as a “face” that is distinct from other objects occurs between 80-200ms as represented by the P1 and N170. Second, the ability for the brain to make distinctions between different faces for specific identity recognition occurs between 200-500ms and is represented by the N250 and FN400 waveforms. The N250 has been demonstrated to be sensitive to familiar family members and faces learned within the context of an experiment (Bentin & Duell, 2000; Gordon & Tanaka, 2011; Gosling & Eimer, 2011; Kaufman, Schweinberger, & Burton, 2009; Nasr & Esteky, 2009; Tanaka et al., 2006) while the FN400 is thought to reflect familiarity-based recognition as in recognizing the face of someone you have met before but you cannot remember where or when you met them (Curran & Hancock, 2007; Galli & Otten, 2011; MacKenzie & Donaldson, 2009; Rugg & Curran, 2007). Therefore, the temporal progression of face processing begins around 80-200ms where the discrimination of facial features from other types of stimuli first occurs as indexed by the P1 and N170, while the discrimination of specific faces occurs 200-500ms as indexed by the N250 and FN400.

However, although the time course of initial face perception and identity recognition has been generally established, the temporal nature of emotional expression recognition has not been established. As the purpose of the current study will be to examine the influence of emotional expression on the P1 and N170, the relation of these two components to the face perception literature needs to be discussed before an examining of their modulation by emotional expressions can proceed.

P1

The P1 has been related to the initial perception of low level perceptual features such as shifts in letter positions of words (Cornelissen, Tarkianinen, Helenius, & Salmelin, 2003) or spatial attention (Mangun, 1995). However, it has more recently been linked to the initial stages of face perception where faces are discriminated from other objects (Herrmann, et al., 2005; Rossion et al., 2003) and words (Schendan et al., 1998). For example, Thierry et al. (2007) presented faces and other objects that were either matched in size, or half the size of all other stimuli in an ERP paradigm. They found that the N170 did not differ for faces compared to other objects but to the size difference within categories (i.e., half sized face/car compared to normal sized face/car) while the P1 differentiated between faces and other object categories. Therefore, the authors argued that the P1 was the earliest temporal marker of face discrimination rather than the often cited N170.

Itier and Taylor (2004) found that both the P1 and N170 discriminated between faces and inverted faces as well as between faces and nine other categories of stimuli that included mushrooms, flowers, houses, lions, tools, roads signs, and various images of texture like surfaces. Participants were instructed to simply view the stimuli while pressing a button to a checkerboard image that appeared between sets of images. The P1 and N170 amplitude for temporal occipital areas was significantly larger for faces compared to all other categories in addition to being significantly larger and delayed for inverted faces compared to upright faces. Face inversion has also been found to influence the temporal occipital P1 component in other ERP studies (Itier & Taylor, 2002; Linkenkaer-Hansen, Palva, Sams, Hietanen, Aronen, Ilmoniemi, 1998; Mohamed, Neumann, & Schweinberger, 2011).

Martin, Moro, Pegna and Thierry (2011) presented participants with cropped and unaltered faces and compared them to cropped and unaltered cars (Experiment 1) and butterflies (Experiment 2). The practice of cropping images is often utilized in face experiments in an attempt to remove extraneous visual information from being processed. Thus, external features such as hair, ears, and the jawline are removed in order to focus on internal features such as the eyes, nose, and mouth. This is because the manipulation of internal features has large influences on participants' ability to process faces in different types of experimental paradigms (Cabeza & Kato, 2000; Maurer, Le Grand & Mondloch, 2002; Tanaka & Sengco, 1997). In Martin et al., participants were asked to press a button to categorize the image as a face or non-face as quickly as possible after the presentation of the stimuli in a forced choice recognition task. The amplitude of the P1 component was higher for faces compared to other categories regardless of being cropped or unaltered while the N170 was not modulated by category differences but was larger for cropped images compared to unaltered images.

Rossion et al. (1999) demonstrated that attentional focus due to the difference between an identity recognition task and a gender recognition task elicited differences in the P1. They presented participants with videos depicting individuals writing letters that were focused on the facial area. They later took part in a test with faces and were asked to determine if a face was previously viewed within the video for the identity task or to simply determine the gender in the gender recognition task. They found that the P1 was larger over occipital areas for the face recognition task and suggested that this increase in P1 amplitude was probably due to attentional modulations of face recognition. That is, the increased P1 amplitude was probably due to the fact that it takes more cognitive processing to discern identity than gender. Thus, it was the type of task that was influencing the P1 rather than the type of stimulus.

The M1 (the MEG corollary of the P1 ERP) has also been demonstrated to differentiate between faces and other categories of stimuli such as animals, houses, human hands and random objects in identity matching tasks where participants are asked to indicate when two images are presented in a row (Halgren, Raij, Marinkovic, Jousmaki, & Hari, 2000; Liu, Harris, &

Kanwisher, 2002). Even earlier MEG temporal differences between faces and other categories such as cups, animals, or cars were found by Braeutigam, Bailey and Swithenby (2001) who presented images of various categories back to back and asked participants to identify if the second presented image matched the first. They found differences between faces and other categories occurring within 30-60ms of the presentation of the first image. The M1 has also been found to be delayed to face inversion (Meeren, Hadjikhani, Ahlfors, Hamalainen, & de Gelder, 2008) and contrast reversal (Itier, Herdman, George, Cheyne, & Taylor, 2006).

In sum, there is a wealth of new studies suggesting that initial face perception occurs as early as 80-120ms post stimulus onset as indexed by the P1. This is in contrast to the original hypothesis that initial face perception occurs approximately 130-200ms post-stimulus as indexed by the N170. Unfortunately, a review of the arguments for or against one or the other as an index of initial face perception is beyond the scope of this paper. For the purposes of this paper a clarification of the exact function of the P1 and N170 is not necessary, thus both the P1 and N170 will be considered indexes of initial face perception.

N170

Although the P1 has recently been identified as a temporal marker for initial face perception, the N170 was the first identified temporal marker tied to initial face perception. The N170 also has a corollary ERP in the Vertex Positive Potential (VPP) which is a positive going waveform occurring within the same time window but is found across the frontal and midline areas of the scalp (Cauquil, Edmonds, & Taylor, 2000; Jeffreys, 1996). The VPP and the N170 have been shown to originate from the same cortical generators and thus are a measure of the same neural process (Joyce & Rossion, 2005). However, because the N170 has been the focus of the majority of face perception studies, it will be discussed in more detail.

The N170 has been shown to have a larger amplitude for faces compared to other object categories such as cars, birds, furniture, ape faces (Carmel & Bentin, 2002), scrambled faces (Henson et al., 2003) and scrambled cars (Bentin et al., 1996), houses (Eimer, 2000a, 2000c; Rousselet et al., 2008), and flowers/leaves (Botzel et al., 1995). Thus, modulations to both the P1 and N170 demonstrate that the brain discriminates faces from other categories of visual stimuli extremely quickly after stimulus onset; usually within 200ms after visual stimulus presentation.

In addition to discriminating faces from other categories of stimuli, evidence also exists that the brain is sensitive to low level perceptual differences of faces inside of the same 200ms time window. These low level perceptual differences are sometimes represented by modulations in amplitude but are usually represented in the form of a delayed or increased latency in response to manipulations such as face orientation (upright vs. inverted; Ashley, Vuilleumier, & Swick, 2004; Eimer, 2000a; Itier, Alain, Sedore, & McIntosh, 2007; Itier, Latinus, & Taylor, 2006; Rossion & Gauthier, 2002; Rossion et al.,2000), head orientation (left, right, back, etc.; Eimer, 2000b), image frequency (high frequency image versus low frequency image; Goffaux, Gauthier, & Rossion, 2003; Nakashima et al., 2008), attractiveness (Halit, de Haan, & Johnson, 2000), and image contrast (Itier & Taylor, 2002).

In sum, studies have shown the P1 and N170 are not only sensitive to manipulations of the face but also demonstrate different amplitudes for faces compared to other categories of stimuli such as houses, cars and animals. Further, The N170 is not sensitive to familiar faces (Eimer, 2000c; Henson et al., 2003) or changes in features or configuration (Jemel, George, Chaby, Fiori, & Renault, 1999; Mercure, Dick, & Johnson, 2008; however see Campanell et al., 2000). Finally, the N170 is not influenced by repetition priming paradigms where faces are immediately repeated within the context of the experiment (Schweinberger et al., 2004; Schweinberger, Pickering, & Burton et al., 2002; Schweinberger et al., 2002). Thus, the N170 is generally considered a temporal marker of initial face perception and not a temporal marker of identity recognition (however, see: Jacques & Rossion, 2006).

Relation of the P1 and N170 to Models of Face Perception

The finding that the temporal occipital P1 and N170 are sensitive to the initial discrimination of faces from objects combined with studies demonstrating that they are typically not sensitive to familiar or learned faces suggest that they are markers of initial face perception and not markers of familiar faces or identity recognition. In fact, although both models do not specifically account for N170 literature in their framework, several authors have proposed that the N170 represents the initial stage of face perception in the Bruce and Young model (Bentin et al., 1996, 1999; Eimer, 1998, 2000; Joyce & Rossion, 2005). Because the N170 ERP has been implicated as the initial stage of face perception in the Bruce and Young model, a logical extension of the model is to assume that the ERPs happening after the N170 are indexes of identity recognition and emotional expression. Thus, the Bruce and Young model would predict that emotional expressions should not influence ERPs such as the temporal occipital N170 because if the initial stage of face perception is independent of the following stages indexing identity and expression recognition, then there should be no influence of expression on early ERPs related to face perception such as the temporal occipital P1 and N170. On the other hand, the interactive model by Haxby et al. suggests that emotional expression should interact with the systems responsible for initial face perception and identity recognition. Thus, the Haxby et al. model would predict that emotional expressions are able to influence early ERPs related to face perception such as the temporal occipital P1 and N170.

However, as mentioned previously, it is still unclear the extent to which emotional expressions influence ERP components of initial face perception such as the P1 and N170. Although some studies have found that emotional expression does influence the N170 (Batty & Taylor, 2003; Blau, Maurer, Tottenham, & McCandliss, 2007; Rellecke, Sommer, & Schacht, 2012), other studies have found no modulation of the P1 and N170 components by emotional expression (Ashley et al., 2004; Bentin & Duell, 2000; Carretie & Iglesias, 1995; Eimer & Holmes, 2002, 2003; Herrmann et al., 2002; Munte et al., 1998; Tsurusawa, Goto, Mitsudome, & Tobimatsu, 2005).

Emotional Expression Influence on the P1 and N170

Perhaps the largest set of studies conducted by one lab examining the influence of emotional expression on early ERP components was done by Eimer, Holmes, and colleagues. They conducted a series of studies where they found that emotional expression had no influence on the occipital temporal P1 and N170 components but did influence frontal-central components on the scalp occurring within the same time window as the P1 (Eimer & Holmes, 2007). Their first experiment (Eimer & Holmes, 2002) compared fearful faces, neutral faces, and houses presented individually while participants were asked to identify when two identical images were presented in a row. They found increased positivity over frontal-central areas occurring approximately 120 - 700ms after stimulus onset in response to fearful faces, but no modulation of the temporal-occipital N170. Eimer, Holmes, and McGlone (2003) presented pairs of faces displaying anger, disgust, fear, happiness, sadness, and surprise were on both sides of a fixation cross. In between the faces and the fixation cross were two vertical bars that were either similar in length or different in length. In implicit and explicit emotional processing tasks participants were asked to determine if the pair of faces displayed emotional or neutral expressions (explicit processing) or if the two vertical bars were the same length (implicit processing). In implicit and explicit tasks, there was no modulation of the P1 and N170 by emotional expression while frontal-central areas again demonstrated a greater positivity occurring around 180 - 700ms post stimulus in the explicit task only. Holmes, Vuilleumier, and Eimer (2003) used an array of two faces and two houses arranged vertically and horizontally around a fixation cross while participants were asked to detect repetitions in either the vertical or horizontal stimuli demonstrated the same implicit/explicit pattern of results. Holmes, Kiss, and Eimer (2006) presented participants with centrally fixated faces flanked by lines on both sides and asked participants to either attend to the faces or the lines. When attending to faces, the same frontal-central positivity from earlier studies was found approximately 160 - 700ms after stimulus onset. However, when making line judgments, the early frontal central positivity was found only from 160 - 200ms after stimulus onset. This demonstrated that the type of implicit and explicit processing task along with foveal and peripheral presentation could modulate early frontal-central ERP components while leaving temporal-occipital P1 and N170

ERPs unchanged. Overall, expressions presented foveally and processed implicitly and explicitly elicited early frontal-central differences compared to neutral expressions. Further, emotional expressions presented peripherally and processed implicitly failed to elicit early frontal-central differences when compared to neutral expressions. Finally, no amplitude modulation of the temporal-occipital P1 and N170 occurred when contrasting emotional expressions with neutral expressions in all of their aforementioned experiments.

In contrast to the findings of Eimer, Holmes, and colleagues, several studies have demonstrated that emotional expressions can modulate the P1 and N170 components. For example, Rellecke et al. (2012) demonstrated that early ERP components could be influenced by implicit/explicit processing tasks of emotional face recognition. They presented participants with angry, happy, and neutral expressions while asking them to either passively view the faces, passively view emotional expressions, explicitly identify the emotional expressions and discriminate between faces and words. They found that angry expressions elicited larger P1 and N170 amplitudes than neutral and happy expressions in implicit and explicit tasks while happy expressions elicited larger amplitudes than neutral expressions only in later time windows (200-600ms) within explicit tasks. Therefore, implicit/explicit processing interacted with emotional expression such that angry expressions influenced early components regardless of tasks while happy expressions only influenced later components when explicitly attended.

Blau et al. (2007) presented participants with images of cropped fearful and neutral facial expressions as an irrelevant first item in a paired associated learning task. After the presentation of the face, participants were presented with a line drawing followed by an auditory word and told to associate the two into one memory representation. Although participants were told the face was an incidental item and the learning task was important, the actual data analysis focused only on the facial expressions and not the learning task. Passive viewing of fearful expressions led to larger N170 amplitudes than passive viewing of the neutral expressions.

Batty and Taylor (2003) demonstrated that the P1 and N170 were influenced by images of emotional facial expressions in an implicit recognition task of static expressions. They presented participants with unaltered images of seven expressions (sadness, fear, surprise, neutral, disgust, anger, and happiness) alongside control stimuli of cars, planes and butterflies while asking them to press a button in response to the control stimuli. They found that the P1 amplitude was smallest for neutral and surprised faces while the N170 demonstrated earlier latencies for neutral, happy, and surprised faces. Additionally, P1 amplitudes were smallest for surprised expressions while the N170 amplitude was largest for fearful expressions.

Calvo and Beltran (2013) had participants judge if happy, angry, fearful, sad, and neutral expressions were correctly labeled by an immediately followed word; the word correctly described the expression 50% of the time. They found that angry, fearful, and sad expressions produced larger N170 amplitudes than happy and neutral expressions while happy and angry expressions produced larger negative amplitudes in the 200-300ms range.

In sum, previous experiments have demonstrated that emotional expression both will and will not modulate the amplitude of the P1 and N170 ERPs. Other paradigms not directly related to the current study that have noted influences of emotional expression on the N170 include dynamic changes in expression (Miyoshi, Katayama, Morotomi, 2004) attentional blink paradigms (Luo et al., 2010; Maratos, 2011), and affective judgments consisting of “like/dislike” ratings (Pizzagalli, Lehmann, Hendrick, Regard, Pascual-Marqui, & Davidson, 2002). Thus, the exact situations where emotional expression may influence early ERPs related to initial face perception remain unclear. The purpose of the current study is to examine how presenting emotional facial expressions influence early ERPs such as the temporal occipital P1 and N170 when presented as basic level- and subordinate level- stimulus categories.

Basic Level vs. Subordinate Level Category Processing

It is often possible to identify any individual item on a number of different levels of categorization. For example, a car can be identified on the superordinate level (non-living thing), the basic level (car) or on the subordinate level (Nissan) while faces can also be identified on the superordinate level (living thing), the basic level (face) or the subordinate level (specific identity, or emotional expression). The basic level is defined as the category representing the most general and observable cues that characterize a class of stimuli (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) and is assumed to take a privileged position in the object recognition hierarchy. The prioritization of the basic level category is evidenced by longer processing times to identify super- and sub-ordinate rather than basic level category labels for various stimuli such as animals and furniture (Jolicoeur, Gluck, & Kosslyn, 1984; Tanaka, 1999) and the recruitment of additional visual cortical areas within the ventral pathway for subordinate level judgements in fMRI tasks (Gauthier, Tarr, Moylan, Anderson, Skudlarski, & Gore, 2000).

However, faces have shown to be an exception to the basic level classification advantage for objects. Famous faces have been shown to be identified faster on the subordinate level (Bill Clinton) than the basic level (human/person) as opposed to objects that are identified faster on the basic level (dog) than the subordinate level (beagle; Tanaka, 2001). It is thought that faces are processed in a different manner than objects because every-day experience with faces makes virtually all adults experts at face recognition (Tanaka & Gauthier, 1997). Accordingly, car and bird experts also demonstrate subordinate level advantages when identifying items in their respective category compared to novices (Tanaka & Taylor, 1991) further demonstrating the impact of expertise on visual perception.

The possibility of basic level- and subordinate level-category stimuli confounds in studies of face discrimination that use objects as control stimuli was raised by Gauthier, Anderson, Tarr, Skudlarski and Gore (1997). They suggested that because faces are typically processed on the subordinate level while objects are typically processed on the basic level, there may be intrinsic confounds within such comparisons. That is, faces are processed as subordinate categories such as, “my friend Jack”, “cashier at the store”, or in the case of experiments - “unfamiliar person”, whereas objects are processed as “cars”, “houses” or “butterflies” as opposed to subordinate categories such as “Chevy”, “Jack’s house” or “monarch butterfly”. This would mean that passive viewing studies comparing face and object stimuli faces would have faces processed on the subordinate level while objects are processed on the basic level. Therefore, increases in the fMRI blood-oxygen-level dependent (BOLD) signal for faces in comparison to objects could partly represent increased visual processing due to faces being processed as a subordinate stimulus category while objects are processed as a basic level category.

In order to control for this difference, Gauthier et al. (2000) had participants listen to aurally presented basic level (bird) and subordinate level (sparrow) labels while judging if the labels matched simultaneously presented visual images. They found that subordinate level judgments for object categorizations produced a BOLD signal in the fusiform face area comparable in magnitude to that of a face perception task within the same study. However, although the magnitude of the BOLD signal related to subordinate object category judgments was equal to that in the face perception task, the cortical activation related to subordinate object categorization was more dispersed compared to the strongly clustered focal activation related to faces within the fusiform face area. They advised that although this does not account for all of the face perception advantages in the fMRI literature (see Kanwisher et al., 1997) it did show that category taxonomy was an issue that should be considered in face perception paradigm design.

If faces are automatically represented at the subordinate level due to categorization of familiarity as Guathier et al. (1997) suggested, then presenting faces alongside other object stimulus control categories would mean that emotional expressions may be relegated to the role of a subordinate object category while facial identity takes on the role of the basic level category. Another alternative is that faces are processed on the basic level of “face” when compared to “objects”; this would still relegate the role of emotional expressions to a subordinate category. However, if faces are presented in isolation with only changes in the emotional expression present, then the emotional expression most likely becomes the basic level category as they will then represent the category change with the most common overlapping features. That is, all the faces are unfamiliar, but the most common change in the unfamiliar faces will be the changes in expression related to happy, neutral and sad expressions. On the other hand presenting faces alongside of objects may change the categorization from expressions being a basic level category to faces vs. objects being the basic level category. This would shift the focus from the categorization of emotional expressions as a basic level category to other features of face more related to identity and the subordinate processing of identity leading to subordinate level categorization of unfamiliar identity. Thus, it is possible that the modulations of the N170 by emotional expression may be influenced by the categorization of the emotional expression as a basic level as opposed to subordinate level category taxonomy. If this is the case, it may be expected that emotional facial expressions presented as a basic level stimulus category would elicit different modulations of the temporal occipital P1 and N170 than facial expressions presented as a subordinate level stimulus category.

Tanaka, Luu, Weisbrod, and Keifer (1999) had participants name object categories at the superordinate (animal), basic level (dog, bird) or subordinate level (beagle, robin) of categorization. They presented images of non-face stimuli consisting of animals, plants, fruits, vegetables, tools, furniture, musical instruments, sports equipment, vehicles, and weapons preceded by a category label denoting correct or incorrect super/basic/sub-ordinate category labels. Participants decided if the following image was correctly described by the preceding category label. Superordinate processing produced increased positivity around 350 ms compared to basic level processing in central electrodes while subordinate level processing produced increased negative amplitudes in waveforms similar to the N170 compared to basic level processing. They suggested that the larger negative N170 amplitude was related to increased visual processing that resulted from the subordinate category discrimination task. This demonstrated that the processing of stimuli according to basic level and subordinate level categories exert different influences on ERP waveforms.

Scott, Tanaka, Sheinberg, and Curran (2006) trained participants to distinguish between wading birds and owls on the basic level (wading bird, owl) and the subordinate level (egret, snowy owl); half the participants were trained on the subordinate level for one category and the basic level for the other. Before and after training participants were run through a matching paradigm while EEG data were collected. Participants were presented with an image of a category (snowy owl) and then after a blank screen they were presented with either the same species of a different example (e.g., a different snowy owl) or a different species within the same category (screech owl). Basic level processing was measured by participants' ERPs in response to untrained subordinate categories while subordinate level processing was measured by ERPs in response to trained subordinate categories. They found that after training, the N170 was still not sensitive to subordinate level processing of birds arguing against any influence of subordinate level processing for the N170. Rather, the N170 increased in size to basic level processing regardless of training type. However, a temporal occipital N250 component increased in response to subordinate category processing only for those trained in that subordinate category. They suggested that the N170 was a marker of basic level processing regardless of expertise while the N250 was a representation of specific subordinate category exemplars.

Until this point in the ERP literature, there is virtually no research exploring how the categorization of emotional expressions relates to the breakdown of basic vs. subordinate stimulus categories in isolation or in comparison to object categorization. It is unclear whether presenting emotional facial expressions in situations where they may be perceived as basic level stimulus categories compared to situations where they may be perceived as subordinate level stimulus categories change the expression of P1 and N170 ERPs related to initial face perception. If faces are normally processed on the identity (i.e., familiar or unfamiliar face) or basic (i.e., "face" vs. "object") when compared to objects, previous studies presenting faces alongside houses or other objects such as houses (e.g., Eimer & Holmes, 2002) may have inadvertently caused facilitation of the face/object basic level category distinction thereby relegating emotional expressions to subordinate-level category status. This is opposed to other studies (e.g. Rellecke et al., 2012) that have presented facial expressions without comparison object categories that may have facilitated the processing of faces according to emotional expressions rather than on the intrinsic subordinate level of identity.

One purpose of the current study is to present happy, neutral and sad emotional facial expressions as basic level stimulus categories and subordinate level stimulus categories by manipulating the context of comparison stimuli. Experiment 1 will present faces differing only in happy, neutral and sad expressions while Experiment 2 will present faces differing in happy, neutral and sad expressions alongside objects consisting of cars, houses and butterflies. If faces are automatically represented on the basic level when compared with objects (faces vs. objects), then there should be no influence of emotional expression on the N170 (e.g., Scott et al., 2006; however, see Tanaka et al., 1999). However, if emotional expressions are presented in isolation, then there should be an influence of expression acting as a basic level category on the N170.

Experiment 1

Experiment 1 examined how emotional expressions are processed as a basic level-category by presenting faces differing only by happy, neutral, or sad emotional expressions.   As reviewed above, Rellecke et al. (2012) demonstrated that implicit/explicit processing of happy, neutral, and angry expressions may impact how emotional expressions influence early ERP components such as the P1 and N170. Experiment 1 will expand upon Rellecke et al. (2012) by examining how happy, neutral and sad expressions influence ERPs. It is important to contrast how angry expressions from Rellecke et al. (2012) and sad expressions from the current study influence ERPs relative to neutral and happy expressions because although angry and sad expressions are both negative in valence, they may differ in arousal. Previous research has shown that while participant's rate angry and sad expressions as negative in valence, angry expressions are rated higher in arousal (Britton, Taylor, Sudheimer, & Liberzon, 2006). Additionally, angry expressions are considered as 'threat related stimuli' that are usually prioritized in ERP studies as evidenced by earlier temporal influences and larger amplitudes in early components (Nomi, Frances, Nguyen, Bastidas, & Troup, 2013; Schupp et. al., 2004; Pourtois & Vuileumier, 2006; Rellecke et. al., 2012; Williams, Palmer, Liddell, Song & Gordon, 2006). Therefore, increased arousal from angry faces may mask any influence of happy expressions on ERPs.

Additionally, Rellecke et. al. (2012) presented the passive viewing implicit task first and the explicit task last in order to avoid contamination of explicit processing within implicit processing tasks. This is despite the fact that no known experiment has demonstrated any confounds of task presentation order while utilizing a blocked design of implicit and explicit face processing tasks. Experiment 1 will also manipulate the task order of implicit and explicit face processing tasks in a between subjects manner where half of the subjects will receive the implicit task first while the other half receive the explicit task first.

The implicit viewing tasks will consist of participants viewing a series of faces with happy, neutral, and sad expressions while attempting to identify if each individual is male or female; in the explicit viewing task, they will identify if the face displays an emotional expression or a neutral expression. The data analysis will focus on task order effects to determine if the presentation order of implicit and explicit emotional expression recognition tasks modulates the amplitude of the P1 and N170.

Methods

Participants

Forty Colorado State University undergraduates participated for course credit. Eight participants had traits of depression (Center for Epidemiological Studies Depression Scale [CES-D > 16]; Radloff, 1977) and eight had traits of anxiety (State Trait Anxiety Inventory [STAI-A > 40]; Spielberger, 1983) and were eliminated from the final analyss; five participants with anxiety also had traits of depression. Twenty Four participants were used in the final analysis: 16 Female, $Age_{\text{Mean}} = 20.46$, $Age_{SD} = 6.47$, 21 right-handed, two left-handed, and one ambidextrous.

Materials

Stimuli consisted of 60 images (30 male and 30 females) each of happy, neutral, and sad emotional expressions taken from various facial stimuli databases including the KDEF (Lundqvist, Flykt, & Ohman, 1998), RafD (Langner, Dotsch, Bijlstra, Wigboldus, Hawk, & van Knippenberg, 2010), and the NimStim (Tottenham et al., 2009) database. Depression (Center for Epidemiological Studies Depression Scale; Radloff, 1977) and anxiety (State Trait Anxiety Inventory; Spielberger, 1983) scales were used to exclude participants with depression and anxiety traits.

EEG acquisition

Continuous EEG data were recorded using a SynAmps RT amplifier in conjunction with Stim^2 presentation software and Neuroscan acquisition software. Cortical signals were acquired with 19 electrodes (Fp1, Fp2, Fz, F3, F4, F7, F8, Cz, C3, C4, Pz, P3, P4, P7, P8, T7, T8, O1, and O2) arranged according to the international 10 – 20 system within a Neuroscan 64 Channel Quick-cap. Reference and ground was acquired using factory placement on the Quick-cap net; reference is posterior to Pz in the midline while the ground was also midline posterior to Fz. Horizontal electro-oculogram (EOG) was recorded bilaterally over the zygomatic bone located just below the eye and over the cheek. Data were digitized using a sampling rate of 500 Hz and band pass filtered on-line between 0.1 and 50 Hz with a 24db cutoff. Impedances were kept below 11 kΩ for scalp electrodes and below 5 kΩ for left and right HEOG electrodes.

Procedure

Twelve participants randomly received the implicit task first while the other 12 randomly received the explicit task first. Implicit task trials consisted of a blank screen (2500ms) followed by a fixation cross (750ms). Each image was presented center-screen (2000ms) followed by an answer screen (3000ms). Participants were randomly assigned to press ‘1’ for “male” and ‘9’ for “female” or ‘9’ for “male” and ‘1’ for “female”. Participants were instructed to respond as quickly as they could but not before the answer screen appeared. The next face immediately appeared until all 160 faces were shown in a random order.

In the explicit task, participants were instructed to identify if each face displayed an emotional or neutral expression. Trials were presented in the same format as Experiment 1. Participants were randomly assigned to press ‘1’ for “neutral” and ‘9’ for “emotion” or press ‘9’ for “neutral” and ‘1’ for “emotion”. Participants were instructed to respond as quickly as they could but not before the answer screen appeared. The next face immediately appeared after an answer was given until all 160 faces were shown in a random order. A two alternative forced-choice task was used for the explicit task instead of a three-way multiple choice task to be consistent with the two-alternative forced-choice format of the implicit task. All participants completed a short block of four practice trials before implicit and explicit tasks.

Data Analysis

Participant’s recognition rates for gender and expression/non expression were greater than 99% for both conditions. EEG data were epoched off-line from 100ms pre-stimulus to

800ms post-stimulus. A dual band-pass filter (.1-30hz) was applied before artifacts were removed. Epochs exceeding +/- 110 µV at HEOG and scalp electrodes were considered contaminated by motion artifacts and were excluded from analysis. Electrode T7 was removed from two participants due to excess voltage readings. A baseline correction was applied before re-referencing to the grand average. Grand averages for nine experimental conditions were then created (explicit happy, explicit neutral, explicit sad, implicit happy, implicit neutral, implicit sad) with an average of 45.4 trials (75%) per condition per subject.

Repeated Measures ANOVAs were conducted on participant's mean amplitudes for six time windows (30-80ms, 80-140ms, 140-200ms, 200-400ms, 400-600ms) across four sets of horizontally arranged electrodes (occipital-O1/O2; temporal-T5 /T6; parietal P3/Pz/P4; central-C3/Cz/C4). Factors for all four sets of electrodes were Block Order (implicit task first, explicit task first), Condition (implicit, explicit) and Emotional Expression (happy, neutral, sad). Additional factors were Hemisphere (left, right) for occipital and temporal electrodes and Electrode (left, center, right) for parietal and central electrodes. Alpha levels were $\alpha<.05$ for all ANOVAs, and a Bonferonni-corrected $\alpha<.017$ for post-hoc paired samples t-tests. Only main effects or interactions including Emotional Expression were considered for analysis (*Figure 2*). The results from Expression interacting with Condition and Hemisphere/Electrode will be presented before Block Order x Expression interactions for ease of interpretation.

Occipital Electrodes

There was a main effect of Emotion in the 80-140 window [$F(2,44)=4.16$, $MSE=.98$, $p=.022$, $\eta_p^2=.159$; *Figure 3*], such that neutral faces ($M=1.9$ µV) were more positive than sad faces (*M*=1.56 µV; *p*=.008). In the 140-200 window there was a main effect of Emotion [*F*(2,44)=27.02, *MSE*=1.97, *p*<.001, η_p^2=.551], such that sad faces (*M*= -.78 µV) were more negative than neutral (*M*= -.33 µV)and happy (*M*=.67 µV) while neutral was also more negative than happy (*p*'s<.003). In the 200-400 window there was also a main effect of Emotion [*F*(2,44)=4.09, *MSE*=1.77, *p*=.024, η_p^2=.157]. Although no post hoc t-tests were significant, the same pattern emerged as the 140-200 window such that sad faces (*M*=.29 µV) were more negative than neutral (*M*=.53 µV) with sad and neutral more negative than happy (*M*=.84 µV). Finally, the 600-800 window had a main effect of Emotion [*F*(2,44)=4.71, *MSE*=.52, *p*=.014, η_p^2=.176], such that happy expressions (*M*= -2.05 µV) were marginally more negative than neutral (*M*= -1.44; *p*=.026). These main effects were modulated by Emotion x Hemisphere interactions below.

An Emotion x Hemisphere interaction [*F*(2,44)=5.10, *MSE*=.25, *p*=.01, η_p^2=.188] in the 30-80ms time window showed that sad expressions had marginally more negative right hemisphere (*M*= -.31 µV) amplitudes than left (*M*= -.04 µV; *p*=.03) while neutral left (*M*= -.05 µV) was marginally more negative than right hemisphere (*M*=.13 µV; *p*=.08); there was no difference between left (*M*= -.04) and right (*M*= -.16) hemispheres for happy (*p*=.20). This interaction continued into all five time windows (*p*'s<.009). In the 80-140 window (η_p^2=.369), only sad differed between hemispheres such that right (*M*=1.35 µV) was marginally lower than the left (*M*=1.77 µV; *p*=.05). In the 140-200 window (η_p^2=.234), neutral left (*M*= -.55 µV) hemisphere amplitudes were significantly more negative than the right (*M*=-.11 µV; *p*=.01) while the right (*M*= -.97) hemisphere was marginally more negative than the left (*M*= -.59 µV; *p*=.066) for sad. In the 200-400 window (η_p^2=.268), sad right (*M*= -.13) hemisphere were more negative than the left (*M*=.71; *p*<.001) with the right (*M*=.62 µV) hemisphere marginally more negative than the left (*M*=1.06 µV) for happy (*p*=.05). From 400-600ms (η_p^2=.286), sad right (*M*= -1.05 µV) hemisphere were significantly more negative than left (*M*= -.13 µV; *p*=.001). This same difference occurred in the 600-800 window (η_p^2=.194) where the right (*M*= -2.05 µV) hemisphere were more negative than left (*M*= -1.13 µV; *p*=.005) for sad. This showed that the Occipital P1 main effect reduction for sad faces was primarily carried by the right hemisphere. Additionally, hemispheric differences for neutral and sad expressions occurred in the 140-200 window for the N170 while hemisphere differences for happy and sad occurred in the 200-400 window for the N250. Finally, a late negativity in the right hemisphere occurred from 600-800ms.

Temporal Electrodes

There was a main effect of Emotion in the 80-140 window [*F*(2,44)=3.87, *MSE*=0.86, *p*=.028, η_p^2=.150], such that happy (*M*=1.82 µV) was marginally more positive than sad (*M*=1.45 µV; *p*=.055). There was also a main effect of Emotion in the 140-200 window [*F*(2,44)=60.79, *MSE*=1.74,*p*<.001, η_p^2=.734], such that sad (*M*= -2.09 µV) and neutral (*M*= -1.86 µV) were more negative than happy (*M*= -.17; *p*'s<.001). Finally, in the 200-400 window there was a main effect of Emotion [*F*(2,44)=15.86, *MSE*=1.15, *p*<.001, η_p^2=.419], such that sad (*M*= -.21 µV) was more negative than neutral (*M*=.01 µV) and happy (*M*=.68; *p*'s<.002). This showed that the temporal P1 was largest for happy expressions while the temporal N170 and N250 were largest for sad and neutral expressions.

Parietal Electrodes

There was a main effect of Emotion in the 140-200 window [$F(2,44)=22.65$, $MSE=2.00$, $p<.001$, $\eta_p^2=.507$], such that sad ($M=.13$ µV) was more negative than neutral ($M=.63$ µV) and happy ($M=1.24$ µV); neutral was also more negative than happy (p's<.016). This main effect was carried by an Emotion x Electrode interaction [$F(4,88)=6.79$, $MSE= -0.78$, $p<.001$, $\eta_p^2=.236$], such that neutral electrodes P3 and P4 were more negative than Pz while sad electrode P4 was more negative than Pz (p's<.009); additionally, sad P4 was marginally more negative than Pz ($p=.02$). There was also a main effect of emotion in the 200-400 window [$F(2,44)=8.14$, $MSE=1.01$, $p=.001$, $\eta_p^2=.270$], such that sad ($M=1.51$ µV) was more negative than happy ($M=1.51$ µV; $p=.001$). This main effect was modulated by a Condition x Emotion interaction such that Implicit sad and neutral were more negative than happy while Explicit sad was more negative than happy (p's<.016). Finally, there was a main effect in the 600-800 window [$F(2,44)=5.22$, $MSE=1.58$,$p=.009$, $\eta_p^2=.192$], such that happy ($M= -1.40$ µV) was marginally more negative than neutral ($M= -.91$ µV; $p=.027$). This showed that the parietal N170 was influenced by neutral and sad expressions across left and right hemispheres while the parietal N250 was greater for neutral and sad compared to happy in the implicit condition but only sad was greater than happy in the explicit condition. This suggests that neutral and sad were similar in the implicit condition but happy and neutral were similar in the explicit condition.

Central Electrodes

In the 140-200 window there was a main effect of Emotion [$F(2,44)=19.51$, $MSE= .92$, $p<.001$, $\eta_p^2=.470$], such that sad ($M=.85$ µV) and neutral ($M=.95$ µV) were more positive than happy (*M*=.29 µV; *p*'s<.002). In the 200-400 window there was main effect of Emotion such that neutral (*M*=.67 µV) and sad (*M*=.67 µV) were more positive than happy (*M*=.34 µV *p*'s<.016). This showed that sad and neutral expressions produced a larger VPP than happy while the central P250/P300 was largest for sad expressions.

Influence of Block Order

There were only two significant Block Order interactions including the condition Emotion (*Figure 4*) that influenced previously described differences. In the 80-140 window for temporal electrodes, there was a Block Order x Emotion interaction [*F*(2,44)=4.46, *MSE*=.87, *p*=.017, η_p^2=.168] that influenced the previously described temporal P1 increase for happy expressions compared to sad (*Figure 5*). The Block Order x Emotion interaction showed that there was no difference between happy (*M*=1.69 µV), neutral (*M*=1.49 µV), and sad (*M*=1.66 µV) expressions when participants were presented with the Explicit processing condition first. When participants were presented with the Implicit processing condition first, both happy (*M*=1.95 µV) and neutral (*M*=1.77 µV) were more positive than sad (*M*=1.23 µV) expressions. This showed that the temporal P1 is reduced for sad and neutral expressions only when presented in an Implicit processing task before an Explicit task.

In the 200-400 window there was a Block Order x Condition x Emotion interaction [*F*(2,44)=3.81, *MSE*=.99, *p*=.03, η_p^2=.148] that influenced the previously described parietal N250 Condition x Emotion interaction where neutral and sad expressions were greater than happy in the Implicit condition , but sad was greater than happy in the Explicit condition (*Figure 6*). The three-way interaction showed that when participants were presented with the Implicit condition first, there was no difference between happy (*M*=1.30 µV), sad (*M*=.94 µV), and neutral (*M*=.97 µV) expressions in the Explicit condition; in the Explicit condition, happy (*M*=.94 µV) and sad (*M*=.46 µV) were more negative than neutral (*M*=1.40 µV; *p*'s<.01). When participants were presented with the Explicit condition first, the Implicit condition showed that neutral (*M*=1.21 µV) and sad (*M*=1.16 µV) were more negative than happy (*M*=2.10 µV); in the explicit condition, neutral (*M*=1.28) was more negative than happy (*M*=1.70 µV; *p*'s<.01). This showed that when participants were presented with the Implicit processing task first there was no difference between expressions in the Implicit condition but then sad expressions elicit a larger parietal N250 than neutral and happy expressions in the Explicit condition. When participants were presented with the Explicit processing task first, neutral expressions had larger parietal N250 than happy in the Explicit task while both neutral and sad had larger parietal N250 amplitudes than happy in the Implicit task.

Latency Analysis

Peak amplitudes were detected for P1 and N170 waveforms for occipital and temporal electrodes only. These waveforms were identified through visual inspection as those showing the most pronounced peaks for follow up latency analysis. Peak amplitudes in the 80-140 and 140-200 time windows were subjected to a repeated measures ANOVAs using Block Order (implicit first, explicit first), Condition (implicit, explicit), Expression (happy, neutral, sad) and Hemisphere (left, right) as factors.

There were no effects or interactions for the 80-140 window for occipital or temporal electrodes (*p*'s>.08). Although there were no significant effects, happy expressions produced slightly longer latencies than neutral and sad expressions for both occipital (happy=117.31ms, neutral=115.08ms, sad=115.15ms) and temporal (happy=122.08ms, neutral=117.82ms, sad=115.15ms) electrodes (*Figure 7*). In the 140-200 window there was a significant Block Order x Expression x Hemisphere interaction [$F(2,22)=3.43$, $MSE=597.13$, $p=.041$, $\eta_p^2=.135$] for occipital electrodes. However, follow up ANOVAs on both Implicit First and Explicit First processing conditions showed no significant interactions of Emotion x Hemisphere (*p*'s>.20). Finally, there were no significant main effects or interactions for temporal electrodes the 140-200 window (*p*'s>.10). Although not significant, there was a trend for longer latencies for happy expressions again (happy=180.19ms, neutral=175.79ms, sad=178.17ms).

Discussion: Experiment 1

The results demonstrate that both the P1 and N170 are sensitive to happy and sad expressions when presented alongside neutral expressions on faces without a competing comparison stimulus category. Sad faces were characterized by an early decrease in the occipital P1 with large increases in the N170 compared to neutral and happy expressions. For the occipital and parietal N170, sad was greater than both neutral and happy while neutral was greater than happy; the temporal N170 showed both sad and neutral were greater than happy but did not differ from each other. Emotion x Hemisphere interactions for the occipital N170 and an Emotion x Electrode for the parietal N170 showed that sad faces also had larger amplitudes in the right hemisphere compared to left hemisphere; however, this effect was not present in temporal electrodes. Additionally, the Emotion x Hemisphere interaction of the occipital N170 showed that neutral expressions had greater amplitudes in the left hemisphere compared to the right – the opposite of sad faces. The Emotion x Electrode interaction for the parietal N170 showed that left and right electrodes were greater than the center electrode for neutral expressions – in contrast to sad faces where only the right electrode was greater than the center electrode. Finally, an Emotion x Hemisphere interaction showed that the occipital N250 was greater in the right hemisphere than the left for happy and sad faces but not neutral faces. Although sad faces led to a greater P3 than happy faces, the fact that the earlier VPP was also greater for sad faces makes it difficult to draw any independent conclusions about the central P3. That is, the P3 difference was not driven by processing differences related to the P3, but rather by the difference in the previous VPP component.

Happy expressions were characterized by an increased temporal P1 and reductions in the N170 compared to sad and neutral faces. Although happy expressions did not influence the N170 or VPP, they did elicit changes in the N250 for occipital and parietal electrodes. For occipital electrodes the N250 was greater in the right hemisphere than the left – the same effect that is found for sad faces. Finally, happy faces led to a late negativity over the 600-800 range compared to sad and neutral expressions over occipital and parietal areas. Visual inspection of the ERP waveforms suggest that this late negativity for happy was driven by an earlier positive component peaking around 400-600ms. It is unclear why this late positive component did not elicit any significant effect in the previous comparisons. It is possible that influences of Block Order may have contributed to null findings as significant Block Order effects exist for the 400-600 range in temporal and parietal electrodes. Because these components did not exert any main effects or interactions of Expression for Implicit and explicit processing conditions, and the difficulty of interpreting the function of late components in relation to earlier component changes, those results were not explored in this study.

The overall results from Experiment 1 show that perception of emotional expressions as basic level-stimulus category is first represented by an early separation of non-positive expressions (sad and neutral) in across hemispheres for occipital electrodes. Negative (sad) and positive (happy) expressions begin to show differences in occipital and temporal P1 components; sad expressions elicit reduced occipital P1 amplitudes while happy expressions elicit increased temporal P1 amplitudes. The N170 component was sensitive to differences for all three emotional expressions such that sad was greatest, followed by neutral then happy. The N170 also showed that sad faces had larger amplitudes in the right hemisphere than the left for occipital and parietal electrodes while neutral expressions had larger left than right hemisphere amplitudes for occipital but larger right than left hemisphere for parietal electrodes. Finally, the occipital N250 component was greater to happy and sad faces in the right hemisphere showing separation of positive and negative from neutral expressions is expressed in the right hemisphere occipital electrode (O2).

The only component to be influenced by Block Order was the temporal P1 where sad faces had a reduced P1 only in the initial Implicit task. The only component to be influenced by both Block Order and Implicit or Explicit processing condition was the parietal N250. This influence of Condition was also part of a Block Order interaction where expression does not influence the parietal N250 for Implicit processing if that condition is presented first. If an explicit processing condition is then presented, the N250 then becomes sensitive to happy and sad expressions. However, if the explicit condition is presented first, the N250 starts as being sensitive to neutral expressions compared to happy and sad, then increases to sad expressions if an Implicit condition is presented later. This modulation of the parietal N250 component seems to be related to the repetition of emotional expressions much like other studies have found the N250 component to be related to the repetition of facial identity (e.g., Schweinberger et al., 2004), and will be discussed in more detail in the general discussion.

In sum, Experiment 1 found that sad and happy emotional expressions influenced the temporal occipital P1 and N170 ERP components when presented as a basic level-stimulus category alongside neutral expressions. This result replicates many other studies finding an influence of expression when presented as a basic level-stimulus category (e.g. Rellecke 2012, 2013). The purpose of Experiment 2 was to determine if the effects found in Experiment 1 could be replicated when the same emotional facial expressions were presented as a subordinate rather than as a basic level-stimulus category.

Experiment 2

For Experiment 2, faces and objects represented the basic-level stimulus categories with happy, sad, and neutral expressions representing sub-ordinate face categories while cars, houses and butterflies represented sub-ordinate object categories. As mentioned in the introduction, presenting faces in isolation with only changes in expression should facilitate processing of emotional facial expressions as a basic level stimulus category. However, presenting emotional facial expressions alongside comparison object category may relegate changes in expression to sub-stimulus category status while the basic level comparison of faces vs. objects takes priority. If emotional facial expressions are relegated to a sub-stimulus category beneath the basic level of the face/object comparison, then there should not be any modulation of the temporal occipital P1 or N170 ERP waveforms.

Additionally, Experiment 2 will also examine how the practice of cropping faces may impact studies of how emotional expression influence ERP components. As reviewed above, Martin et al. (2011) examined how the cropping of faces influences the P1 and N170 as they cited the inconsistent application of cropping on faces and comparison stimuli in face processing studies. Further, Thierry et al. (2007) demonstrated that the size of the image (large vs. small) modulates the N170 while the category of the image (face vs. object) modulates the P1. Accordingly, Eimer (2011) specifically argued for the need to equate cropping and unaltered stimuli in face studies of the N170 to avoid amplitude modulations caused by size/shape/luminance differences between cropped and unaltered stimuli. Although both cropped (Blau et al., 2007) and unaltered faces (Batty & Taylor, 2003) displaying emotional expressions have influenced the N170, no study has contrasted cropped and unaltered images of emotional expressions and control images within the same study.

Experiment 2 will examine how cropping and unaltered presentation of face and object stimuli will interact with emotional expression recognition in Implicit and explicit viewing tasks to modulate the amplitudes of the P1 and N170. Participants will be presented with happy, neutral, and angry emotional expressions in addition to comparison stimuli consisting of cars, houses, and butterflies in cropped and unaltered conditions. Participants identified if each image presented was a face or a non-face in the Implicit task while identifying the specific emotional expression or object in the Explicit task.

Methods

Participants

Twenty-two Colorado State University undergraduates participated for course credit. Seven participants with removed due to depression traits (Center for Epidemiological Studies Depression Scale[CES-D > 16]; Radloff, 1977); five of these participants also demonstrated anxiety traits (State Trait Anxiety Inventory[STAI-A > 40]; Spielberger, 1983). Three participants were removed from the analysis due to being left-handed. Twelve participants (eight female; Age $_{\text{Mean}}$=18.5, Age $_{\text{SD}}$=0.9; all right-handed) were included in the final data analysis.

Materials

Stimuli consisted of the same 60 images of happy, sad and neutral expressions from Experiment 1. Comparison stimuli consisted of 30 images each of cars, houses, and butterflies equated for size, contrast, and luminance. Faces and comparison stimuli were cropped using Photoshop with an approximate border size of 210 x 270 pixels such that an oval shape preserving the middle features of the face such as the eyes, nose and mouth was used to exclude outer features such as the hair, ears, and jawline. Cars, houses, and butterflies were also cropped using an oval shape that preserved the features in the middle of the image while excluding some external features.

Depression (Center for Epidemiological Studies Depression Scale; Radloff, 1977) and anxiety (State Trait Anxiety Inventory; Spielberger, 1983) scales were utilized to exclude participants with depression and anxiety traits.

EEG acquisition

Same methodology from Experiment 1 was utilized

Procedure

The Implicit recognition task consisted of one block of 180 trials consisting of 30 images each of happy, neutral, and sad emotional expressions and 30 images each of cars, houses and butterflies. The same trial procedure as in Experiment 1 was used. Participants were randomly assigned to push ‘1’ to designate a “face” and ‘9’ for “non-face” or push ‘9’ for “face” and ‘1’ for “non-face”. Participants were instructed to respond as quickly as they can but not before the answer screen appeared. As soon as participants gave a response, the next trial immediately began.

The Explicit recognition task consisted of one block of 180 trials consisting of a new set of 30 images of happy, neutral, and sad emotional expressions and the same set of object stimuli. The same trial procedure was used from the Implicit condition. Presentation of cropping will be presented so each image is presented as cropped and unaltered in a random manner across subjects. Participants were randomly assigned to use ‘1’ for “happy” and ‘9’ for “sad”, or use ‘9’ for “happy” and ‘1’ for “sad”. Participants always responded ‘5’ for a neutral face. For object recognition, participants were randomly assigned to use ‘1’ for “cars” and ‘9’ for “butterflies”, or ‘1’ for “butterflies” and ‘9’ for “cars”. Participants always responded ‘5’ for a house.

Data Analysis

Participants’ recognition rates for object/face discrimination in the Implicit condition and specific recognition or cars, houses, butterflies, happy expressions, neutral expressions, and sad expressions was greater than 99% for all conditions. The same methodology for EEG analysis was used as in Experiment 1. Electrode T8 was removed from one participant due to excess voltage readings. Grand averages for 24 experimental conditions were created. Six stimulus categories (car, house, butterfly, happy, neutral, and sad) were then created for implicit, explicit, cropped, and non-cropped presentations (6x4=24) with an average of 10.34 trials (69%) for each of the 24 conditions per subject.

Repeated Measures ANOVAs were conducted on participants’ mean amplitudes for six time windows (30-80ms, 80-140ms, 140-200ms, 200-400ms, 400-600ms) across four sets of horizontally arranged electrodes (occipital-O1/O2; temporal-T5 /T6; parietal P3/Pz/P4; central-

C3/Cz/C4). Three different types of data analysis were conducted. In order to compare basic level-categories of faces and objects, ANOVAs were conducted with Condition (implicit, explicit), Category (faces, objects), Category Type (1, 2, 3), and Hemisphere/Electrode (left, right; left, center, right; *Figure 8*). Category Type was a pseudo-category where cars were paired with happy expressions for "1", houses with neutral expressions for "2", and butterflies with sad expressions for "3". Because of this, main effects or interactions of Category Type were not considered in the results. For example, a main effect or interaction of Category Type "1" compared to Type "2" would mean that cars/happy expressions differed from houses/neutral expressions. Interpretation of such effects would not be feasible.

In order to compare subordinate face and object stimulus categories, ANOVAs were run on faces and objects separately using Condition (implicit, explicit), Category Type (1,2,3) and Hemisphere/Electrode (left, right; left, center, right) as repeated measures factors (*Figure 9*). For objects, Category Type was represented by cars, houses, and butterflies with faces represented by happy, neutral, and sad expressions. Alpha levels were $\alpha<.05$ for all ANOVAs and a Bonferonni-corrected $\alpha<.017$ for post-hoc paired samples t-tests. The results from the basic level analysis comparing objects and faces will be presented before the results from sub-ordinate level categories of objects and faces.

Basic Level-Stimulus Category Analysis for Faces vs. Objects: Occipital Electrodes

There was an early Condition x Category x Hemisphere interaction [$F(1,10)=3.31$, $MSE=1.48$, $p=.044$, $\eta_p^2=.347$] in the 30-80 window. Follow up ANOVAs showed a marginal Category x Hemisphere interaction for Explicit [$F(1,10)=4.18$,$MSE=3.05$, $p=.068$, $\eta_p^2=.295$] but not Implicit (*p*=.26). Post-hoc paired-samples t-tests in the Explicit condition showed that right hemisphere (*M*=.16 µV) face amplitudes were more positive than left (*M*= -.18 µV) while left hemisphere (*M*=.38 µV) object amplitudes were more positive than right (*M*= -.16 µV). This showed an early separation between objects and faces occurred in occipital electrodes from 30-80ms for the Explicit but not Implicit condition.

A main effect of Category occurred in the 140-200 window [*F*(1,10)=11.59, *MSE*=19.32, *p*=.007, η_p^2=.537], such that faces (*M*=1.22 µV) were more negative than objects (*M*=1.87 µV). In the 140-200 window there was also a main effect of Cropping [*F*(1,10)=5.92, *MSE*=12.24, *p*=.035, η_p^2=.372], such that cropped images (*M*=1.41 µV) were more negative than non-cropped images (*M*=1.68 µV). Finally, a main effect of Category occurred in the 200-400 window [*F*(1,10)=6.53, *MSE*=8.32, *p*=.029, η_p^2=.395], such that objects (*M*= -2.23 µV) had more negative amplitudes than faces (*M*= -1.28 µV). This showed that the occipital N170 was larger for faces compared to objects as well as being larger for cropped images compared to non-cropped images.

Faces vs. Objects: Temporal Electrodes

There was a main effect of Category in the 80-140 window [*F*(1,10)=4.90, *MSE*=1.89, *p*=.051, η_p^2=.329], such that objects (*M*=2.11 µV) were more positive than faces (*M*=1.84 µV; *Figure 10*). In the 140-200 window there was a main effect of Category [*F*(1,10)=52.25, *MSE*=10.54, *p*<.001, η_p^2=.839], such that faces (*M*= -.28 µV) were more negative than objects (*M*=1.77 µV). There was also main effect of Cropping in the 140-200 window [*F*(1,10)=14.74, *MSE*= 11.83, *p*=.003, η_p^2=.596], such that copped faces (*M*=.17 µV) were more negative than non-cropped faces (*M*=1.32 µV). Both the main effects of Category and Cropping in the 140-200 window were carried by a Category x Cropping interaction [*F*(1,10)=10.92, *MSE*=10.70, *p*=.008, η_p^2=.522], such that cropped faces (*M*= -1.32 µV) were more negative than non-cropped faces (*M*=.77 µV), cropped objects (*M*=1.87 µV), and non-cropped objects (*M*=1.66). This showed that objects were greater than faces for the temporal P1 while cropped faces were larger than non-cropped faces and cropped/non-cropped objects for the temporal N170.

In the 200-400 window there was a main effect of Category [*F*(1,10)=13.84, *MSE*= 13.06, *p*=.004, η_p^2=.581], such that faces (*M*=1.87 µV) were more negative than objects (*M*=3.04 µV). In the 200-400 window there was also a main effect of Cropping [*F*(1,10)=13.81, *MSE*=5.48, *p*=.004, η_p^2=.580], such that cropped images (*M*=2.08 µV) were more negative than non-cropped images (*M*=2.84 µV). These main effects in the 200-400 window were modulated by a Category x Cropping interaction [*F*(1,10)=12.28, *MSE*=3.66, *p*=.006, η_p^2=.551], such that cropped faces (*M*=1.20 µV) were more negative than non-cropped faces (*M*=2.54 µV), cropped objects (*M*=2.96 µV), and non-cropped objects (*M*=3.13 µV). Finally, there was a Condition x Category interaction in the 600-800 window [*F*(1,10)=11.14, *MSE*=5.75, *p*=.008, η_p^2=.527], such that Explicit faces (*M*= -1.06 µV) were more positive than Explicit objects (*M*= -2.12 µV), Implicit objects (*M*= -2.09 µV), and Implicit faces (*M*= -2.43 µV). This showed that the temporal N170 advantage for cropped images compared to non-cropped images continued into the 200-400 time window.

Faces vs. Objects: Parietal Electrodes

There was a main effect of Cropping in the 80-140 window [*F*(1,10)=5.50, *MSE*=2.43, *p*=.041, η_p^2=.355], such that non-cropped images (*M*=1.87 µV) were more positive than cropped images (*M*=1.61 µV). This showed that non-cropped images produced larger parietal P1 amplitudes than cropped images.

In the 140-200 window there was a main effect of Cropping [*F*(1,10)=13.87, *MSE*=11.05, *p*=.004, η_p^2=.581], such that cropped images (*M*=.73 µV) were more negative than non-cropped images (*M*=1.61 µV). There was also a main effect of Category in the 140-200 window [*F*(1,10)=9.73, *MSE*=34.17, *p*=.011, η_p^2=.493], such that faces (*M*=.52 µV) were more negative than objects (*M*=1.82 µV). As with temporal electrodes, these main effects of Category and Cropping were carried by a Category x Cropping interaction in the 140-200 window [*F*(1,10)=5.18, *MSE*=6.63, *p*=.046, η_p^2=.341], such that cropped faces (*M*= -.13 µV) were more negative than non-cropped faces (*M*=1.17 µV), cropped objects (*M*=1.59 µV) and non-cropped objects (*M*=2.05 µV). There was also a Category x Electrode interaction in the 140-200 window [*F*(2,20)=4.65, *MSE*=8.46, *p*=.022, η_p^2=.317], such that no difference occurred between P3 (*M*=.50 µV), Pz (*M*=.57 µV) and P4 (*M*=.49 µV) electrodes for faces while for objects P3 (*M*=1.61 µV) and Pz (*M*=1.21 µV) were more negative than P4 (*M*=2.64 µV; *p*'s<.001). This showed that cropped faces produced the largest parietal N170 and also showed that the parietal N170 was sensitive to faces across all three parietal electrodes but was sensitive to objects only across left and central parietal electrodes.

There was a main effect of Category in the 200-400 window [$F(1,10)=12.30$, $MSE=13.61$, $p=.006$, $\eta_p^2=.552$], such that faces ($M=2.58$ µV) were more positive than objects ($M=1.67$ µV). There was also a main effect of Cropping in the 200-400 window [$F(1,10)=9.73$, $MSE=2.83$, $p=.011$, $\eta_p^2=.493$], such that cropped images ($M=1.93$) were more negative than non-cropped images ($M=2.31$). This showed that the interaction of Category and Cropping was limited to the N170 and did not extend into the 200-400 window. Rather, there were main effects of Category and Cropping individually.

In the 400-600 window there was a Category x Cropping interaction [$F(1,10)=5.75$, $MSE=1.17$, $p=.038$, $\eta_p^2=.365$], such that cropped faces ($M= -.16$ µV) were more negative than non-cropped faces ($M=.38$ µV) while non-cropped objects ($M=.21$ µV) were more negative than cropped objects ($M=.40$ µV). There was also a main effect of Category in the 600-800 window [$F(1,10)=6.54$, $MSE=30.16$, $p=.028$, $\eta_p^2=.396$], such that objects ($M= -2.31$ µV) were more negative than faces ($M=-1.31$ µV). Finally, there was a Condition x Category interaction in the 600-800 window [$F(1,10=8.09$, $MSE=18.81$, $p=.017$, $\eta_p^2=.447$] such that there was no difference between Implicit objects ($M= -1.93$ µV) and Implicit faces ($M= -1.81$ µV) while Explicit objects ($M= -2.68$ µV) were more negative than Explicit faces ($M= -.81$ µV). This showed that objects and faces did not differ in the late window for Implicit processing, but demonstrated a difference for Explicit processing.

Faces vs. Objects: Central Electrodes

There was a Category x Electrode interaction in the 80-140 window [$F(2,20)=3.95$, $MSE=0.60$, $p=.035$, $\eta_p^2=.285$], such that for objects, Cz ($M= -.96$ µV) was more negative than C3

(*M*= -.55 µV; *p*=.010) and marginally more negative than C4 (*M*= -.51 µV; *p*=.04) while for faces, Cz (*M*= -.83 µV) was marginally more negative than C3 (*M*= -.52 µV; *p*=.04) but not C4 (*M*= -.74 µV; *p*=.64). This showed that the central N1 for objects and faces was similar for the center and left electrodes but faces had a greater influence in the right electrode compared to objects.

There was a main effect of Category in the 140-200 window [*F*(1,10)=6.53, *MSE*=8.03, *p*=.029, η_p^2=.395], such that faces (*M*=.11) were more positive than Objects (*M*= -.41 µV). There was also a Category x Cropping interaction in the 140-200 window [*F*(1,10)=10.98, *MSE*=2.55, *p*=.008, η_p^2=.523], such that cropped faces (*M*=.46 µV) were more positive than non-cropped faces (*M*= -.25 µV), cropped objects (*M*= -.43 µV) and non-cropped objects (*M*= -.38 µV). These effects in the 140-200 window were modulated by a Condition x Category x Cropping interaction [*F*(1,10)=5.18, *MSE*=1.85, *p*=.046, η_p^2=.341] (*Figure 11*). Follow up ANOVAs on Implicit and Explicit conditions showed a significant Category x Cropping interaction for the Explicit [*F*(1,10)=11.60, *MSE*=3.03, *p*=.007, η_p^2=.537] but not Implicit condition (*p*=.35). The two-way interaction for the Explicit condition showed that cropped faces (*M*=.54 µV) were more positive than non-cropped faces (*M*= -.33 µV) while non-cropped objects (*M*=.02 µV) were more positive than cropped objects (*M*= -.30 µV). This showed that the VPP differed according to cropping and category for Explicit processing but not Implicit processing.

A Condition x Category x Cropping interaction was found through all time windows from 200-800 (*p*'s<.003, η_p^2's=.365 - .493). Follow up ANOVAs showed that only Implicit processing categories produced significant Category x Cropping interactions (*p*'s<.025, η_p^2's=.274 - .473). In the Implicit 200-400 window non-cropped objects (*M*= -.89 µV) were more negative than cropped objects (*M*= -.21 μV), non-cropped faces (*M*= -.26 μV) and cropped faces (*M*= -.08 μV). In the Implicit 400-600 window non-cropped faces (*M*=.41 μV) were more positive than cropped faces (*M*= -.10 μV) while cropped objects (*M*=.43 μV) were more positive than uncropped objects (*M*= -.10 μV). This showed that central electrodes in the 200-800 time windows were sensitive to cropping and category for Implicit but not Explicit processing.

Subordinate Level for Happy, Neutral and Sad Expressions: Occipital Electrodes

There was an Emotion x Cropping interaction in the 200-400 window [$F(2,22)=3.87$, $MSE=5.61$, $p=.036$, $\eta_p^2=.260$], such that cropped happy (*M*=.18 μV) was more negative than non-cropped happy (*M*=2.18 μV; *p*=.001) while no difference between cropped neutral (*M*=1.05 μV)/non-cropped neutral (*M*=1.19 μV; *p*=.71) and cropped sad (*M*=.82)/non-cropped sad (*M*=1.52 μV; *p*=.13) existed (*Figure 12*). This showed that the Occipital N250 was sensitive to cropped and non-cropped happy faces but not for cropped and non-cropped neutral and sad faces.

Happy, Neutral and Sad Expressions: Temporal Electrodes

There was an early Emotion x Hemisphere interaction in the 30-80 window [$F(2,22)=5.35$, $MSE=5.84$, $p=.013$, $\eta_p^2=.327$] such that sad right hemisphere (*M*=.28 μV) was more positive than the left (*M*= -.88 μV), neutral left hemisphere (*M*=.57 μV) was more positive than right (*M*= -.54 μV; *p*'s<.02), with no difference between happy left (*M*= -.28 μV) and right (*M*= -.10 μV; *p*=.57). This showed that temporal electrodes started to differentiate according to neutral and sad expressions in the early time window of 30-80ms.

Happy, Neutral and Sad Expressions: Parietal Electrodes

No effects or interactions of Emotion occurred for parietal electrodes (*p*'s>.10)

Happy, Neutral and Sad Expressions: Central Electrodes

There was an early Condition x Emotion x Electrode interaction [*F*(4,44)=2.93, *MSE*=1.02, *p*=.031, η_p^2=.210] in the 30-80 window. Follow up ANOVAs on Implicit and Explicit conditions showed a marginal Emotion x Electrode interaction for the Explicit [*F*(4,44)=2.54, *MSE*=2.02, *p*=.052, η_p^2=.188] but not Implicit condition (*p*=.08). Follow up t-tests on the Explicit two-way Emotion x Electrode interaction showed sad faces had marginally more positive C4 (*M*=.36 µV) than C3 (*M*= -.91 µV; *p*=.029) electrodes with no difference between Happy C4 (*M*=.04 µV) /C3 (*M*=.42 µV) and sad C4 (*M*=.04 µV) /C3 (*M*=.29 µV).

There was a Condition x Emotion x Electrode interaction in the 140-200 window [*F*(4,44)=3.83, *MSE*=.87, *p*=.009, η_p^2=.258] . Follow up ANOVAs on Implicit and Explicit conditions showed a marginal Emotion x Electrode interaction in the Explicit condition [*F*(4,44)=2.52, *MSE*=1.48, *p*=.054, η_p^2=.187] and significant Emotion x Electrode interaction [*F*(4,44)=3.29, *MSE*=.66, *p*=.019, η_p^2=.230] in the Implicit condition. In the Explicit condition, Cz (*M*= -.90 µV) was marginally more negative than C3 (*M*= -.26 µV) for neutral (*p*=.055) while C3 (*M*= -1.43 µV) was marginally more negative than C4 (*M*= -.66 µV; *p*=.07) for sad; there were no differences between happy electrodes (*p*'s>.2). In the Implicit condition, C4 (*M*= -1.26) was more negative than Cz (*M*= -.63 µV) and C3 (*M*= -.32 µV) for neutral (*p*'s<.018) while Cz (*M*= -1.24 µV) was marginally more negative than C3 (*M*= -.68 µV) for sad (*p*=.03). This showed that the central N1 was sensitive to both Explicit and Implicit processing of neutral and sad faces but not happy faces.

Finally, there was a late main effect of Emotion in the 600-800 window [$F(2,22)=4.17$, $MSE=3.24$, $p=.029$, $\eta_p^2=.275$], such that happy ($M=.65$ µV) was marginally more positive ($M=.10$ µV) than neutral ($p=.049$). This showed that happy expressions produced a late positive increase across central electrodes in the 600-800 time window.

Subordinate Level for Cars, Houses and Butterflies: Occipital Electrodes

There was a main effect of Object in the 140-200 window [$F(2,20)=7.23$, $MSE=4.00$, $p=.004$, $\eta_p^2=.420$], such that butterflies ($M=1.11$ µV) were marginally more negative than houses ($M=2.22$ µV; $p=.022$); neither were different than cars ($M=1.88$ µV; p's>.10; *Figure 13*). This main effect of Object continued into the 200-400 window [$F(2,20)=3.51$, $MSE=4.63$, $p=.049$, $\eta_p^2=.260$] with butterflies ($M=1.39$ µV) being more negative than cars ($M=1.98$ µV) and houses ($M=2.22$ µV) although no post-hoc differences occurred (p's>.19). This showed that the occipital N170 was greater for butterflies compared to houses and this greater negativity continued through the 200-400ms time window.

There was a main effect of Object in the 400-600 window [$F(2,20)=4.37$, $MSE=4.43$, $p=.027$, $\eta_p^2=.272$], such that butterflies ($M=-.85$ µV) being more negative than cars ($M=-.22$ µV) and houses ($M=.11$ µV) with no post-hoc differences between the three (p's> .17). This was primarily carried by an Object x Cropping interaction in the 400-600 window [$F(2,20)=3.53$, $MSE=2.43$, $p=.049$, $\eta_p^2=.261$], such that non-cropped butterflies ($M=-1.46$ µV) were more negative than cropped butterflies ($M=-.24$ µV; $p=.002$) with no differences between cropped cars (*M*= -.07 µV)/non-cropped cars (*M*= -.36 µV) and cropped houses (*M*=.09 µV)/non-cropped houses (*M*=.12 µV; *p*'s>.80). This showed that late occipital waveforms were more negative for cropped butterflies compared to all other categories.

Finally, there was a Condition x Object x Cropping interaction [*F*(2,20)=6.14, *MSE*=2.59, *p*=.008, η_p^2=.380] in the 600-800 window. Post hoc t-tests showed that Explicit cropped houses (*M*= -2.54 µV) were more negative than Explicit non-cropped houses (*M*= -1.62 µV) while Implicit non-cropped houses (*M*= -2.75 µV) were more negative than Implicit cropped houses (*M*= -1.37 µV); no differences occurred between Explicit cropped/non cropped cars (*M*= -1.95 µV/*M*= -2.61 µV), Explicit cropped/non-cropped butterflies (*M*= -2.83 µV/*M*= -3.68 µV), Implicit cropped/non-cropped cars (*M*= -1.60 µV /*M*= -1.39 µV) and Implicit cropped/non-cropped butterflies (*M*= -1.99/*M*= -2.51; *p*'s>.10). This showed that cropped and non-cropped houses differed according to Implicit or Explicit processing with no differences for cropped/non-cropped cars and butterflies.

Cars, Houses and Butterflies: Temporal Electrodes

There was a main effect of Object in the 140-200 window [*F*(2,20)=5.74, *MSE*=5.92, *p*=.011, η_p^2=.365], such that butterflies (*M*=1.05 µV) were marginally more negative than houses (*M*=2.20 µV; *p*=.031) with no differences occurring for cars (*M*=2.05 µV; *p*'s>.10) This showed that the temporal N170 was largest for butterflies.

There was a main effect of Object in the 400-600 window [*F*(2,20)=4.37, *MSE*=4.43, *p*=.027, η_p^2=.304], such that butterflies (*M*= -.013) had marginally more negative amplitudes than houses (*M*= .92; *p*=.065) with no differences for cars (*M*=.43; *p*'s>.40). There was also an

Object x Cropping interaction in the 400-600 window [*F*(2,20)=3.72, *MSE*=9.42, *p*=.042, η_p^2=.271], such that cropped cars (*M*= -.047) had marginally more negative amplitudes non-cropped cars (*M*=.90) while non-cropped butterflies (*M*= -.79) had marginally more negative amplitudes than cropped butterflies (*M*=.77; *p*'s<.03); there was no difference between non-cropped houses (*M*=.93) and cropped houses (*M*=.92; *p*=.87). This showed that cropping influenced amplitudes for cars and butterflies but not houses in the late 400-600 window across temporal electrodes.

Cars, Houses and Butterflies: Parietal Electrodes

There was a main effect of Object in the 140-200 window [*F*(2,20)=5.62, *MSE*=6.23, *p*=.012, η_p^2=.360], such that butterflies (*M*=1.22) were marginally more negative than houses (*M*=2.10 µV; *p*>.06) with no differences occurring for cars (*M*=2.13 µV; *p*'s>.10). This main effect was modulated by a Condition x Object x Cropping x Electrode interaction in the 140-200 window [*F*(4,40)=2.86, *MSE*=2.15, *p*=.036, η_p^2=.222]. Follow up ANOVAs showed a significant Objects x Cropping x Electrode interaction for Explicit [*F*(4,40)=2.66, *MSE*=0.78, *p*=.047, η_p^2=.210] but not Implicit (*p*=.13) conditions. Additional follow up ANOVAs showed no Cropping x Electrode interactions for cars, houses, or butterflies (*p*'s>.18). Post-hoc t-tests for the Explicit condition showed that Pz was more negative than P3 for non-cropped butterflies (*M*=.38 µV/*M*=1.78 µV; *p*=.016) while Pz was marginally more negative than P3 for cropped cars (*M*=1.23 µV/*M*=2.43 µV) and non-cropped houses (*M*=1.56 µV/*M*=3.61 µV; *p*'s<.026); no differences for Pz and P4 occurred for non-cropped cars (*M*=1.99 µV /*M*=3.45 µV), cropped houses (*M*=1.13 µV /*M*=2.02 µV), or cropped butterflies (*M*=1.23 µV/*M*=1.47 µV; *p*'s>.05).

The main effect for Object continued into the 200-400 window [*F*(2,20)=4.32, *MSE*=6.39, *p*=.027, η_p^2=.302] with butterflies (*M*=2.14 µV) slightly more negative than cars (*M*=3.06 µV; *p*'s>.07); houses (*M*=2.54 µV) did differ from either butterflies or cars (*p*'s>.23). This main effect was also modulated by a Condition x Object x Cropping x Electrode interaction in the 200-400 window [*F*(4,40)=2.97, *MSE*=2.32, *p*=.031, η_p^2=.229]. Follow up ANOVAs on Implicit and Explicit processing conditions showed an Object x Cropping x Electrode interaction for Implicit [*F*(4,44)=2.90, *MSE*=2.73, *p*=.032, η_p^2=.209] but not Explicit (*p*=.16) conditions. Additional follow up ANOVAs showed that cars produced a significant Cropping x Electrode interaction (*p*=.027) but not houses or butterflies (*p*'s>.17). Post-hoc paired samples t-tests showed that for non-cropped cars, Pz (*M*=1.00 µV) was more negative than P4 (*M*=3.49 µV; *p*=.008) and marginally more negative than P3 (*M*=2.68 µV; *p*=.035) while for cropped cars, only Pz (*M*=.76 µV) was more negative than P4 (*M*=1.89 µV; *p*=.01) with no difference between P3 (*M*=1.53 µV) and Pz (*p*=.61). The two four-way interactions showed that Explicit processing of cropped and non-cropped houses and butterflies occurred in the 140-200 window while Implicit processing of cropped and non-cropped cars were processed in the 200-400 window across parietal electrodes.

Cars, Houses and Butterflies: Central Electrodes

There was an Object x Cropping interaction in the 400-600 window [*F*(2,20)=11.06, *MSE*=1.41, *p*=.001, η_p^2=.525], such that cropped butterflies (*M*= .74 µV) were more positive than non-cropped butterflies (*M*= -.09 µV; *p*=.002) with no difference between non-cropped/cropped houses (*M*=.32 µV /*M*=.40 µV) or non-cropped/cropped cars (*M*=.11/*M*=.62;

p's>.40). This Object x Cropping interaction continued in the 600-800 window [$F(2,20)=4.21$, $MSE=3.41$, $p=.030$, $\eta_p^2=.296$], such that cropped butterflies ($M=.25$ µV) were more positive than non-cropped butterflies ($M= -.48$ µV; $p=.005$) with no difference for cropped/non-cropped houses ($M=.26$ µV /$M=.60$ µV) or cropped/non-cropped cars ($M= -.04$ µV /$M=.44$ µV; p's>.09). This showed that cropped butterflies led to larger late positive amplitudes than all other categories.

Finally, there was an Object x Electrode interaction in the 600-800 window [$F(4, 40)=2.74$, $MSE=4.93$, $p=.042$, $\eta_p^2=.215$], such that C3 was marginally more positive than C4 for houses ($M=.94$ µV /$M= -.35$ µV) while C4 was marginally more positive than C3 for cars ($M=.48$ µV /$M= -.32$ µV; p's<.031); no difference between C3 and C4 occurred for butterflies ($M= -.23$ µV /$M=.01$ µV; p's>.42). This showed that cars and houses showed differences in late positive potentials across left and right hemispheres in the 600-800 but not butterflies.

Latency Analysis: Basic Level – Faces vs. Objects

Peak amplitudes were detected for the 80-140ms (P1) and 140-200ms (N170) time window for occipital and temporal electrodes only. These waveforms were identified through visual inspection as those showing the most pronounced peaks for follow up latency analysis. Maximum latencies taken from peak amplitudes in the 80-140 and 140-200 time windows were subjected to repeated measures ANOVAs using Condition (implicit, explicit), Category (face, object), Category Type (one, two, three), Cropping (non-cropped, cropped) and Hemisphere (left, right) as factors. Just as with ANOVAs for mean amplitudes, interactions of Category Type were not considered in the results. In order to examine maximum latencies for subordinate face and object categories, ANOVAs were conducted for faces using Condition (implicit, explicit), Expression (happy, neutral, sad), Cropping (non-cropped, cropped) and Hemisphere (left, right) as repeated measures factors; subordinate objects were examined using Object (car, house, butterfly) instead of Expression as a repeated measures factor.

There was a Category x Hemisphere interaction for occipital electrodes in the 80-140 window [$F(1,10)=6.79$, $MSE=94.62$, $p=.026$, $\eta_p^2=.404$], such that latencies for faces were shorter in the right hemisphere ($M=114.35$ms) than left ($M=116.74$ms) while latencies for objects were shorter in the left hemisphere ($M=119.03$ms) than the right ($M=121.05$ms). This showed the occipital P1 component had shorter latencies for faces on the right and objects on the left (*Figure 7*).

There was a main effect of Category for temporal electrodes in the 80-140 window [$F(1,10)=7.48$, $MSE=522.63$, $p=.021$, $\eta_p^2=.428$], such that faces ($M=116.14$ms) had faster latencies than objects ($M=122.06$ms). There was also a main effect of Condition for temporal electrodes in the 80-140 window [$F(1,10)=4.66$, $MSE=212.56$, $p=.056$, $\eta_p^2=.318$], such that the Implicit condition ($M=118.38$ms) had faster latencies than the Explicit condition ($M=120.10$ms). This showed that latencies for the temporal P1 were shorter for faces and Implicit processing condition.

There was a main effect of Condition for occipital electrodes in the 140-200 window [$F(1,10)=5.49$, $MSE=878.44$, $p=.041$, $\eta_p^2=.354$], such that the Implicit condition ($M=163.19$ms) had faster latencies than the Explicit condition ($M=169.24$ms). There was also a main effect of Hemisphere for occipital electrodes in the 140-200 window such that right hemisphere

(*M*=163.83ms) latencies were faster than the left hemisphere (*M*=168.60ms). This showed that the occipital N170 had faster latencies for Implicit compared to Explicit processing and also faster latencies in the right hemisphere than the left.

There was a Condition x Category x Cropping x Hemisphere interaction for temporal electrodes in the 140-200 window [$F(1,10)=12.53$, $MSE=471.51$, $p=.005$, $\eta_p^2=.556$]. Follow up ANOVAs showed a Category x Cropping x Hemisphere interaction for Explicit [$F(1,10)=5.47$, $MSE=824.85$, $p=.041$, $\eta_p^2=.353$] but not Implicit ($p=.19$) conditions. Follow up paired samples t-tests showed that non-cropped faces had marginally faster right hemisphere latencies (*M*=157.38ms) compared to the left (*M*=164.09ms; $p=.026$) with no differences between left and right hemispheres for non-cropped objects (*M*=169.85ms/*M*=172.32ms), cropped objects (*M*=183.74ms/*M*=166.00ms) and cropped faces (*M*=167.35ms/*M*=173.67ms; *p*'s>.20). This showed that for the temporal N170 cropped faces in the Explicit condition only had differences in latency such that the right hemisphere was faster than the left while all other categories showed no differences.

Latency Analysis: Happy, Neutral and Sad Expressions

Subordinate latency analysis of Emotional Expressions produced no significant main effects or interactions in the 80-140 window for both occipital and temporal electrodes as well as the 140-200 window for temporal electrodes (*p*'s>.08). There was a main effect of Hemisphere in the 140-200 window for occipital electrodes [$F(1,11)=7.88$, $MSE=486.40$, $p=.017$, $\eta_p^2=.417$], such that the right hemisphere (*M*=161.82ms) latencies were faster than the left

(*M*=169.12ms). This main effect of hemisphere was part of the Category x Hemisphere interaction found in the basic level analysis.

Latency Analysis: Cars, Houses and Butterflies

Subordinate analysis of Objects produced no significant main effects or interactions in the 80-140 window for both occipital and temporal electrodes as well as the 140-200 window for occipital electrodes (p's>.07). There was a Condition x Cropping x Hemisphere interaction for temporal electrodes in the 140-200 window [$F(1,10)=6.84$, $MSE=923.69$, $p=.026$, $\eta_p^2=.406$]. Follow up ANOVAs showed that there was a marginal Cropping x Hemisphere interaction for Implicit [$F(1,11)=3.85$, $MSE=626.42$, $p=.076$, $\eta_p^2=.259$] but not Explicit ($p=.15$) condition such that non-cropped objects had faster latencies for the right (*M*=169.89ms) than the left (*M*=181.75ms) while cropped objects had faster latencies for the left (*M*=164.67ms) than the right (*M*=169.17ms). This showed that Implicit processing of objects interacted with cropping to influence the latency of the temporal N170.

Latency Analysis for Expressions: Experiment 1 vs. Experiment 2

Although there were no latency differences for Experiment 1 between different emotional expressions, it is possible that latency differences may exist for expressions between Experiment 1 and Experiment 2. In order to explore this possibility, the data from 12 subjects in Experiment 1 were randomly selected to compare against the data from the 12 subjects from Experiment 2. The data from cropped happy, neutral and sad expressions from Experiment 2 (only cropped expressions from Experiment 2 were utilized as Experiment 1 did not present any non-cropped images) were entered into a mixed model ANOVA with the data from Experiment

1 that included Expression (happy, neutral, sad), Condition (implicit, explicit) and Hemisphere (left, right) as repeated measures factors with a between subjects factor of Experiment Type (Experiment 1, Experiment 2).

The results show that there were no main effects or interactions for Experiment Type in the 80-140 time window for occipital electrodes (*p*'s>.08). Temporal electrodes in the 80-140 time window showed a Condition x Experiment Type interaction [$F(1,10)=5.68$, $MSE=499.25$, $p=.026$, $\eta_p^2=.205$], such that for Experiment 1, Explicit processing ($M=114.47$ms) had faster latencies than the Implicit processing ($M=123.64$ms) while for Experiment 2, Implicit processing ($M=113.69$ms) had faster latencies than Explicit processing ($M=117.08$ms). There were no other main effects of Experiment Type of interactions including Expression (*p*'s>.10). This showed that Explicit processing latencies were faster for Experiment 1 while Implicit processing latencies were faster for Experiment 2.

There was a main effect of Experiment Type for occipital electrodes in the 140-200 window [$F(1,22)=5.37$, $MSE=2110.95$, $p=.30$, $\eta_p^2=.196$], such that Experiment 1 ($M=178.65$ms) had longer latencies than Experiment 2 ($M=166.10$ms). There was also an Experiment Type x Condition interaction [$F(1,22)=4.81$, $MSE=659.08$, $p=.039$, $\eta_p^2=.179$] such that in Experiment 1, Explicit processing ($M=174.21$ms) had faster latencies than Implicit processing ($M=183.08$ms) while in Experiment 2, led to longer latencies than Implicit processing ($M=163.90$ms) had faster latencies than Explicit processing ($M=168.29$ms). This showed that occipital electrodes were influenced by latency in the time window after temporal electrodes although the same latency modulations could be found - the occipital N170 was again faster for Explicit than Implicit in Experiment 1 with Implicit being faster than Explicit in Experiment 2.

There was an Experiment Type x Condition x Hemisphere interaction for temporal electrodes in the 140-200 window [$F(1,22)=6.18$, $MSE=190.95$, $p=.021$, $\eta_p^2=.219$]. Follow up ANOVAs showed a marginal Condition x Hemisphere interaction for Experiment 2 [$F(1,11)=3.80$, $MSE=225.032$, $p=.077$, $\eta_p^2=.257$] but not Experiment 1 ($p=.15$) such that in the Explicit task right hemisphere latencies ($M=164.69$ms) were faster than the left hemisphere ($M=167.69$ms) while in the Implicit task, right hemisphere latencies ($M=163.47$ms) was also faster than the left hemisphere ($M=176.22$ms) with this also being slower than Explicit left hemisphere latencies. This showed that in Experiment 2, right hemisphere latencies were faster than the left hemisphere for both Explicit and Implicit processing tasks, but also that left latencies were slower in Implicit compared to Explicit processing tasks.

Amplitude Analysis for Expressions: Experiment 1 vs. Experiment 2

In order to examine differences in amplitudes related to emotional expressions between Experiment 1 and Experiment 2, mean amplitudes from the same 12 subjects randomly selected for the Between experiments latency analysis were entered into a Mixed-Model ANOVA with the data from 12 subjects from Experiment 2. Only cropped images from Experiment 2 were entered into the analysis because there were no non-cropped images utilized in Experiment 1. Repeated measures factors included Condition (explicit, implicit), Expression (happy, neutral, sad) and hemisphere (left, right) with a between measures factor of

Experiment Type (Experiment 1, Experiment 2). The analysis focused on the 80-140 and 140-200ms time windows for occipital and temporal electrodes.

For both occipital and temporal electrodes in the 80-140 window there was no main effect of Experiment Type or interaction of Experiment Type (p's>.10; *Figures 14 & 15*). For both occipital and temporal electrodes in the 140-200 window there were Experiment Type x Expression interactions for both occipital [$F(2,44)=12.94$, $MSE=3.32$, $p<.001$, $\eta_p^2=.370$] and temporal [$F(2,44)=3.58$, $MSE=3.59$, $p<.001$, $\eta_p^2=.327$] electrodes. Follow up t-tests showed that for occipital electrodes, Experiment 1 produced larger N170 amplitudes for sad (M= -1.11 µV) than for neutral (M= -.66 µV) and happy (M=.50 µV; p's<.003) while Experiment 2 produced no differences between neutral (M= -.16 µV) and sad (M= -.18 µV; p's>.10), while happy (M= -1.11 µV) was marginally larger than sad (p=.065). For temporal electrodes, Experiment 1 again produced larger amplitudes for sad (M= -2.39 µV) compared to neutral (M= -2.00 µV) and happy (M= -.47 µV; p's<.01) while in Experiment 2, there was no difference for sad (M= -1.89 µV), neutral (M= -1.77 µV) and happy (M= -2.23 µV; p's>.20). This confirmed that the increase found for sad expressions compared to neutral and happy expressions in the occipital and temporal N170 from Experiment 1 was not present in Experiment 2.

Discussion: Experiment 2

The results of Experiment 2 show that when sad and happy emotional expressions are presented as a subordinate category of faces alongside superordinate category of faces and objects, there were no influences of emotional expression on the temporal occipital P1 or N170 amplitude. There was a difference for Objects such that butterflies had larger N170 amplitudes than cars and houses. There were also Cropping and Category influences on the occipital N170 such that cropped stimuli and faces produced larger N170 amplitudes than non-cropped stimuli and objects respectively. Additionally, a Cropping x Category interaction showed that cropped faces produced larger temporal and parietal N170 amplitudes than non-cropped faces, cropped and non-cropped objects. This influence on cropping faces was present despite the absence of N170 modulation of emotional expression. This showed that even while differences in presentation of face stimuli such as cropping of an image were found for the N170, changes in emotional expression did not influence the N170. It is possible that the number of trials or subjects used was not enough to detect changes in the N170 by emotional expression as a subordinate category. However, the fact that butterflies produced larger N170 amplitude than houses or cars shows that subordinate category differences can still be found in the current paradigm. This suggests that even if N170 differences by emotional expressions processed on a subordinate stimulus category level would emerge with more power, it would not be as robust as the differences between faces and objects, cropping and non-cropping, and the difference between butterflies and cars/houses.

Although there was no influence of Expression on the P1 or N170 amplitude in either the basic level or subordinate level analysis, there were early influences of faces and expression across hemispheres for occipital and temporal amplitudes respectively. In the 30-80 window for the Face vs. Object analysis there was an early occipital difference between objects and faces whereas in the 30-80 window for the subordinate expression category there was an early temporal difference for neutral and sad expressions across hemispheres. This showed an early separation of faces for objects on the superordinate level occurs across hemispheres in occipital electrodes while an early separation of expressions on the subordinate level occurs across hemispheres for temporal electrodes. The only other influence of expression as a subordinate stimulus category was a greater occipital N250 for cropped happy faces compared to non-cropped happy faces and a late positive potential for happy faces across central electrodes in the 600-800 window.

Subordinate-level analysis for objects showed that butterflies produced larger N170 amplitudes than cars or houses across occipital, temporal and parietal electrodes, but no influence on the VPP for central electrodes. Interactions of Objects and Cropping began to emerge in the 400-600 window such that cropped/non-cropped houses influence occipital electrodes, cropped/non-cropped cars and butterflies influence temporal electrodes and cropped/non-cropped butterflies influence central electrodes. This interaction of Objects and Cropping started in a slightly later time window than the interaction of Expression and Cropping that occurred only for happy expressions in the 200-400 time window.

The influence of Implicit and Explicit processing Condition was expressed differently for the basic level analysis between objects and faces and for the subordinate analysis of expression type. For the basic level analysis between faces and objects in Experiment 1, the influence of condition was found in the 30-80 window over occipital electrodes. For the subordinate level analysis of expression in Experiment 2, the influence of condition was found in the 30-80 and 80-140 window for central electrodes. There was no influence of Implicit or Explicit processing condition for Objects in early windows. Rather, the influence of Condition for Objects was found in the 140-200 and 200-400 window in parietal electrodes and in the

600-800 window for occipital and parietal electrodes. This showed that Implicit and Explicit processing differences for faces and objects occurred in the earliest time window of 30-80 in occipital electrodes while the processing differences for Expressions occurred in the 30-140 range in central electrodes while processing differences for Objects occurred in the 140-400 range in parietal electrodes.

The occipital P1 also showed shorter latencies for Faces in the right hemisphere than the left while Objects had shorter latencies in the left then the right hemisphere. Thus, while there were no amplitude differences between Faces and Objects for the occipital P1, there were latency differences showing faster processing of Faces in the right hemisphere and faster processing of Objects in the left hemisphere.

The temporal P1 was earlier for Faces than Objects across both hemispheres and also earlier for Implicit than Explicit processing for both hemispheres. On the other hand, the temporal P1 showed that objects had larger amplitudes than faces. Thus, although Objects had larger temporal P1 amplitudes than faces, faces were processed faster.

The occipital N170 showed faster latencies for Implicit compared to Explicit processing and also faster latencies in the right hemisphere compared to the left. This was in contrast to the amplitude increases for Faces compared to Objects and the amplitude increases for cropped compared to non-cropped images in the basic level analysis and butterflies compared to houses and cars in the subordinate level object analysis. Thus, the amplitudes of the occipital N170 were sensitive to category differences while latencies were sensitive to processing task.

The temporal N170 showed faster latencies for cropped faces compared to non-cropped faces, cropped and non-cropped objects in the right hemisphere for the Explicit but not Implicit processing task. This was in contrast to the increased in amplitude related to cropped-faces across both hemispheres regardless of task. Thus, while amplitudes for the temporal N170 reflect general processing of Implicit and Explicit cropped images in a bilateral manner, the latency of the temporal N170 is faster only on the right side for the Explicit processing of cropped faces. This demonstrates further specialized processing of cropped-faces in related to all other stimulus categories. However, this specialized processing was only related to Explicit but not Implicit task conditions.

The subordinate latency analysis showed no interactions of Expression or Object. This showed that although there were significant differences in latency for the basic level stimulus category analysis between Faces and Objects, there were no significant latency differences for subordinate stimulus categories of Expressions or Objects. Thus, latency was only influenced by the difference between basic-level stimulus categories consisting of Faces and Objects but was not influenced by differences between subordinate-level stimulus categories of happy, neutral or sad expressions or differences between subordinate-level stimulus categories of cars, houses or butterflies.

Finally, the latency analysis between Experiments 1 and 2 showed that for the temporal P1, Explicit processing latencies were faster for Experiment 1 while Implicit processing latencies were faster for Experiment 2. This same pattern emerged for the occipital N170 where latencies for Implicit processing were faster for Experiment 1 while Implicit processing latencies were faster for Experiment 2. Finally, the temporal N170 was mediated by a three-way interaction, such that left hemisphere latencies were longest for the Implicit processing task in Experiment 2 but not in Experiment 1.

General Discussion

The main results of interest in the current study support the notion that presenting happy, neutral, and sad emotional facial expressions as basic level- or subordinate-level stimulus categories can influence the expression of temporal occipital P1 and N170 ERPs. When happy, neutral and sad faces were presented as a basic level-stimulus category where faces are held constant with only changes in expression, influences of both sad and happy expressions are found on the temporal occipital P1 and N170. However, when happy, neutral and sad expressions were presented as a subordinate stimulus category under a superordinate category of faces and houses, there were no influences of happy or sad expressions on the temporal occipital P1 or N170.

Basic Level and Subordinate Level Category Processing: Emotional Expressions

A likely explanation for the findings is that emotional expressions were processed as a basic level category in Experiment 1 because faces were presented in isolation with changes in happy, neutral and sad expressions. In Experiment 2, emotional expressions were probably processed as a subordinate level category alongside cars, houses and butterflies with faces and objects being categorized at the basic level; this is why there were differences for faces and objects for the N170 but not specific emotional expressions. This is in line with the argument by Gauthier et al. (2000) that faces are processed automatically at the level of identity when presented alongside objects; this in turn probably relegates emotional expressions to subordinate stimulus category status. This is also in accord with the findings of Scott et al.

(2006) who showed that basic level but not subordinate level category discrimination influenced the N170. It is important to note that while expressions were differentiated in Experiment 1 as a basic level category with faces and objects were differentiated in Experiment 2 as a basic level category, these differences were represented by different components and electrodes. This suggests that although the type of category processing can be manipulated, if isolated correctly, ERP changes can reflect individual characteristics of that basic level category rather than a general differentiation of two basic level categories.

There were no latency interactions with Expression and Experiment Type for the temporal and Occipital P1 and N170. Rather, Experiment Type x Condition latency modulations were found for the temporal P1 and occipital N170 such that Experiment 1 Explicit processing latencies were faster than Implicit while Experiment 2 Implicit latencies were faster than Explicit. Between-experiment modulations were found for the temporal P1 and the occipital N170 while latency modulations of the temporal N170 were limited to Experiment 2. In Experiment 2, the temporal N170 was faster in the right hemisphere for Implicit and Explicit processing tasks, but the left hemisphere was also faster in Explicit rather than Implicit processing tasks. One reason why Experiment 1 latencies would be faster for Explicit while Experiment 2 was faster for Implicit expression processing is that the Experiment 1 Implicit task was a gender identification task while the Experiment 1 Explicit task was an expression/non-expression identification task. Paying explicit attention to the expression caused faster latencies than paying explicit attention to the gender in absence of a competing object category. That is, participants did not have to discriminate a face from an object first; they could go straight to expression discrimination because only faces with changes in expression were presented. This may indicate prioritized processing of expression as an important social and threat communicator whereas gender typically offers no information about the nature of the environment.

Experiment 2 face latencies were faster for face and object discrimination (implicit) as opposed to specific object and expression discrimination (explicit). One possible explanation for Experiment 2 is that there was no interference from emotional expressions in the Implicit condition because faces and objects are automatically processed at the basic level; this allows for fluent discrimination of faces and objects. However, attempting to identify the specific object or expression may have interfered with the natural fluency of discriminating faces compared to objects and slightly delayed the latencies. This is because before expression or object discrimination can occur on a subordinate level, faces and objects must be distinguished on the basic level first. In this case, attempting to bypass basic level processing caused interference in the natural fluency of the face/object categorization, resulting in a slight delay in processing. Alternatively, faces may have took general priority over objects for the Implicit task and expressions had nothing to do with the faster latencies while attempting specific expression identification still interfered with face/object discrimination in the Explicit task. Thus, Experiment 2 latency differences could be attributed to the influences of faces and objects and not necessarily the expressions themselves. In either case, it does suggest some factors to consider when comparing the latencies of different expressions across experiments that present them in such situations.

The results from previous studies are in accord with the idea that stimulus context category can influence emotional expression modulation of the P1 and N170. Eimer, Holmes, and colleagues have mostly used paradigms that could be considered as presenting basic-level categories such as faces, lines, and houses while finding no influence on the P1 and N170 (Eimer & Holmes, 2002; Eimer, Holmes, & McGlone, 2003). They did however find late increased positivity in frontal and central electrodes extending from 200-800ms. On the other hand, previous studies using paradigms presenting only faces with changes in expressions have found influences of expression on the P1 and N170 (Calvo & Beltran, 2013; Rellecke et al., 2012, 2013). However, this cannot be the only consideration as studies have found an influence of emotional expression when presenting faces alongside objects within an experimental paradigm. Batty and Taylor (2003) presented emotional facial expressions alongside object categories of cars, planes and butterflies while subjects identified the presentation of objects in an implicit expression processing task. They found decreased P1 amplitudes for surprised faces and increased N170 amplitudes for fearful faces demonstrating that emotional expressions are able to influence the P1 and N170 when presented as subordinate stimulus categories. However, it should be noted that fearful expressions are considered threat expressions that activate prioritized attentional processing due to their evolutionary importance for survival mechanisms (Pourois, Thus, Grave de Peralta, Michel, & Vuilleumier, 2005) and are considered a part of the previously mentioned ‘threat related stimuli’ category typically prioritized in ERP studies compared to other expressions (e.g., Schupp et. al., 2004). While surprised faces are typically not included as a threat expression, their similarity to fearful faces may indicate that the visual system treats these expressions in a similar manner due to the importance of detecting fearful faces. Additionally, the expression of surprise may indicate a sudden change in ones surroundings, something that would be important to attend to in dangerous situations. Thus, it could be argued that surprise is a possible indicator of threat related changes within the environment. Finally, it is possible that only non-threat related emotional expressions have no influence when presented as a subordinate processing category. The results of Batty and Taylor would support this notion as they found no other differences between other expressions such as sad or happy for the P1 and N170. Unfortunately, Batty and Taylor did not analyze ERP data for faces vs. objects of subordinate object categories of cars, planes or butterflies so comparisons between those findings with the current study cannot be made.

Basic Level and Subordinate Level: Experiment 2

In addition to differences between basic- and subordinate-level processing for emotional expressions between Experiment 1 and 2, Experiment 2 showed differences in basic- and subordinate-level face and object processing. The differences between Experiments 1 and 2 were characterized by N170 amplitude modulations by expression in Experiment 1 but not in Experiment 2. Additionally, there were no latency interactions of Expression with Experiment Type showing that the difference between basic level and subordinate level of processing for emotional expressions was limited to amplitude modulations between Experiments 1 and 2. In contrast, basic level object and face differences in Experiment 2 were characterized by both amplitude and latency modulations while subordinate level expression and object differences were characterized mainly by amplitude modulations.

It should also be noted that tasks in Experiment 2 were labeled according to emotional expression processing. The Implicit and Explicit processing task could also be considered as basic level or subordinate level processing tasks. In Experiment 2, Implicit processing of emotional expressions was also a basic level-category discrimination task. That is, participants discriminated between faces and objects. The Explicit processing task for emotional expression was a subordinate-level category discrimination task. That is, participants were asked to specifically identity cars, houses and butterflies along with happy, neutral and sad expressions. Thus, in addition to the dichotomy of basic level and subordinate level presentation of category stimuli across experiments (i.e., basic level expressions in Experiment 1 and subordinate level expressions in Experiment 2) there was also the dichotomy of basic level and subordinate level processing tasks within Experiment 2 only (basic level processing by identifying faces and objects in the Implicit task and subordinate level processing by identifying specific cars, houses and butterflies alongside happy, neutral and sad expressions in the Explicit task). According to prior literature (e.g. Tanaka et al., 1999), there was the possibility of an expression influence on the N170 for the subordinate level categorization task where participants explicitly identified each object and each emotional expression. However, there was no Condition x Expression or Condition x Object interactions where subordinate stimulus categories influenced amplitudes in the explicit condition only. Another reason why this may not have happened is that the simultaneous presentation of faces and objects in Experiment 2 determined the type of categorization process rather than the basic level (implicit) or subordinate level (explicit) processing tasks. The type of presentation format that was used for the subordinate processing task in Experiment 2 was to present all items in a mixed fashion with the participant unaware of the next items status as a face or object. That is, because there were faces and objects present, it did not matter that subordinate processing was initiated for specific objects and expressions – faces and objects still needed to be discriminated on a basic level before the specific expression or specific object was identified. This would also explain why there was an influence for butterflies compared to cars and houses that was found across both implicit and explicit tasks and not only in explicit tasks. If subordinate processing was the reason for butterflies producing larger N170 amplitudes than cars and houses, then this effect should have been isolated to the explicit processing task. However, the larger amplitudes for butterflies was found for both implicit and explicit tasks further suggesting that the simultaneous presentation of objects and faces were responsible for amplitude differences rather than basic level (implicit) or subordinate level (explicit) processing. Perhaps a subordinate processing task that divides faces and objects into separate blocks will find influences of subordinate processing tasks compared to basic level processing tasks. This way, the visual system would not have to categorize stimuli according to objects and faces before going on to the subordinate level – the visual system could go directly to the subordinate level. In either situation, the results are in accord with Scott et al. (2006) who found that only basic level category differences influenced the N170, while subordinate category differences were found later for the N250.

There were several differences between basic level (implicit task) and subordinate level (explicit task) processing that occurred in Experiment 2 for both amplitude and latency. In the basic level analysis, there was an early occipital influence of Condition in the 30-80ms window such that object and face amplitudes differed across hemispheres in the explicit but not the implicit task. The 30-80ms window captures the amplitudes of a component labeled C1 that reflects early processing within area V1 of the occipital cortex (Di Russo, Martinex, Sereno, Pitzalis, & Hillyard, 2001). This early C1 difference for Experiment 2 explicit condition amplitudes occurred when participants identified specific objects and expressions. When participants simply discriminated between faces and objects, there were no early occipital C1 amplitude differences for Experiment 2. Additionally, the Experiment 2 Implicit task is labeled for the type of emotional expression processing within the current paradigm. It would also be reasonable to consider that the Experiment 2 implicit task was also an explicit object and face discrimination task. That is, although the purpose of the task was to measure implicit processing of emotional expressions, it was also incidentally a task of explicit identification of faces and objects. This demonstrates that the task of discriminating objects from faces did not influence the early C1 component, but the task of discriminating specific subordinate categories of cars, houses and butterflies alongside of subordinate categories of happy, neutral and sad expressions did influence the C1 component. This finding is earlier than then the N170 modulation of subordinate category object processing by Tanaka et al. (1999) and the N250 modulation of subordinate bird processing by Scott et al. (2006). One possible reason for the earlier modulation is that the current study presented faces and objects whereas Tanaka presented only non-face categories. Additionally, Tanaka et al. (1999) presented various category labels before the images in a mixed design whereas the current study presented images before participants identified them on either a basic or subordinate level in a blocked design. Scott et al. (2006) had participants retain a bird in working memory for a short inter-stimulus interval before presenting a comparison picture. It is certainly plausible that the processes involved in holding a category label or item in working memory and matching it an image are different than the processes involved in reacting to an unknown image.

There were two latency differences related to processing task in the basic level analysis comparing faces and objects for Experiment 2. The occipital N170 showed faster latencies for explicit compared to implicit processing in the basic level analysis while the temporal N170 showed faster latencies for cropped faces in the right hemisphere for the explicit but not implicit processing tasks. However, although there were latency differences for implicit and explicit processing tasks in the basic level analysis comparing faces and objects, there were no latency differences for the subordinate level analysis for specific objects or specific emotional expressions. In contrast, Tanaka et al., (1999) found no latency differences when exploring super/basic/sub-ordinate level processing. This could again be explained by the fact that Tanaka et al. (1999) presented subjects with the category label before the image appeared whereas the current study presented participants with images not preceded by any category label. Unfortunately, Scott et al. (2006) did not examine latency of the N170 so a comparison cannot be made with the current study.

The majority of the results could be reasonably explained by task complexity. That is, the more complex the task is made, whether by asking to identify more types of stimuli or by adding more categories of stimuli, the more differences between implicit and explicit processing will probably be found. Previously mentioned studies examining basic level and subordinate level category processing have typically presented non-face stimuli in isolated tasks (Scott et al., 2006; Tanaka et al., 1999) as opposed to the mixed presentation within the current study. This would suggest that there are different levels of complexity regarding implicit and explicit processing tasks and that identification of specific subordinate categories may elicit more changes in earlier time windows than identification of more general basic level categories to account for the increased amount of specific items that need to be eventually identified; yet not take overall longer processing time due to the evolutionary importance of item discrimination. Thus, the more complex the task, the more changes need to occur in order to ensure identification is still made in a timely manner.

Experiment 1: Happy, Neutral and Sad Expressions, Block Order, and the N250

In Experiment 1, sad expressions led to decreased occipital P1 amplitudes and increased N170 amplitudes while happy expressions led to increased temporal P1 amplitudes but had no influence on N170 amplitudes. Batty and Taylor (2003) found that neutral and surprised expressions produced smaller P1 amplitudes than happy and sad expressions while happy produced slightly earlier N170 latencies than sad, disgusted and fearful expressions. Rellecke et al. (2012) found that angry expressions produced larger N170 amplitudes than neutral or happy while Schacht and Sommer (2009) found happy expressions produced larger amplitudes than angry in the N170 window. Calvo and Beltran (2013) found that angry, fearful and sad faces produced larger N170 amplitudes than happy and neutral expressions while happy and angry expressions produced larger N250 amplitudes. In studies finding a prioritization of negative expressions compared to happy expressions, the presence of threat-related expressions such as angry or fearful expressions may have covered some of the influence of sad and happy expressions due their evolutionary importance of danger detection mentioned above (Ohman, 1986; but see: Schacht & Sommer, 2009). The context of the current study suggests that when threat related expressions are not present, happy expressions have an influence on the parietal P1 component while sad expressions have an influence on the N170 component. However, there was an early C1 modulation by neutral and sad expressions across hemispheres suggesting that expressions with a non-positive valence still took temporal priority over happy expressions in the current study. Additionally, the N170 component in the current study was largest for sad and neutral expressions compared to happy expressions suggesting that even in the absence of threat related expressions the N170 was still larger for expressions with a non-positive compared to positive valence. Finally, the N170 was significantly larger for sad expressions compared to neutral expressions showing that expressions with a negative valence were prioritized for the N170 in accord with the early negativity bias typically found in emotional stimulus processing (Smith, Cacioppo, Larsen, & Chartrand, 2003).

Two components of primary interest from Experiment 1 showing influences of emotional expression were influenced by Block Order – the temporal P1 and parietal N250. The temporal P1 was smaller for sad expressions compared to happy and neutral expressions only when implicit processing conditions were presented first. This suggests the temporal P1 is sensitive to negative expressions when attention is not initially directed towards an emotional expression. That is, when attention is explicit directed to sad expressions, the P1 does not differentiate between expressions. It is only if one is not directly paying attention to the expressions presented to them does the P1 become smaller for sad expressions.

The parietal N250 was sensitive to both block order and processing tasks such that implicit and explicit processing exerted influences on the N250 in addition to the order that they were presented. When implicit tasks are presented first, there were no differences in the N250 for implicit processing; explicit processing then led to larger N250 for sad expressions. When explicit tasks were presented first neutral expressions led to a larger N250 than happy and sad expressions; implicit processing than produced larger N250 amplitudes for neutral and sad expressions. Thus, when implicit processing occurs first, the N250 shows no difference to expression; explicit processing then favors sad expressions. When explicit processing occurs first, the N250 still shows no difference to expression, but this is manifested in a different way, shown by greater N250 amplitudes for neutral compared to happy; explicit processing then again favors sad expressions along with neutral expressions. The results suggest that the parietal N250 is an implicit repetition marker of non-positive expressions. That is, the N250 is not sensitive to emotional expressions regardless of implicit or explicit processing task until the participant has experienced a number of presentations of emotional expressions. After the participant has been presented with a series of emotional expressions, the N250 becomes sensitive to non-positive expressions represented by different influences of implicit or explicit processing task.

Both components appear to be markers of exposure to sad expressions. The temporal P1 appears to be a marker of implicit exposure to negative expressions – it demonstrates changes in amplitude when negative expressions have been present but not attended to. The parietal N250 appears to be a more complicated manifestation of the temporal P1 in that in addition to being sensitive to the implicit exposure to negative expressions, it is also sensitive to the explicit exposure of negative expressions by increasing in size to sad expressions once they have been explicitly identified in the environment and continue to be explicitly identified. In both cases, these components may serve to warn of possible important social cues that someone in the group is distressed or something is wrong. It would makes sense that such a component would be sensitive to sad expressions and not positive expressions as the welfare of the group could depend on the intuitive recognition of an individual becoming more lethargic or distant from the group.

The N250 has previously been identified as a marker of identity repetition in studies using various faces stimuli such as famous faces (Schweinberger et al., 2002) and faces learned within the context of an experiment (Itier & Taylor, 2004) as well as to the subjects own face (Tanaka et al., 2006). Tanaka et al. demonstrated that an individual's own face elicits a temporal occipital N250 in early and late trials whereas unfamiliar faces show no N250 in early trials but will elicit an N250 in late trials with repeated presentation. Itier and Taylor showed that the N250 grew in response to upright, inverted, and contrast-reversed faces in later trials after repeated presentations. Thus, Tanaka et al. suggested that the N250 is sensitive to previously familiar (such as an individual's own face) and newly familiar (such as repeated presentation of unfamiliar faces) information related to face perception. Additionally, Scott et al. (2006) demonstrated that the N250 was not sensitive to learned basic-level category differences between owls and wading birds, but it was sensitive to learned subordinate level stimulus categories of owls and wading birds (i.e., "snowy owl" as a specific subordinate category of "owls"). This suggests the N250 is not limited to familiar faces, but rather extends to other situations of subordinate category discrimination tasks.

The current study found two different modulations of the N250. The occipital N250 was influenced by happy and sad expressions but not neutral expressions regardless of processing task or block order presentation. Thus, it is possible that the occipital N250 found in the current study represents the aspect of the N250 that is sensitive to pre-existing subordinate category representations. This is because the modulation of the N250 was sensitive to happy and sad expressions regardless of processing task or repeated presentations. On the other hand, the parietal N250 was sensitive to emotional expressions, task type, and block order showing that repeated presentation of emotional expressions in various processing tasks suggesting that the parietal N250 is sensitive to newly learned familiar affective information. This is because the modulation of the parietal N250 was not present after the first block of the experiment regardless of processing task. In the second half of the experiment, the parietal N250 was influenced mainly by sad expressions regardless of the processing task. This showed that only repeated exposure to emotional expressions influenced the N250 suggesting that this represented newly learned familiar affective information. Further, the current study utilized 160 images of different unfamiliar individuals displaying emotional expressions presented just twice (once in the implicit and once in the explicit condition) making it highly unlikely that the N250 modulation in the current study is related to facial identity as in previous studies (e.g., Tanaka et al., 2006). Unfortunately, previous studies identifying N250 modulations have used high-density systems that cluster parietal, temporal and occipital areas together so it cannot be determined if occipital and parietal electrodes produced two different manifestations of the N250. Regardless, the current study extends the situations regarding the influence of pre-existing and newly learned subordinate category information on the N250 to the area of affective representations whereas previous findings focused mainly on own-faces (Tanaka et al., 2006), repetition of unfamiliar faces (Schweinberger, 2002, 2004), and subordinate category processing (Scott et al., 2006).

Experiment 2: Happy, Neutral and Sad Expressions

In Experiment 2, the pattern of ERP modulations for happy, neutral and sad expressions were different than those in Experiment 1. In Experiment 2, there was an Emotion x Hemisphere interaction for the 30-80 time window for temporal electrodes such that sad had more negative amplitudes in the left compared to the right while neutral had more negative amplitudes in the right compared to the left; this was essentially the opposite of the occipital Emotion x Hemisphere interaction from Experiment 1 where sad had more negative amplitudes in the right compared to left and vice versa for neutral. For Experiment 2, cropped happy expressions produced a greater occipital N250 in the right hemisphere compared to the left with no differences for neutral and sad while happy expressions also led to greater late positivity in the 600-800 range for central electrodes. Central electrodes for Experiment 2 also produced a Condition x Emotion x Electrode interaction for the 30-140 time windows. In the 30-80 window, sad expressions differed across left, center and right electrodes for the Explicit condition only while for the 80-140 window neutral and sad expressions differed across electrodes for both Implicit and Explicit processing.

Thus, Experiment 2 demonstrated a slightly different pattern of amplitude modulation for the expression of happy, neutral and sad expressions. The separation of neutral and sad expressions occurred in the same early time window for both experiments but was found in the occipital electrodes for Experiment 1 and temporal electrodes for Experiment 2. Happy expressions on the other hand showed differences for the P1 and N170 in Experiment 1 but none in Experiment 2. Rather, only cropped happy expressions modulated the right hemisphere occipital N250 in Experiment 2 whereas happy and sad expressions both influenced the right hemisphere occipital N250 in Experiment 1 (note that there were no non-cropped images shown in Experiment 1, so there was no possibility of a cropping influence on the N250). Additionally, happy expressions modulated late positivity in the 600-800 window for central electrodes in Experiment 2 while no such modulation was found in Experiment 1. Although there were some late influences of happy expressions in the 400-800 window mentioned in the discussion for occipital, temporal, and parietal electrodes these effects were not explored due to their likely reliance on the Block Order analysis and not the primary expression analysis. Finally, the differences between neutral and sad expressions were influenced by Condition in the 30-140 windows for the inversion of the temporal occipital C1 and the N1 for central electrodes in Experiment 2. This is opposed to Experiment 1 where the only influence of condition was found for the parietal N250 and where neutral and sad expressions influenced the P1, N170 and N250.

The amplitude modulations between Experiment 1 and Experiment 2 show that when emotional expressions are presented as a basic level category (Experiment 1) the differences between happy, neutral and sad expression occur from 30-400ms with most modulations occurring for the N170 and N250 components in the 140-200 and the 200-400 time windows. When emotional expressions are presented as a subordinate level category (Experiment 2) the differences between happy, neutral and sad expressions occur in a shorter time window of 30-

140ms with additional processing for cropped happy expressions in the 200-400 window and then again in the 600-800 window. The same argument about the visual system having to account for more stimulus possibilities but having to complete the job in the same amount of time could apply to the processing of emotional expressions as well. However, the while the process for Experiment 2 appears to resolve quicker than the process for Experiment 1, there seems to be much more in-depth processing of emotional expressions in Experiment 1 as evidenced by the modulation of the N250 in both occipital and parietal electrodes for both happy and sad expressions compared to the modulation of the N250 by only cropped happy expressions in Experiment 2.

Influence of Implicit and Explicit Processing of Emotional Expressions

The current study found no influence of implicit and explicit processing task in either Experiment for temporal occipital N170 amplitudes suggesting an automatic influence of expression regardless of task. The finding of no influence of processing condition is similar to Rellecke et. al. (2012) who found no influence of implicit and explicit processing for P1 and N170 amplitudes; both P1 and N170 were greater in response to angry expressions regardless of task. The current study extends these findings of automatic influences of emotional expressions to the P1 and N170 using a stimulus set that did not include any threat-related expressions. This suggests an automatic role for emotional expressions related to categorical processing that does not rely on the proposed evolutionary adapted “quick” recognition route for emotional expressions.

Although no influences of implicit and explicit processing on the N170 occurred, there were other differences for implicit and explicit processing of emotional expressions in both Experiment 1 and Experiment 2. The Experiment 2 subordinate level analysis for faces and objects showed implicit and explicit processing condition amplitude differences such that the expression analysis showed an influence of task type in the 30-140 range across central electrodes while the object analysis showed an influence of task type in the 80-140 range across parietal electrodes. For both expression and objects, explicit processing showed influences in the earlier time window while implicit processing showed influences in the later time window. This showed that expressions were differentiated in the earlier time window than objects and that explicit processing caused earlier modulations than implicit processing in both cases. The earlier differentiation of specific faces compared to specific objects probably reflects the increased social informative nature of emotional expressions compared to various non-threatening objects such as cars, houses and butterflies.

In addition to modulation by Condition in the windows before the N170, there was also a modulation by Condition for the window after the N170 – the previously discussed N250. The finding in the current study that sad expressions are modulated by implicit and explicit processing task for the N250, are in contrast to the findings of Rellecke et. al. (2012), who found that happy expressions modulated ERPs in later time window in the explicit processing task only. There are two possibilities for this difference. First, Rellecke et. al. utilized happy, neutral, and angry expressions. As previously mentioned, angry expressions are considered threat related stimuli that tend to be prioritized over other expressions within ERP studies. Thus, the influence of threat-related angry expressions may not differ according to implicit or explicit processing due to the importance of perceiving angry expressions no matter what the participant may be currently doing. However, because sad expressions are not considered threat related, yet still provide important information for social interaction, it may be the case that sad expressions are modulated by implicit and explicit processing while threat related expressions such as angry rely on more automatic processing. Second, as previously discussed, the current study found an influence of implicit and explicit processing for the N250 only within the context of a Block Order interaction. Because Rellecke et al. (2012) did not conduct a Block Order analysis, it is not possible to tell if they would have found an influence of implicit and explicit processing of angry expressions within the bigger context of Block Order presentation.

Influence of Image Cropping

The current study found that cropping an image to eliminate outside features such as hair, ears and the jawline in expressions and outer edges of houses, cars and butterflies produced greater N170 amplitudes than images that were non-cropped in occipital electrodes while cropped faces were larger than non-cropped faces and cropped/non-cropped objects across temporal, parietal and central electrodes for the N170 and VPP respectively. This was in addition to the main effect of Category showing that faces led to larger N170 amplitudes than objects across all electrodes. This suggests that low level image manipulations such as cropping can differentiated from stimulus category discrimination such as faces vs. objects by activity sensitive to cropping and category individually across occipital electrodes while activity sensitive to the interaction of cropping and category are found across temporal, parietal and occipital electrodes.

The only previous study to compare face and object discrimination while manipulating image cropping found no influence of image cropping on the P1 (Dering et al., 2011). They did find that the P1 was sensitive to category differences between faces and objects such as butterflies and cars. They also found an influence of image cropping on the N170 such that cropped stimuli elicited greater N170 amplitudes than non-cropped stimuli and a category x cropping interaction such that cropped faces elicited larger N170 amplitudes than non-cropped faces, cropped and non-cropped objects. They did not find any individual main effect of category such that faces led to greater N170 amplitudes than objects in the absence of a category x cropping interaction.

The current study found results similar to Dering et al. (2011) where cropped images led to greater N170 amplitudes with cropped faces causing the largest increase in temporal, parietal and central electrodes. Along these lines both studies found a main effect of category such that faces were greater than objects for the N170, but effects in both studies were carried by a cropping x category interaction where cropped faces led to significantly larger amplitudes than non-cropped faces and cropped/non-cropped objects. Additionally, whereas Dering found that the P1 was sensitive only to category such that faces were larger than objects, the current study found that the P1 was sensitive to both category and cropping; the temporal P1 was greater for objects than faces while the parietal P1 was greater for non-cropped images than cropped images.

The important similarities between the current study and Dering et al. (2011) is that the Category x Cropping interaction found in both studies demonstrated that cropped faces led to significantly larger amplitudes than non-cropped and cropped objects when compared to the difference between non-cropped faces and cropped objects and non-cropped objects. This is often the important comparison in previous studies that have used cropped faces and non-cropped objects in studies of faces discrimination. This shows that cropping faces but not objects in a within subjects comparison leads to increased category differences as opposed to comparing non-cropped faces with non-cropped objects. In contrast to Dering et al., the current study did find a main effect of category and a main effect of cropping across occipital electrodes without a category x cropping interaction demonstrating that the N170 can differentiate faces from objects without relying on the influence of cropping. However, it must be noted that this was found across occipital electrodes instead of the most-oft focused on temporal electrodes when exploring the N170 in relation to face discrimination.

There are several paradigm differences between the current study and Dering et al. (2011) that could account for the differences between the two studies. One major difference between the two studies is that Dering utilized two experiments in a between-subjects design where in each experiment they compared a single object category to a single face category (Experiment 1: faces vs cars; Experiment 2: faces vs butterflies) whereas the current study utilized a within subject design and compared all objects to faces simultaneously. Additionally the current study utilized a more elaborate processing design by presenting participants with 6 stimulus categories instead of 2 - this may have led to subjects increased attention throughout the tasks. Finally, the current experiment utilized emotional expressions as face stimuli and images of cars from the top whereas Dering only used neutral expressions and images from cars from the front. It is possible that the slight differences in the specific type of subordinate stimulus categories are partly responsible for differences between the two studies.

Differences between the N170 and VPP

The relationship between the N170 and VPP has rarely been the focus of studies exploring face and expression perception. Joyce and Rossion (2005) systematically manipulated reference location to compare the temporal occipital N170 and VPP for faces and objects found that the VPP was essentially the inverse of the temporal occipital N170. This is because the electrical signals responsible for generating the temporal occipital N170 also propagate throughout the cortex to influence the ERPs in frontal and central areas of the scalp as well. In fact, if one “flips” over the ERP waveforms from temporal-occipital areas, they are essentially the inverse of frontal-central electrodes. That is, the temporal occipital P1 and N170 are represented by their complimentary frontal-central N1 and P170 (VPP) components. Accordingly, amplitude increases in response to faces compared to objects (Jemel et al., 2003) and latency delays for inverted faces compared to upright faces (Rossion et al., 1999) that are present in the N170 are also found in the VPP within the same studies.

Rellecke, Summer, and Schacht (2013) showed that the placement of the reference electrode was able to mediate the probability of finding an influence of emotional expression on the temporal occipital N170. Because ERPs are based on differences in voltage readings at electrodes of interest and the reference electrode, the closer the electrode of interest is to the reference, the smaller the effects that will occur. One way around this is to use the “average reference” where no one electrode is used as a reference but rather a sum of all electrodes is used to provide a baseline for voltage changes in electrodes of interest. In this case, because effects become smaller the closer they are to the reference point this would predict that the closer the reference is to temporal occipital areas, the less likely it will be that modulations of the temporal occipital N170 will occur. Rellecke et al. (2013) demonstrated this by showing that when the mastoid reference (near the mastoid bone by the back of the ears) is used the influence of emotional expressions on the temporal occipital N170 is decreased (Experiment 1) and even eliminated (Experiment 2) when compared to “average reference” ERPs of the same data.

This is important because Eimer, Holmes, and Colleagues used the mastoid reference in their series of studies that found no influence of emotional expression on the N170 but late increased positivity in frontal central areas (e.g., Eimer et al., 2003). This does not completely explain the lack of N170 modulations in their studies as other studies using the mastoid reference have found influences of expression on the N170 (Rellecke et al., 2013; Williams, Palmer, Liddell, Song, & Gordon, 2006). However, the evidence of reference placement combined with the idea that stimulus category can also account for some of the different findings in the literature.

With regards to the current study, there were several similarities and differences between the N170 and VPP. In Experiment 1, although both waveforms showed larger amplitudes for sad compared to happy, the N170 for sad was significantly larger than both neutral and happy whereas for the VPP sad was significantly larger than happy only. In Experiment 2, both the temporal and parietal N170 showed a Category x Cropping interaction where cropped faces produced the largest amplitudes compared to non-cropped faces, cropped/non-cropped objects that was not sensitive to Implicit or Explicit processing tasks. However, the VPP for Experiment 2 was sensitive to Condition evidenced by a three-way Condition x Category x Cropping interaction where only Explicit tasks showed an advantage for cropped faces but not Implicit tasks. Finally, Experiment 2 also demonstrated larger occipital, temporal, and parietal amplitudes for butterflies compared to houses but there was no complimentary difference in the VPP for butterflies.

The amount of overlap between the N170 and VPP in the current study is in line with the assumption that the same cortical generators are responsible for both waveforms. However, the current study also demonstrates that additional cortical areas must be responsible for the modulation of the VPP compared to the N170. For example, the N170 Category x Cropping interaction in temporal and parietal electrodes was present in the VPP but only for the Explicit task; this suggests that additional cortical generators responsible for task modulation were able to influence the VPP but not the N170. Accordingly, the fact that butterflies elicited larger N170 amplitudes than houses, yet did not exert any difference in the VPP points to different cortical generators being able to influence the VPP and not the N170 and vice versa.

This view is in line with other studies that have suggested different cortical generators may influence the temporal occipital N170 and the VPP (Eimer, 2000d; Taylor et al., 1999). The N170 appears in infants as young as 6-12 months presenting with a longer latency then adults (De Hann et al., 2002) while the VPP appears around 12 years of age (Taylor et al., 1999) showing that each waveform develops independently on a developmental level. Eimer (2000d) found that faces produced larger N170 amplitudes than chairs in the fovea but this difference was reduced in the peripheral. Additionally, he found only presentation of images in the fovea produced an increase for faces for the VPP while peripheral presentations eliminated this effect showing that presentation of stimuli of the fovea was necessary for the VPP advantage for faces.

Although these two lines of research suggest that different cortical generators are responsible for the N170 and VPP both findings can be explained in other terms. Taylor et al. (1999) suggested that changes in cortical folding that is prevalent throughout childhood could be responsible for the differential emergence of the N170 compared to the VPP while Joyce and Rossion (2005) suggested that because peripheral presentations of stimuli have been shown to increase the N170, that the results of Eimer (2000d) could be explained by the fact that peripheral presentation modulated the N170 rather than the categories. The current study speaks against both these interpretations as all stimuli were presented in the fovea to young adults of similar age. Thus, modulations of the VPP not found in the N170 within the current study are probably not a result of cortical folding or peripheral presentation of stimuli. Rather, it is more plausible that additional cortical generators are responsible for the influence found for the VPP but not the N170 because of differences in task design and complexity.

ERPs for Object Perception

Experiment 2 showed that differences for specific object categories began to occur in the 140-200 time such that butterflies produced larger occipital, temporal and parietal N170 amplitudes than houses but not cars; the VPP did not show this difference. Cropped butterflies showed differences in the 200-600 window for occipital electrodes while cropped houses and butterflies showed differences in the 200-400 window for parietal electrodes. Cropped cars began to show differences in the 400-600 window relative to cropped butterflies while only cropped butterflies influenced central electrodes in the same time window. Finally, cars and houses showed late positive differences mainly across left and right central electrodes. The data seem to suggest that butterflies were prioritized in relation to cars and houses. The data also show that differences for specific objects started in the 140-200 window – slightly later than that of specific expressions (30-140 window). This suggests that although objects modulated the N170, the discrimination of specific expressions still took temporal priority by initiating changes earlier than objects.

The finding that butterflies produced larger N170 amplitudes than cars and houses in the current study are similar to other studies finding differences in N170 amplitudes for comparison subordinate object stimulus categories. However, whereas the current study found larger N170 amplitudes for butterflies, other studies have found other N170 differences for houses and cars. Rossion et al. (2000) found that houses produced longer N170 latencies than faces, cars, houses, chairs and shoes while N170 amplitudes were largest for faces and cars (no difference) with a subordinate object analysis showing cars and chairs were larger than houses and shoes. Rossion et al. (2003) found that faces produced larger N170 amplitudes with right-hemisphere being larger than left, cars produced smaller amplitudes equally across both hemispheres with printed words being as large as faces in the left hemisphere. One factor that may account for the difference is that the current study used images of cars from a birds-eye-view looking straight down whereas the cited studies used images of cars from the front (Rossion et al., 2000) and three-fourths frontal view (Rossion et al., 2003).

The finding that butterflies produced the largest N170 for subordinate object categories compared to houses or cars could be explained by the fact that butterflies are animate objects compared to inanimate objects such as houses and cars. Clinical patients have presented with impaired ability in identifying living things such as plants and animals (Farah, McMullen, & Meyer, 1991; Warrington & Shalice, 1984) while others have presented with the impaired ability to identify non-living things such as a towel or briefcase (Warrington & McCarthy, 1983; 1987). Accordingly, Carmel and Bentin (2002) found that faces produced larger N170 amplitudes than cars, birds and furniture but equal amplitudes as ape faces regardless of when they identified cars (Experiment 1) or faces (Experiment 2) as targets; they also found that cars produced larger N170 amplitudes when they were a target category. Itier and Taylor (2004) used mushrooms, flowers, houses, lions, tools and road signs as comparison stimuli to faces and found that lions produced equal P1 amplitudes to faces. Thus, it could also be the case that butterflies were classified as their own subordinate level object category with cars and houses forming another general subordinate object category.

The situations regarding the influence of non-face category processing is certainly much more complex than the two previously mentioned possible influences. However, because the focus of this paper is on faces and emotional expressions, the object recognition literature will not be reviewed. There are other more thorough reviews related to object categorization that would be more informative than this paper allows (see: Joseph, 2001; Palmeri & Gauthier, 2004).

N170 as a "salient category marker"

Currently, one dominant theory regarding the N170 is that it is a "face selective" because of the increased amplitudes for faces compared to other stimulus categories (Bentin et al., 1996; Carmel & Bentin, 2002; Itier & Taylor, 2002; Rossion & Jacques, 2008). Other theories have considered the N170 as an "eye detection system" (Eimer, 1988) or an index of "expert object recognition" (Gauthier, Curran, Curby & Collins, 2003; Rossion, Gauthier, Goffaux, Tarr & Crommelinck, 2002). However, these theories have trouble explaining how why variables such as image frequency, emotional expression and object categories elicit significant differences in amplitude for the N170. Additionally, this would not explain the current findings of why emotional expressions would elicit N170 modulations when presented as a basic level category in Experiment 1 and produced no N170 amplitude modulations when presented as a subordinate processing category in Experiment 2.

A more likely explanation is that the N170 is sensitive to salient category differences depending on the context of stimulus presentation and that it is often the case that faces or some modulation of faces are the most salient stimulus category. When face stimuli are presented in isolation, other aspects become responsible for categorization such as image frequency or emotional expression. Car and bird experts showing increased amplitudes of the N170 could also be explained by assuming those categories are now more salient through general experience (see Scott et al., 2006). Accordingly, Itier and Taylor (2004) suggested that the increased N170 amplitude to road signs reflected increased salience through repeated exposure from everyday driving.

This view is more in line with two-stage process of affective attention accounts from studies of emotional images and scenes (Schupp et al., 2006; Uusberg, Uibo, Kreegipuu, Tamm, Raidvee, & Allik, 2013) and extended to the emotional facial expression literature (Calvo & Beltran, 2013) . The first stage differentiates among categories through the use of low-level differences while the second stage focuses on processing of the specific expression exemplar themselves. The P1 and N170 in the current study reflect the first stage of processing where it is not the specific expression itself that determines categorization, but rather more general features that differentiate positive from non-positive expressions. This is in line with the idea discussed earlier that the differences for the N170 in Experiment 1 were characterized by a reduction in amplitude caused by the categorization of the expression category rather than the specific emotional expression per se. In the second stage, processing of the expression exemplar itself occurs rather than the differentiation of categories according to crude features. This stage can be related to the occipital N250 in the current study. As previously discussed, the N250 is also related to the subordinate processing of category exemplars suggesting it is the waveform responsible for processing of the specific expression exemplar. In the current study, the occipital N250 was sensitive to both happy and sad expressions in the right hemisphere regardless of Block Order or Implicit or Explicit Condition. This suggests that the N250 is where the second stage of the affective attention two-stage theory (Schupp et al., 2006) coincides with the finding from Scott et al. (2006) that the N250 is sensitive to pre-existing subordinate category exemplars.

Although the two-stage theory of affective information can explain the expression differences for the N170 and N250, it does not explain the basic level differences between faces and objects and the subordinate level differences between specific expressions and objects. There was an influence of Condition on the VPP for the specific expression analysis for happy, sad and neutral expressions in Experiment 2 where explicit processing influenced central electrodes in the 30-80 window while both explicit and implicit processing influenced central electrodes in the 80-140 window. Both of these effects were found in time windows before the N170 suggesting that not all processing for the N170 and earlier components are immune from the influence of implicit and explicit processing.

The early differences related to the influence of Condition can again be explained by task complexity. Because previous studies used to formulate the two-stage theory of affective information typically look at only one stimulus category (e.g., only emotional images), the comparison of faces and objects in the current study allowed for a more general exploration of how the visual system processes competing stimulus categories. The early influence of Condition was not present in Experiment 1 where there was only one stimulus category (faces) but was present in Experiment 2 for both the basic level analysis between faces and objects and also the subordinate analysis of specific expressions showing that at least two stimulus categories were necessary (faces and objects) to elicit the early influence of Condition within the current study.

Cortical Generators of ERP Effects

Source modeling of early components in the 30-80ms window (C1 component), P1 and N170 ERPs using correlations between fMRI and ERP experiments of checkerboard stimuli have shown that C1 is related to the primary visual cortex (V1) while the P1 was related to cortical areas in two different visual areas (Di Russo, et al., 2001). The early part of the P1 was related to V3, V3a with the late part of the P1 related to cortical areas adjacent to area V4 in the fusiform gyrus. The N170 was related to four temporally overlapping subcomponents found in multiple areas of the extrastriate cortex that included cortical areas related to P1 processing. Additionally, subcortical ERP (Puce et al., 1994) and MEG studies (Streit et al., 2003) have demonstrated cortical activity related to components similar to the N170 within the fusiform gyrus suggesting strong role of the fusiform gyrus in the P1 and N170 components. Source modeling of ERP components for repetition tasks of facial identity have shown that the N170 was localized to the occipital lobes while the N250 was localized to the fusiform gyrus (Schweinberger, 2002, 2004; Scott et al., 2006). Although source localizing of ERPs are not as reliable as fMRI for spatial resolution, the general differentiation of cortical generators of the N170 and N250 is the important distinction. The source localization of the N170 and N250 ERPs line up well with the previously fMRI cortical activity correlated with visually evoked ERPs (DeRusso et al., 2001). This suggests that early processing such as the C1 is primarily found in the occipital cortex while later processing involving the P1, N170 and N250 are primarily found in the fusiform gyrus and adjacent medial temporal cortical areas with additional influence from occipital areas probably involved in feedback loops providing continual information to the medial temporal cortex.

The early separation of neutral and sad expressions in the 30-80ms window found in the current study most likely reflects the previously described C1 component where early separation within the primary visual cortex (V1) influences what information passes on to regions V3 and V4 for the P1 component. The occipital lobes have been shown to have its own face area called the “occipital face area” that mirrors the functionality of the fusiform gyrus within the temporal lobes (Gauthier, 2000; Halgren, Dale, Sereno, Tootell, Marinkovic & Rosen, 1999; Nomi et al., 2008). Within the current study, early hemisphere separations between neutral and sad expressions in the occipital face area alongside bilateral hemisphere projections from happy expressions could create several streams of information able to influence cortical projections into temporal areas V3 and V4 for the P1.

The P1 difference between sad and happy expressions found in temporal and parietal electrodes probably reflect activity related to early and late stages in the P1 component related to activity in areas V3 and V4 respectively. Next, the separation of happy, neutral and sad expressions found for the N170 probably reflects multiple cortical areas that are independent from- and overlap with- cortical areas in the fusiform gyrus active for the P1 that crudely differentiate between emotional expressions. Finally, the later influence of happy and sad expressions on the N250 may reflect higher order cognitive processing related to processing of specific expressions (Rellecke et. al, 2012; Scott et al., 2006). Thus, processing of early components such as the C1, N1, and N170 reflect successive visual stages of basic level expression categorization while later components such as the N250 reflect specialized processing of the specific emotional expression.

Models of Face and Expression Perception

The results of the current study fit within the Haxby, Hoffman and Gobbini (2000) model of face perception where mechanisms of emotional expression may interact with those responsible for initial face perception. The modulation of the N170 that is typically associated with initial face perception (e.g., Joyce & Rossion, 2005) by emotional expression in Experiment 1 suggests that regions responsible for processing emotional expressions can influence the N170. Additionally, the early influence of expression on the temporal C1 component in Experiment 2 for sad expressions further demonstrates the early influence of expression on early ERPs related to initial face perception. Although the finding of no modulation of the N170 in Experiment 2 would support the idea that emotional expression cannot influence mechanisms related to initial face perception, the overall results of both Experiments in the current study favor the model by Haxby et al. (2000) by considering the extended system of the interactive Haxby model. Because the Bruce and Young model does not allow for the influence of emotional expression on mechanisms responsible for initial face perception, the data will discussed within the framework of the Haxby model.

In Experiment 1, expressions modulated both the P1 and N170 – two components that have been established as being sensitive to initial face perception and also specifically associated with the initial stage of face perception in the Bruce and Young (1986) model. Additionally in Experiment 1, the processing of the specific expression was reflected in the N250 – a component that has been established as being sensitive to the identity of a specific individual. These findings support the proposal by the Haxby et al. (2000) model that the mechanisms responsible for emotional expression detection are able to interact with the mechanisms responsible for initial face perception (P1 and N170) and also interact with the mechanisms responsible for identification of a specific face (N250). In Experiment 2, expressions modulated early components such as the C1 and N1 also providing evidence for the interaction of mechanisms responsible for initial face discrimination and expression detection. Although the interaction of these mechanisms occurred earlier in Experiment 2 than in Experiment 1, they still represent the interaction of invariant and variant processing mechanisms interacting. Thus, the interactive nature of the Haxby et al. model allows for the flexibility to fully explain the findings of the current study where emotional expressions influenced early C1, N1, P1 and N170 components related to initial face discrimination and the later N250 component related to specific identity detection.

Within the Haxby et al. model early information is passed through lateral occipital areas into the fusiform gyrus for invariant aspects of faces and the superior temporal sulcus for variant aspects of faces. The early modulation of C1 most likely reflect the early information passed through later occipital areas while the modulations of the P1, N170 and N250 most likely reflect the interaction of information being passed from the occipital lobe to the fusiform gyrus and superior temporal sulcus. Within the current study the modulation of the P1 and N170 in Experiment 1 by emotional expression probably reflected increased activity in the superior temporal sulcus related to changes in expression interacting with the fusiform face area to change the amplitude of the P1 and N170. It is important to remember that these activations from the superior temporal sulcus related to expression perception are not the representation of the expression exemplar, but are rather more crude representations allowing the visual system to distinguish between course categories such as positive and negative, or neutral and negative. The N250 then represents the processing of the expression exemplar through signals coming from occipital and medial temporal regions that help to decode the specific category exemplar.

It is important to remember that there was no modulation of emotional expression in Experiment 2 suggesting that there are situations where the two systems do not interact to influence early ERPs such as the P1 and N170. As discussed earlier, the reason for the lack of the N170 modulation in Experiment 2 was because emotional expressions were presented as a subordinate rather than a basic level category. The reason being that it was related to the presentation of faces next to objects that caused basic level processing of faces while relegating emotional expressions to a subordinate level category. While the Haxby et al. model specifically includes different systems that can mediate the core system such as attention, the limbic system, and a semantic knowledge system for name retrieval, these systems do not explain how category processing influences the processing of faces and emotional expressions. The current study would suggest that the visual system for the perception of faces is influenced by the type of visual processing task and comparison categories that are present.

Although there were no modulations of the P1 or N170 in Experiment 2 there were early C1 amplitude modulations for temporal electrodes differentiating neutral and sad expressions across electrodes. The fact that these modulations occurred in temporal electrodes opposed to occipital electrodes would suggest different cortical generators, or at least different patterns of activity from cortical generators from the early occipital C1 modulations found in Experiment 1.

Additionally, the early modulation of the C1 inverse found in central electrodes from 30-80 ms suggest that the early occipital differences were also modulated by additional cortical generators that were previously mentioned as influencing the VPP but not the N170. This early modulation was represented by an influence of the Explicit condition across left (C3) and right (C4) electrodes. This finding would be in accord with the extended system from the Haxby model representing the influence of extended attentional systems on the core system of face perception.

Conclusions

The novel findings of the current study are that the influence of emotional facial expressions on ERPs is modulated by the presence of the comparison stimuli such that ERPs modulations in the absence of comparison stimuli (Experiment 1) mainly occurred in the 140-400ms range while ERP modulations in the presence of comparison stimuli mainly occurred in the 30-140ms range. The current study also replicates previous research showing no influence of implicit or explicit processing task on the N170 and extends on research linking the N250 to specific facial identity and subordinate category discrimination to the area of affective information for sad and happy expressions. Additionally, the demonstration that the VPP did not mirror the N170 suggests that additional cortical generators are responsible for the modulation of the VPP and that they are not driven by exactly similar cortical generators. Finally, the current study also found early differences related to implicit and explicit processing condition in the 30-140 windows in front of the commonly assumed window exclusively responsible for bottom-up processing suggesting early top-down influences on visual evoked potentials normally associated with automaticity.

The results suggest two additional factors to consider in emotional expression ERP research. The modulations of happy and sad expressions in Experiment 1 suggest that expression influence on ERPs may be different in the absence of threat related angry and fearful facial expressions. Accordingly, the finding of an N250 for sad and happy expressions may have been because there were no threat related stimuli present with the potential to cover up such effects. The modulations of happy and sad expressions not found in Experiment

2 suggest that presenting emotional facial expressions in a context where they may be processed on a subordinate level stimulus category as opposed to a basic level stimulus category suggest that studies aiming to explore emotional expressions should present them in isolation. These findings may help to isolate expression processes that would potentially not be found in the presence of threat related expressions and also help to account for some of the inconsistencies found in the emotional facial expression ERP literature between studies. The presentation of expressions as a basic level category would be informative to those wishing to focus on affective processing related to a specific facial expression while presentation of expressions as a subordinate level category would be informative to those wishing to focus on a more general account of visual processing accounting for a more general categorization of a wider range of visual stimuli.

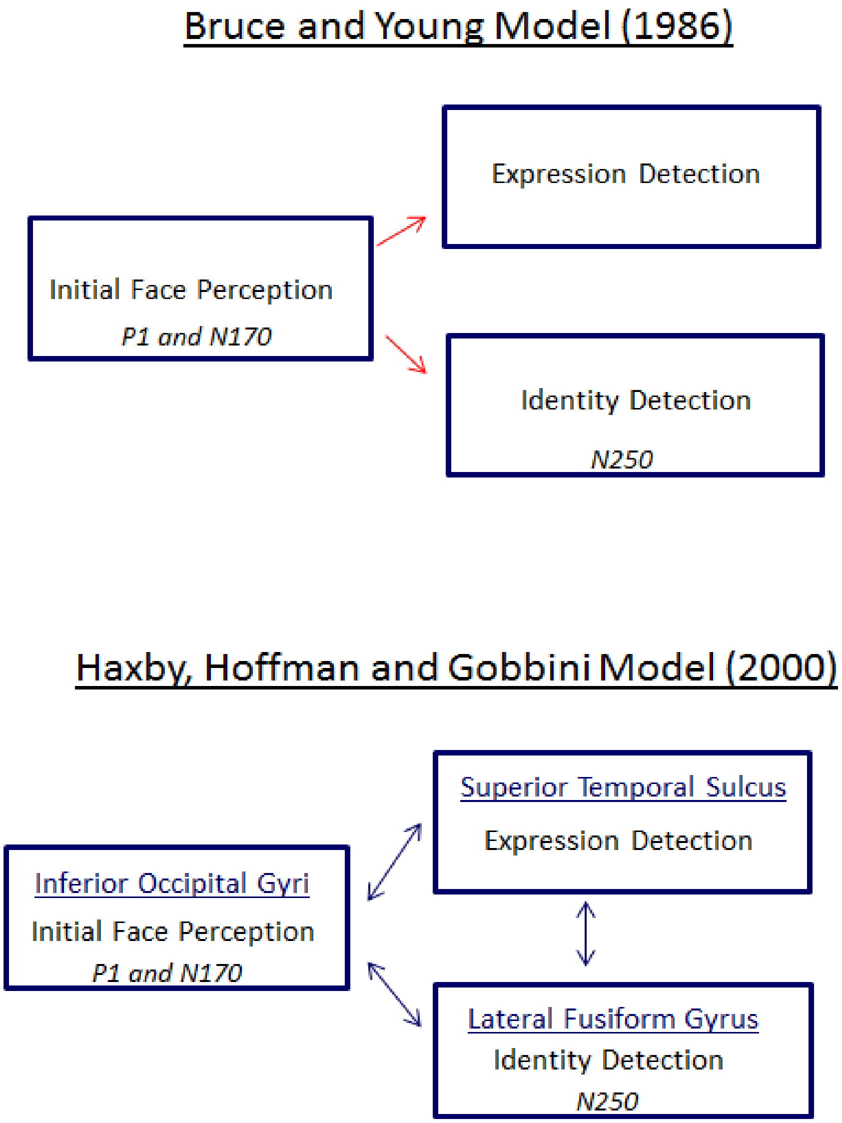
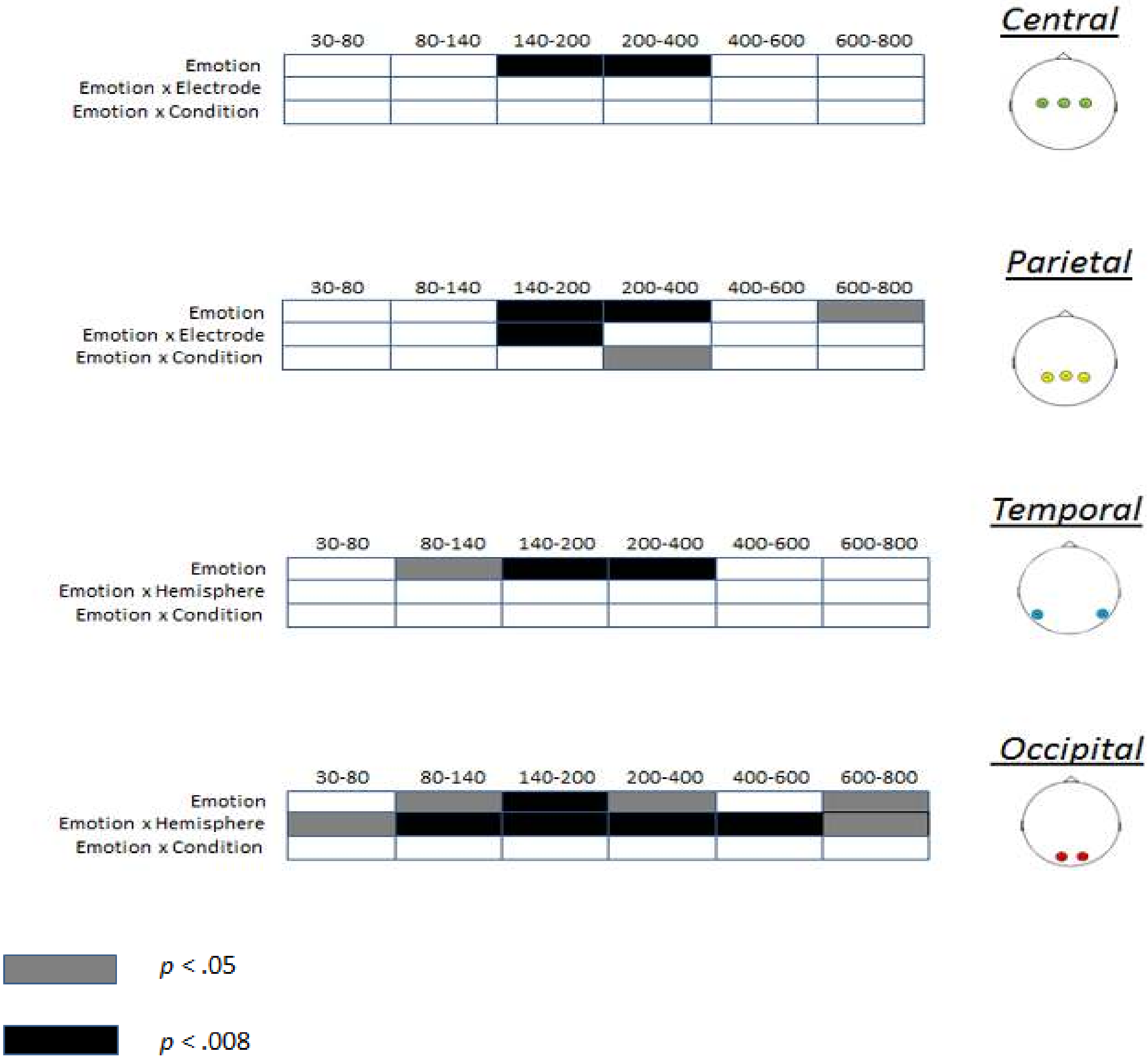


Figure 1: *Simplified versions of the two models of face perception. The Bruce and Young (1986) linear model of face perception proposes that expression and identity detection occur in independent but parallel mechanisms only after initial face perception. Haxby, Hoffman and Gobbini (2000) interactive model of face perception proposes that initial face perception, expression and identity detection occur in individual mechanisms that can interact with each other. The P1 and N170 waveforms reflect initial face processing while the N250 represents identity detection. The current study examined what ERPs are influenced by expression detection. The Bruce and Young model does not allow for expression to influence the P1 and N170 while Haxby, Hoffman and Gobbini model allows for expression to influence the P1 and N170.*



Central

	30-80	80-140	140-200	200-400	400-600	600-800
Emotion			■	■		
Emotion x Electrode						
Emotion x Condition						

Parietal

	30-80	80-140	140-200	200-400	400-600	600-800
Emotion			■	■		▨
Emotion x Electrode			■			
Emotion x Condition				▨		

Temporal

	30-80	80-140	140-200	200-400	400-600	600-800
Emotion		▨	■	■		
Emotion x Hemisphere						
Emotion x Condition						

Occipital

	30-80	80-140	140-200	200-400	400-600	600-800
Emotion		▨	■	▨		▨
Emotion x Hemisphere	▨	■	■	■	■	▨
Emotion x Condition						

▨	$p < .05$
■	$p < .008$

Figure 2: *ANOVAs for Experiment 1 showing effects of Condition, Emotion, and Hemisphere/Electrode.*

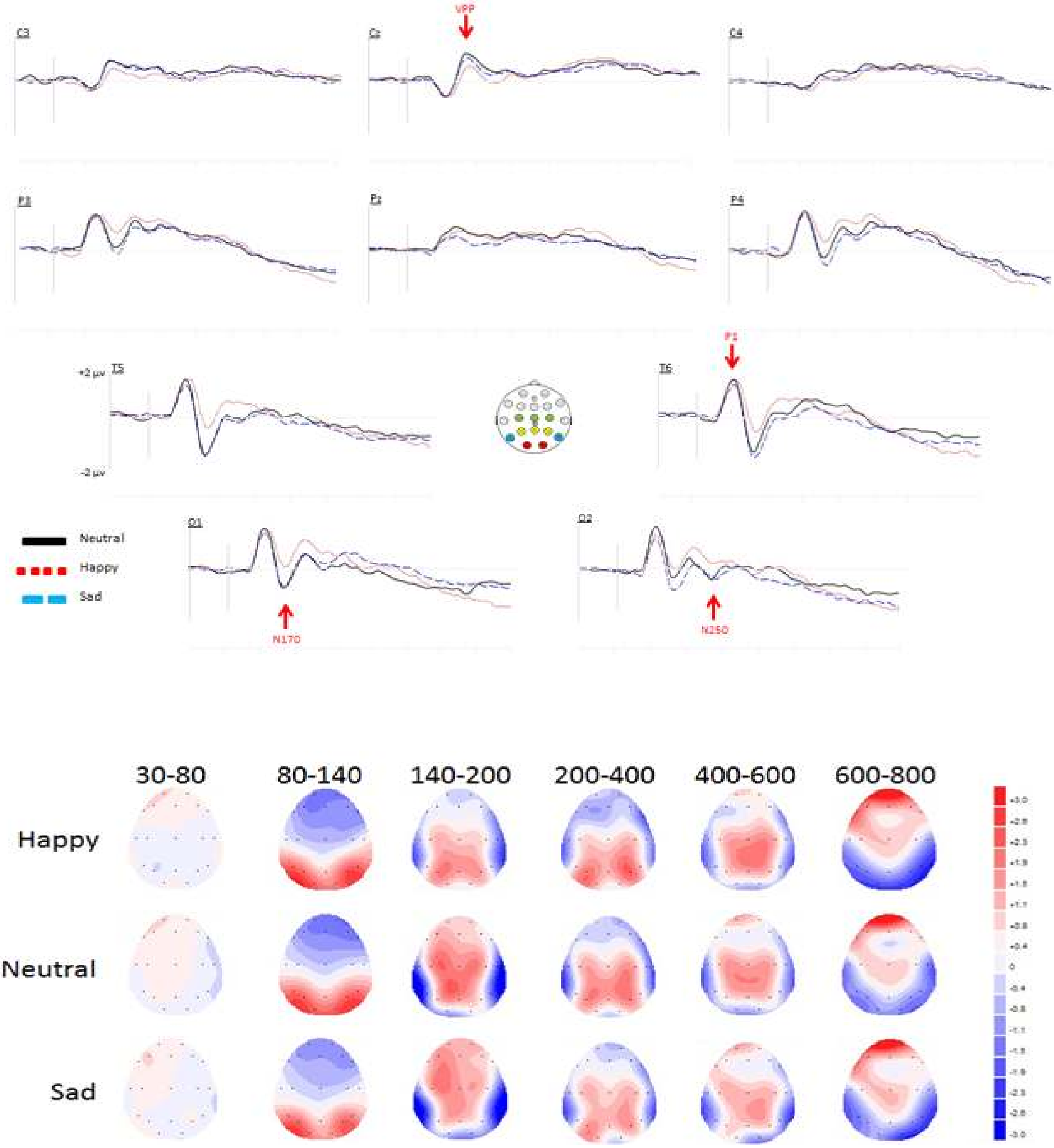
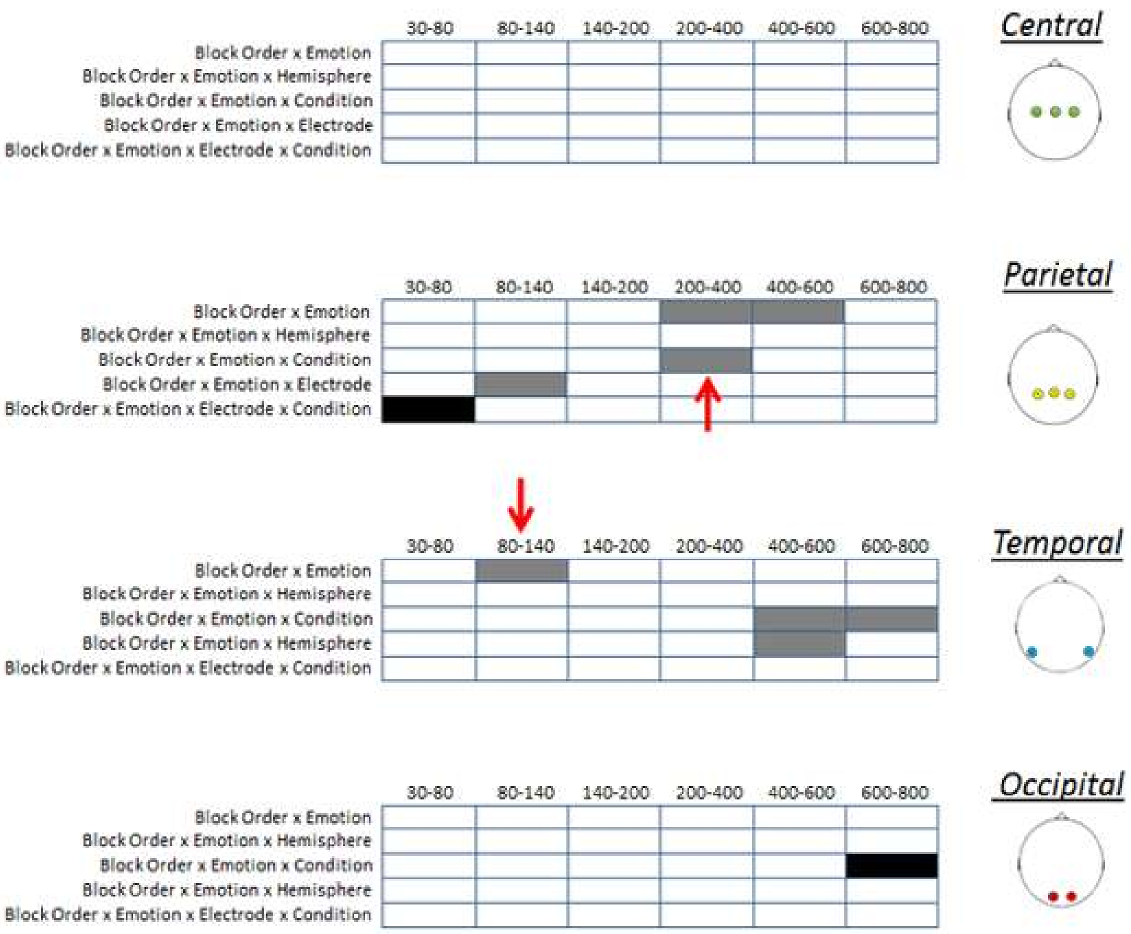


Figure 3: *ERP waveforms and Topographic maps for Experiment 1. 30-80: Early difference for occipital electrodes – sad right > sad left and neutral left > sad left. Occipital P1: sad < neutral. Temporal P1: happy > sad. Occipital, parietal: sad right > sad left. Occipital N250: sad and happy right > left. Parietal N250: sad > neutral and happy. VPP: sad and neutral > happy*



Central

	30-80	80-140	140-200	200-400	400-600	600-800
Block Order x Emotion						
Block Order x Emotion x Hemisphere						
Block Order x Emotion x Condition						
Block Order x Emotion x Electrode						
Block Order x Emotion x Electrode x Condition						

Parietal

	30-80	80-140	140-200	200-400	400-600	600-800
Block Order x Emotion				▨	▨	
Block Order x Emotion x Hemisphere						
Block Order x Emotion x Condition				▨		
Block Order x Emotion x Electrode		▨				
Block Order x Emotion x Electrode x Condition	■					

Temporal

	30-80	80-140	140-200	200-400	400-600	600-800
Block Order x Emotion		▨				
Block Order x Emotion x Hemisphere						
Block Order x Emotion x Condition					▨	▨
Block Order x Emotion x Hemisphere					▨	
Block Order x Emotion x Electrode x Condition						

Occipital

	30-80	80-140	140-200	200-400	400-600	600-800
Block Order x Emotion						
Block Order x Emotion x Hemisphere						
Block Order x Emotion x Condition						■
Block Order x Emotion x Hemisphere						
Block Order x Emotion x Electrode x Condition						

▨ $p < .05$

■ $p < .008$

Figure 4: *ANOVAs for Block Order Analysis of Implicit and Explicit presentation order for Experiment 1. Only two significant effects exerted influence on components of interest: 80-140 for occipital and 200-400 for parietal electrodes.*

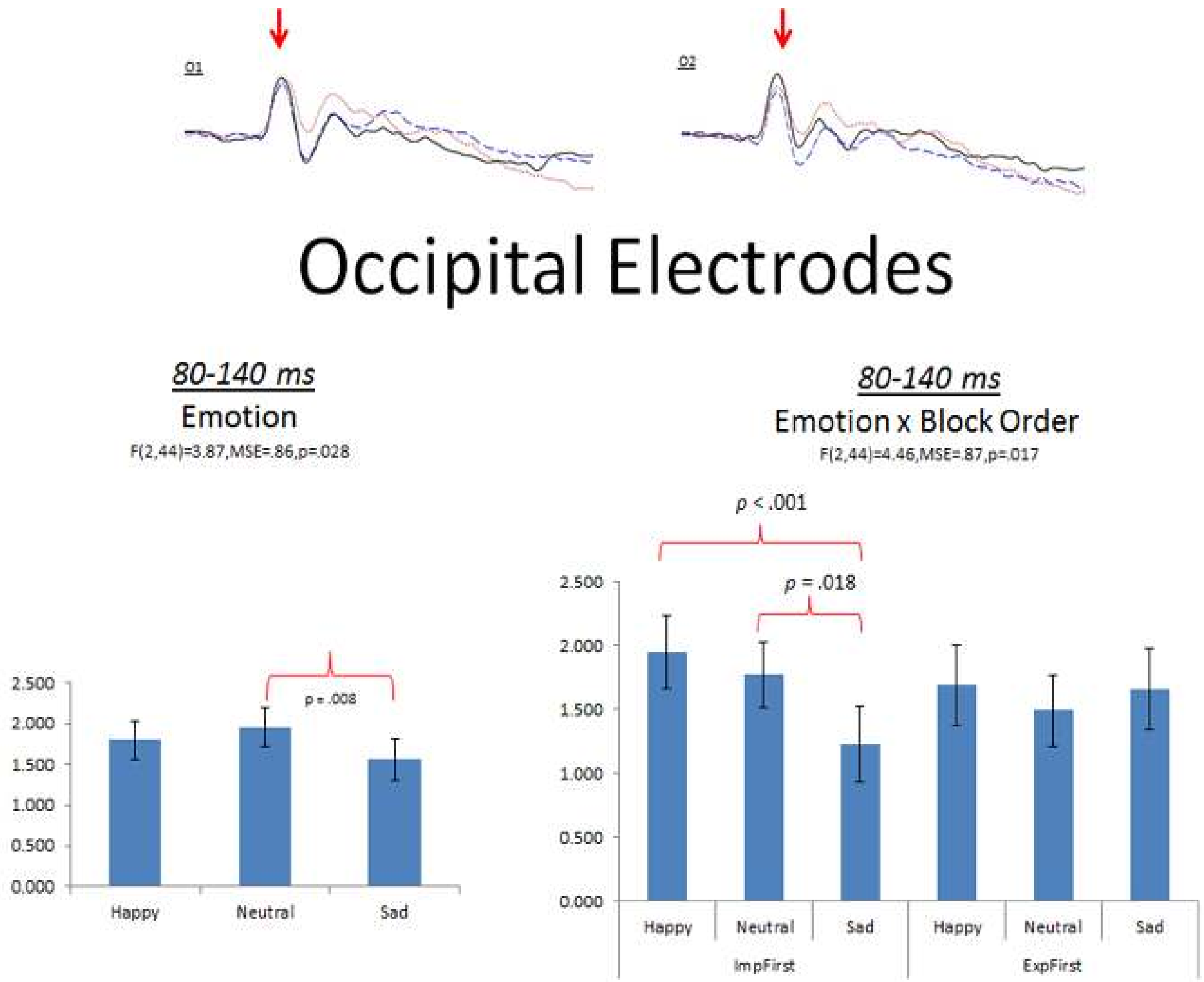


Figure 5: *Influence of Block order on the occipital P1 and parietal N250. Occipital P1: Main effect of Emotion carried by Implicit first condition. Error bars represent Standard Error of the Mean (SEM).*

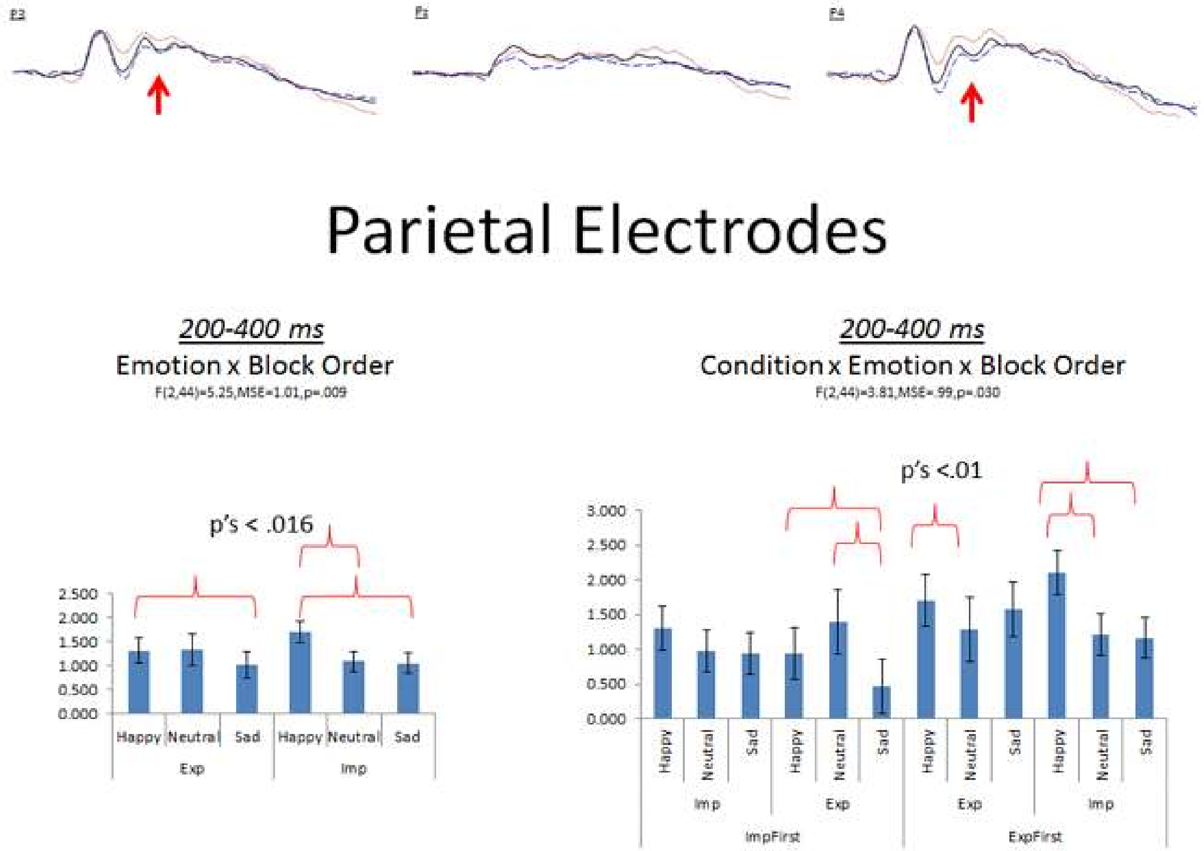
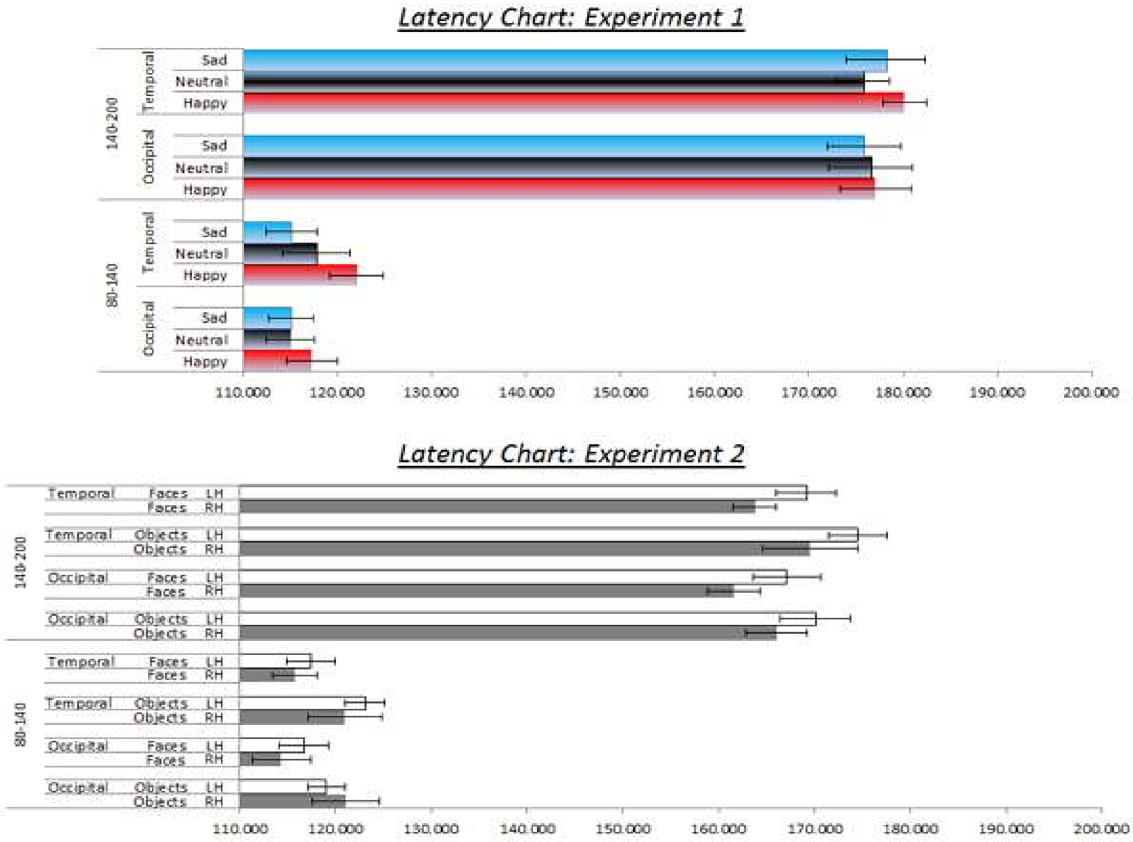
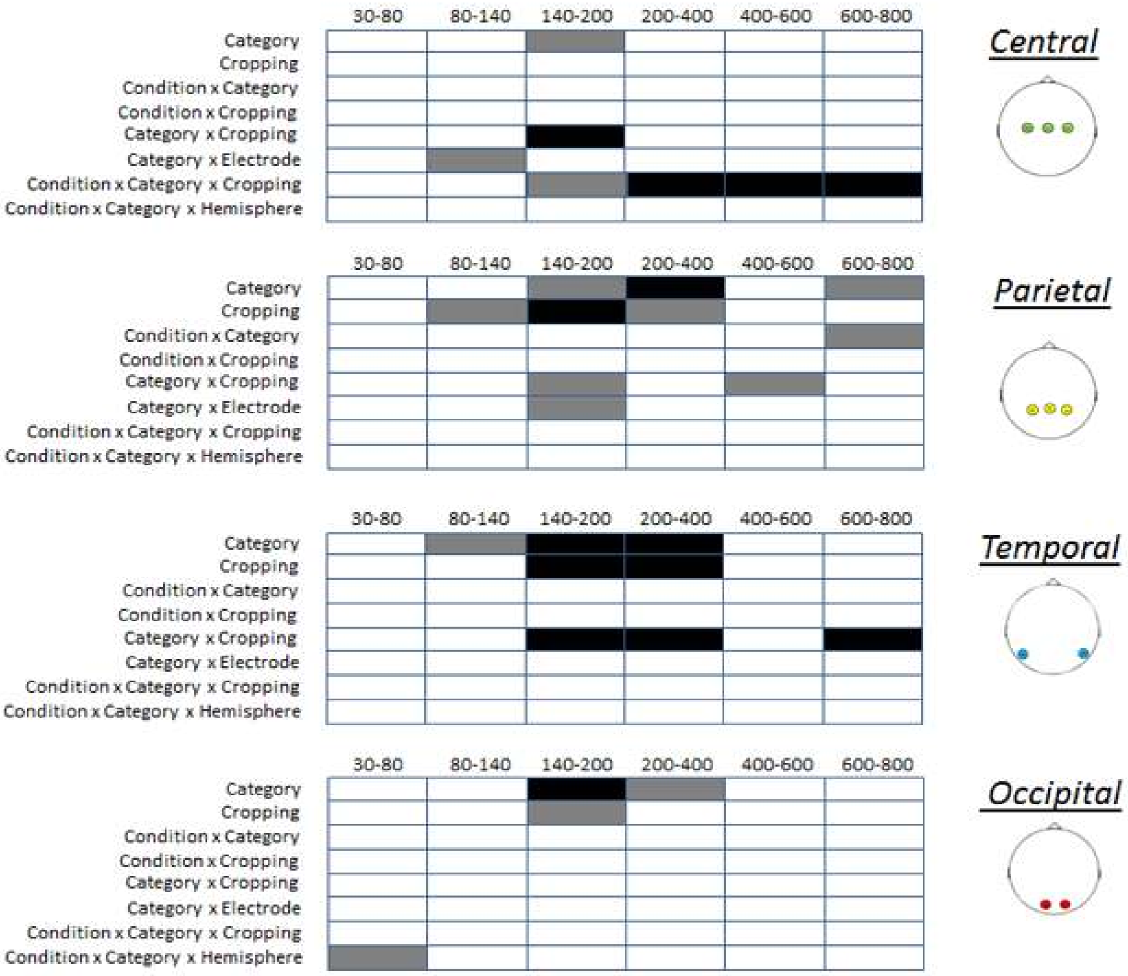


Figure 6: Parietal N250: Implicit first condition: No change for Implicit then greater N250 for sad than happy and neutral in Explicit. Explicit first condition: Neutral greater than happy for Implicit, then sad and neutral greater than happy for Explicit. Error bars represent Standard Error of the Mean (SEM).


Latency Chart: Experiment 1

Latency Chart: Experiment 2

Figure 7: *Latencies for Experiment 1 and Experiment 2. Experiment 1: No significant differences although happy has a trend for slightly slower latencies. Experiment 2: Occipital P1 Category x Hemisphere (80-140): Right faces > Left faces and Left objects > Right objects. Temporal P1 Main effect of Category: Faces > Objects. Error bars represent Standard Error of the Mean (SEM). LH=Left Hemisphere/RH=Right Hemisphere*



Central

	30-80	80-140	140-200	200-400	400-600	600-800
Category			▨			
Cropping						
Condition x Category						
Condition x Cropping						
Category x Cropping			■			
Category x Electrode		▨				
Condition x Category x Cropping			▨	■	■	■
Condition x Category x Hemisphere						

Parietal

	30-80	80-140	140-200	200-400	400-600	600-800
Category			▨	■		▨
Cropping		▨	■	▨		
Condition x Category						▨
Condition x Cropping						
Category x Cropping			▨		▨	
Category x Electrode			▨			
Condition x Category x Cropping						
Condition x Category x Hemisphere						

Temporal

	30-80	80-140	140-200	200-400	400-600	600-800
Category		▨	■	■		
Cropping			■	■		
Condition x Category						
Condition x Cropping						
Category x Cropping			■	■		■
Category x Electrode						
Condition x Category x Cropping						
Condition x Category x Hemisphere						

Occipital

	30-80	80-140	140-200	200-400	400-600	600-800
Category			■	▨		
Cropping			▨			
Condition x Category						
Condition x Cropping						
Category x Cropping						
Category x Electrode						
Condition x Category x Cropping						
Condition x Category x Hemisphere	▨					

▨ $p < .05$

■ $p < .008$

Figure 8: *ANOVAs for Basic Level Analysis of Objects vs. Faces for Experiment 2*

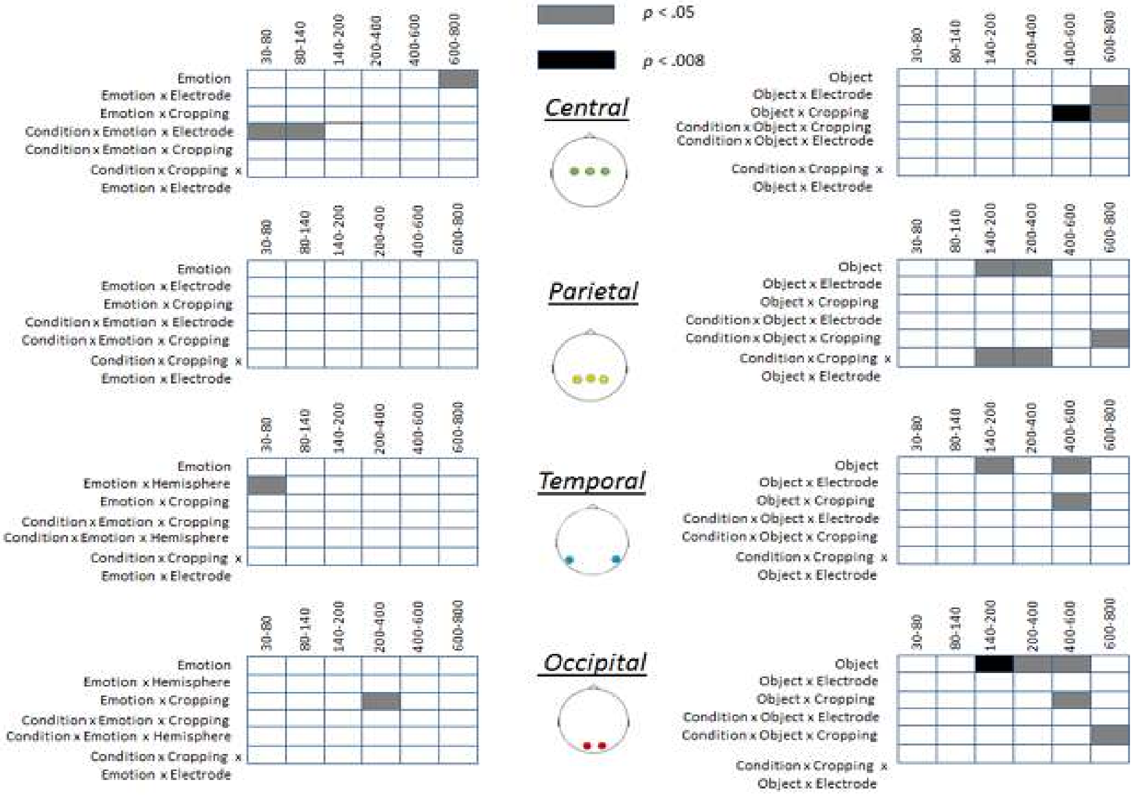


Figure 9: *ANOVAs for subordinate analysis of expressions (happy, neutral, sad) and objects (cars, houses, butterflies). No influence of Expression in the 140-200 range for the N170 while Expressions (left) mostly influence amplitudes in the 30-140 range while Objects (Right) mostly influence amplitudes in the 140-200 range.*

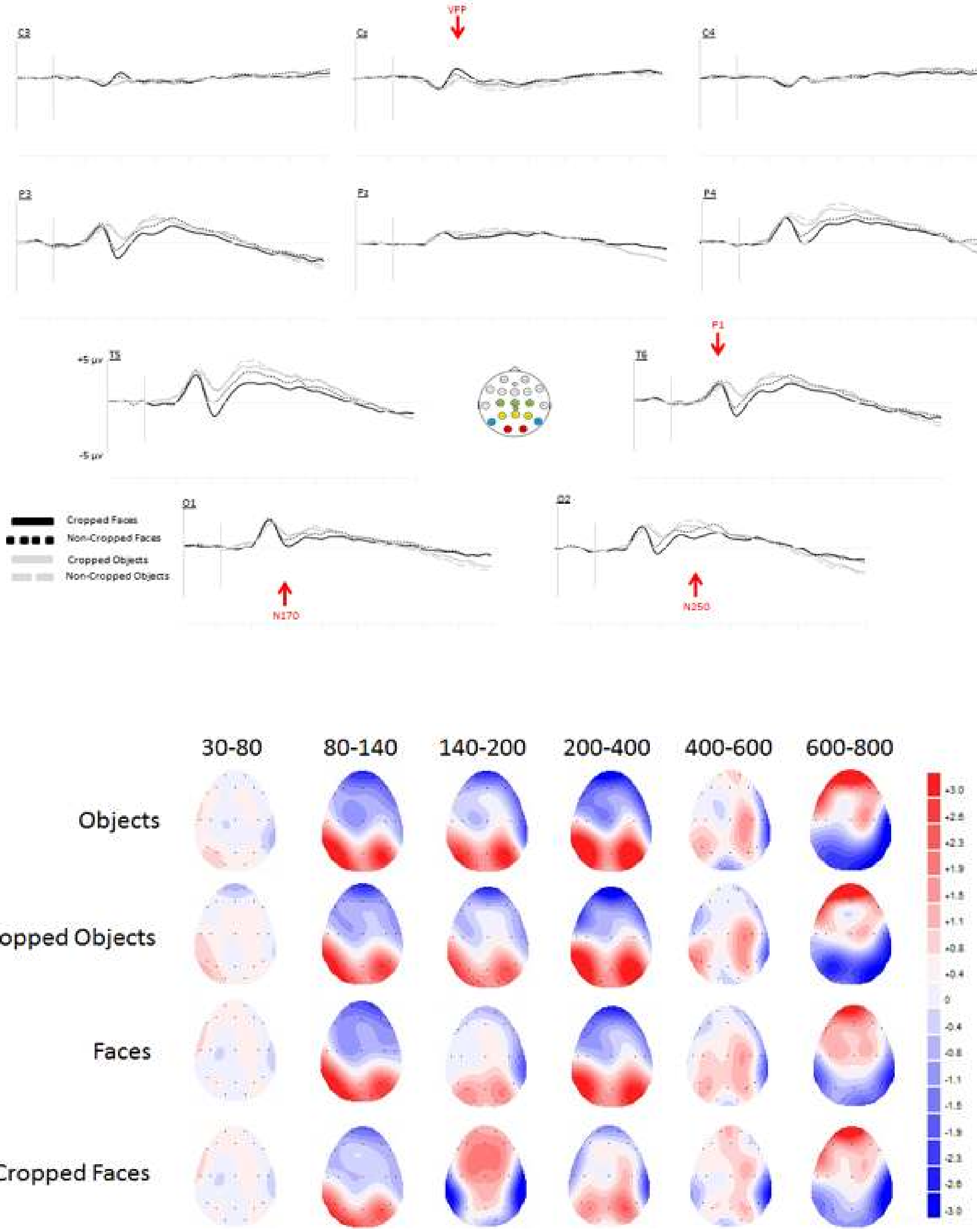


Figure 10: *ERP waveforms and Topographic plots for Experiment 2: Cropped and Non-cropped Objects and Faces. Temporal P1: main amplitude effect – objects > faces. Parietal P1: main amplitude effect: non-cropped > cropped. Temporal (N170), parietal (N170) and central (VPP): Category x Cropping interaction - cropped faces > all others.*

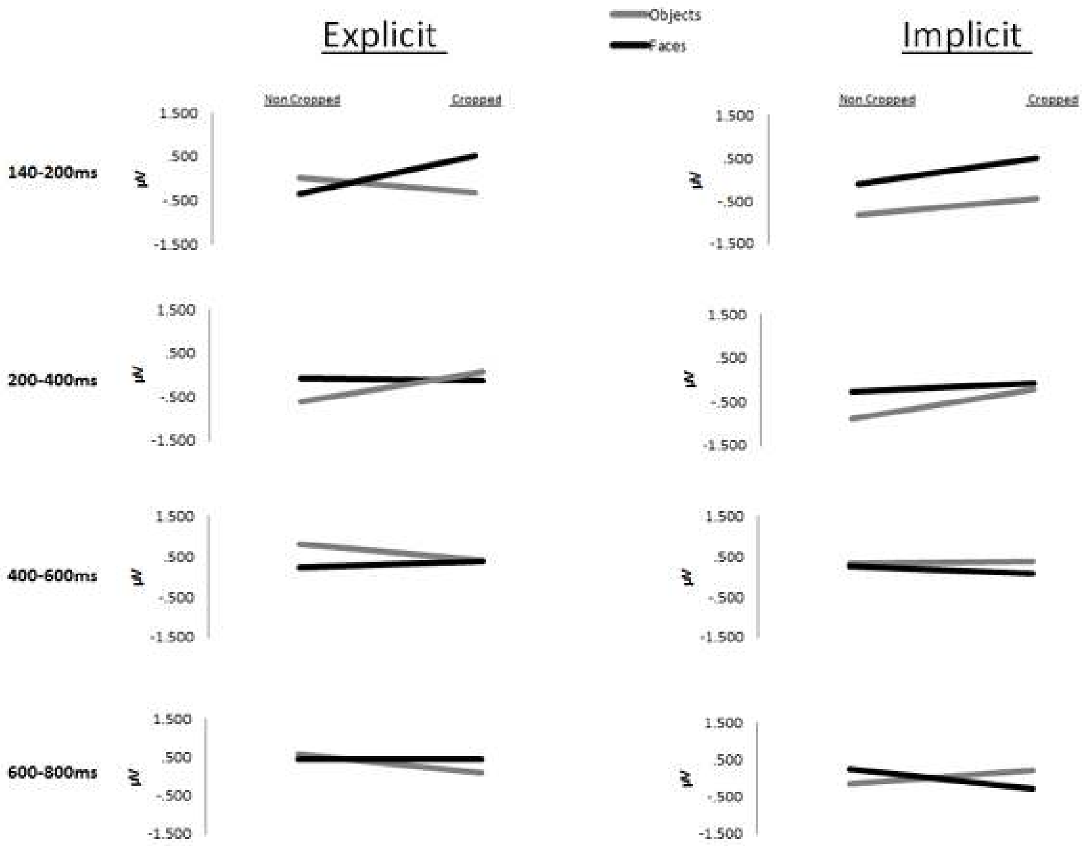


Figure 11: *Condition x Category x Cropping interactions across the 140-800 time windows for the Face vs. Object analysis in Experiment 2. Significant Category x Cropping for Explicit in 140-200 time window. Significant Category x Cropping for Implicit from 200-800 time windows.*

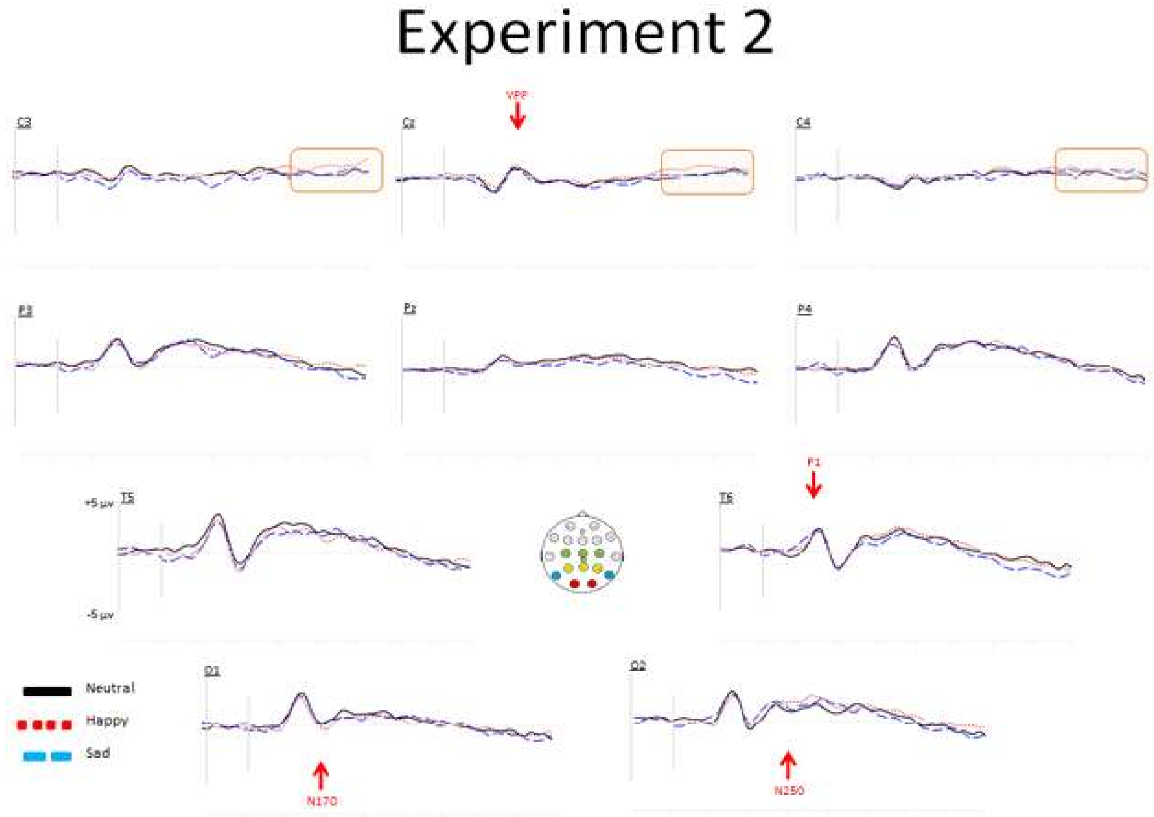


Figure 12: *ERP waveforms for Happy, Neutral and Sad expressions for Experiment 2. Temporal 30-80ms: Sad right > sad left and neutral left > neutral right. No influence of expression on the P1, N170 or VPP. Shadow boxes highlight the late influence of happy expressions in the 600-800 window for central electrodes.*

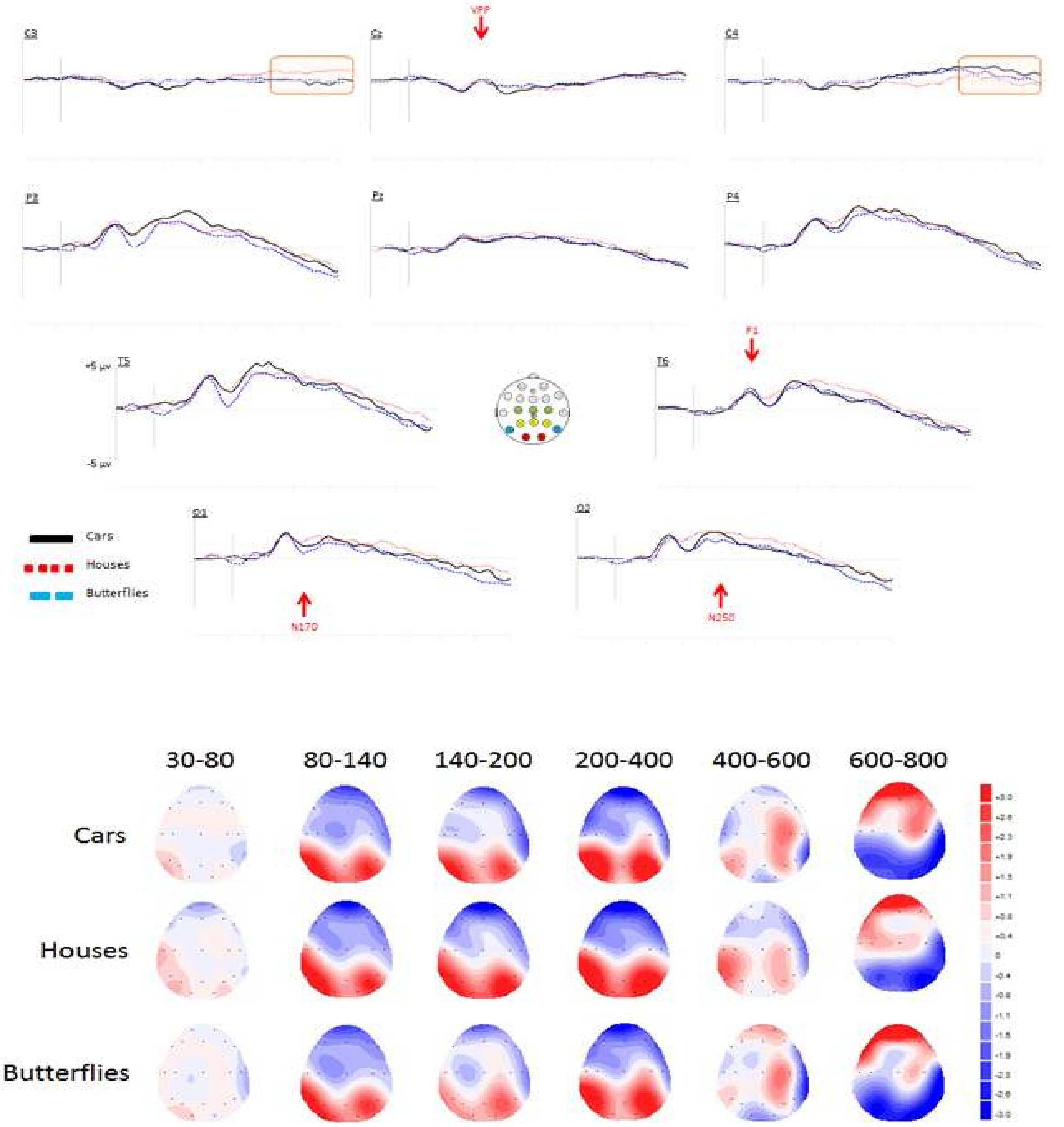


Figure 13: *ERP waveforms and Topographic maps for Cars, Houses and Butterflies in Experiment 2. Occipital, temporal and parietal N170: Butterflies > houses. No influence on VPP. Shadowboxes highlight the late influence of houses and cars across C3 and C4 electrodes.*

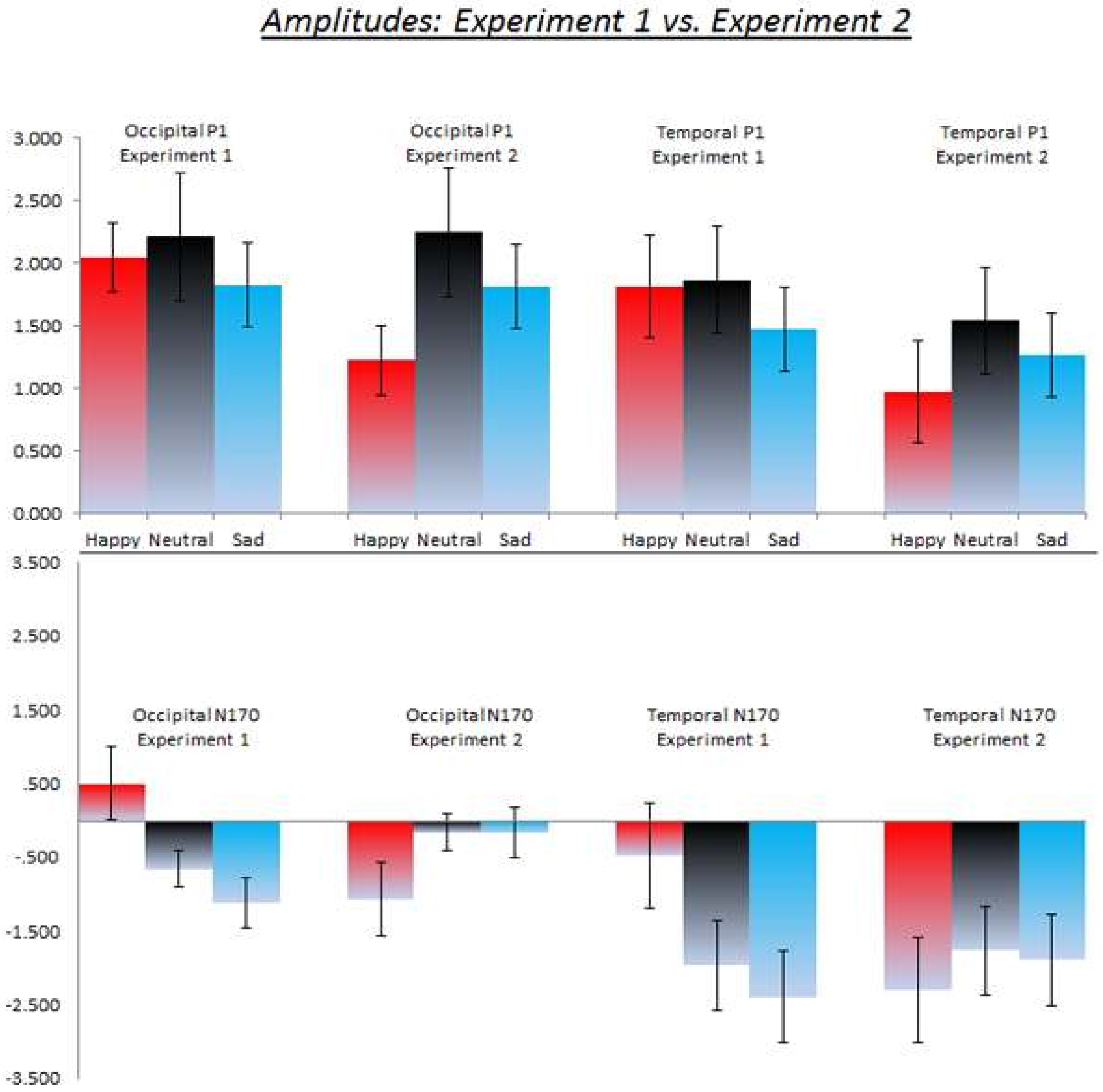


Figure 14: *Experiment Type x Expression interactions for the N170 but not the P1 for both occipital and temporal electrodes. Twelve randomly selected participants from Experiment 1 are represented against all Experiment 2 subjects for cropped images only. There were no differences for P1 amplitudes. Temporal and occipital N170 amplitudes were significantly different for Experiment 1 (sad > neutral > happy) while happy was marginally greater than sad only for occipital amplitudes in Experiment 2. Error bars represent Standard Error of the Mean (SEM).*

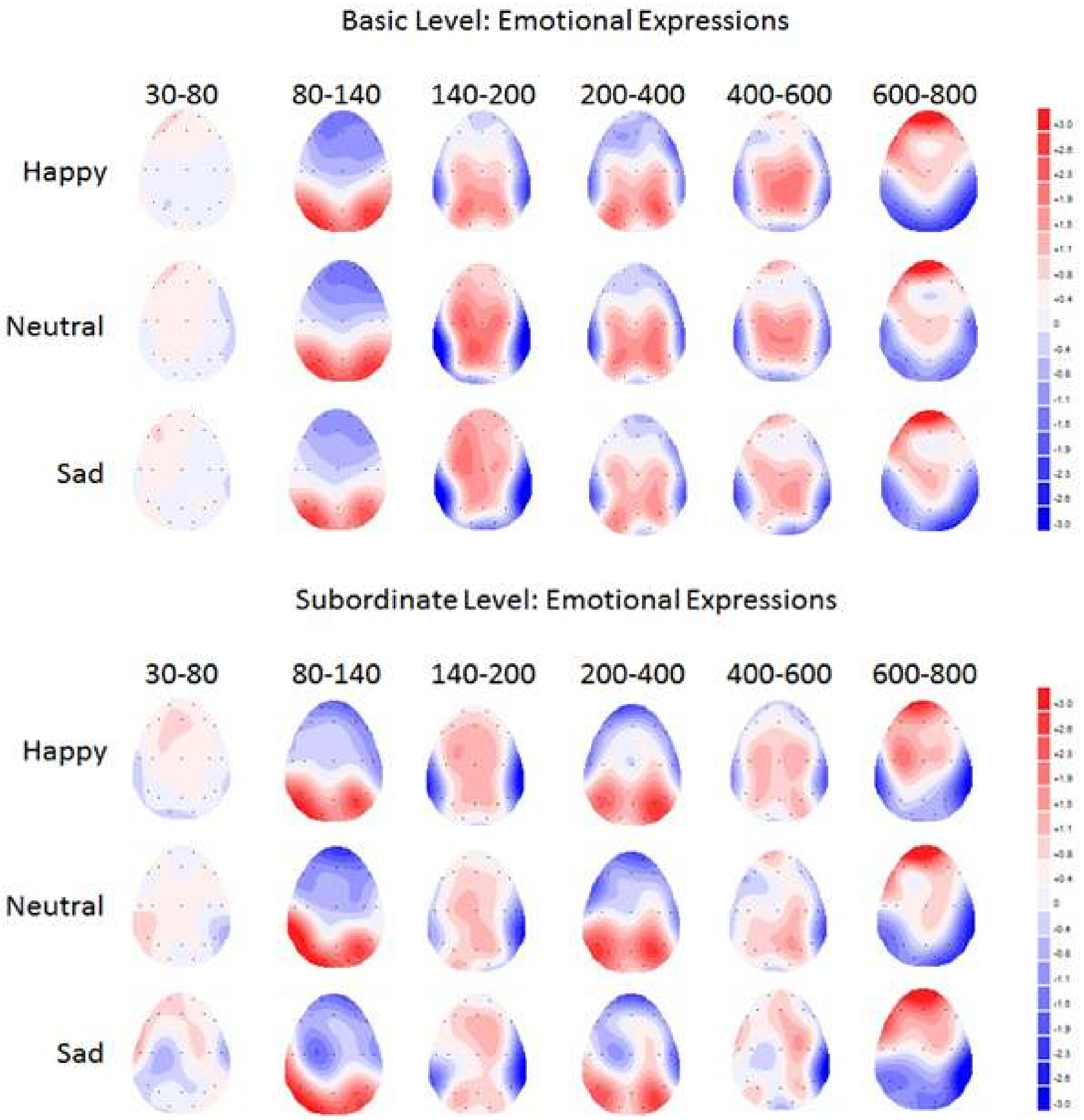


Figure 15: *Topographic maps for Experiment 1 and 2 for Happy, Neutral and Sad expressions. Basic Level topographic maps are from above representing all 24 participants from Experiment 1 for comparison to Experiment 2 topographic maps represented all 12 participants. Notice the differences for the P1 (80-140) and N170 (140-200) for emotional expressions between Experiment 1 and Experiment 2. Also notice the early modulation of sad in the 30-80 time window for Experiment 2.*

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