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# The Good, The Bad, and The Funny: A Neurocognitive Study of Laughter as a Meaningful Socioemotional Cue

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# THE GOOD, THE BAD, AND THE FUNNY:
# A NEUROCOGNITIVE STUDY OF LAUGHTER AS A MEANINGFUL SOCIOEMOTIONAL CUE

by

R. TOBY AMOSS

Under the Direction of Gwen Frishkoff

## ABSTRACT

Laughter is a socioemotional cue that is characteristically positive and historically served to facilitate social bonding. Like other communicative gestures (e.g., facial expressions, groans, sighs), however, the interpretation of laughter is no longer bound to a particular affective state. Thus, an important question is how basic psychological mechanisms, such as early sensory arousal, emotion evaluation, and meaning representation, contribute to the interpretation of laughter in different contexts. A related question is how brain dynamic processes reflect these different aspects of laughter comprehension.

The present study addressed these questions using event-related potentials (ERP) to examine laughter comprehension within a cross-modal priming paradigm. Target stimuli were visually presented words, which were preceded by either laughs or environmental sounds (500 ms versions of the International Affective Digitized Sounds, IADS). The study addressed four questions: (1) Does emotion priming lead to N400 effects? (2) Do positive and negative sounds elicit different neurocognitive responses? (3) Are there laughter-specific ERPs? (4) Can laughter priming of good and bad concepts be reversed under social anxiety? Four experiments were conducted. In all four experiments, participants were asked to make speeded judgments about the valence of the target words. Experiments 1-3 examined behavioral effects of emotion priming using variations on this paradigm. In Experiment 4, participants performed the task while their electroencephalographic (EEG) data were recorded. After six experimental blocks, a mood manipulation was administered to activate negative responses to laughter. The task was then repeated.

Accuracy and reaction time showed a small but significant priming effect across studies. Surprisingly, N400 effects of emotion priming were absent. Instead, there was a later (~400–600 ms) effect over orbitofrontal electrodes (orbitofrontal priming effect, OPE). Valence-specific effects were observed in the early posterior negativity (EPN, ~275 ms) and in the late positive potential (LPP, ~600 ms). Laughter-specific effects were observed over orbitofrontal sites beginning approximately 200 ms after target onset. Finally, the OPE was observed for laughs before and after the mood manipulation. The direction of priming did not reverse, contrary to hypothesis. Interestingly, the OPE was observed for IADS only prior to the mood manipulation, providing some evidence for laughter-specific effects in emotion priming.

These findings question the N400 as a marker of emotion priming and contribute to the understanding of neurocognitive stages of laughter perception. More generally, they add to the growing literature on the neurophysiology of emotion and emotion representation.

INDEX WORDS: Laughter, Emotion, Priming, ERP

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by

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# 1 INTRODUCTION

Laughs are easy to recognize, but the psychological basis for laughter perception is not well understood. For example, laughter is often assumed to signify a positive emotion: e.g., a giggling infant is assumed to be happy. On the other hand, the laughter of a bully is just as likely to signal contempt as to signal pleasure or mirth. This suggests that the interpretation of laughter as a positive or a negative cue may depend on the context in which the laughter is heard. An important question, then, is how basic psychological mechanisms, such as early sensory arousal, emotion evaluation, and meaning comprehension, contribute to the interpretation of laughter in different contexts. Of particular interest in the present investigation is whether laughter functions as an emotional prime to facilitate processing of subsequent stimuli that are emotionally "congruent" (i.e., positive) versus incongruent (i.e., negative). In emotion priming, the interpretation of one stimulus (the prime) as good or bad contributes to the appraisal and understanding of subsequent (target) stimuli. Thus, our first aim was to determine whether laughter would prime words with pleasant, versus unpleasant, connotations.

A related question is whether emotion priming shares the same underlying processes with conceptual, or semantic, priming. In semantic priming, activation of a concept (semantic prime) leads to facilitated processing of related concepts (targets), and unrelated meanings result in absence of priming or interference (Meyer & Schvaneveldt, 1971; Neely, 1991). Thus, the interpretation of a stimulus often includes both emotional and symbolic aspects of meaning. Semantic priming also elicits characteristic effects on brain activity, such as the well-known N400 semantic priming effect (Kutas & Federmeier, 2000; Frishkoff, Tucker, Davey, & Scherg, 2004; Frishkoff, 2007), an increased negative potential over centroparietal electrodes from ~300-500 ms after the appearance of the target.

The relationship between emotional and semantic priming is not well understood. In particular, it is unclear to what degree conceptual–semantic processing and emotion processing make unique contributions to the interpretation of a stimulus. The potential overlap of these two processes complicates the interpretation of brain activity differences found between conditions, and has produced inconsistent evidence with regard effects such as the N400. In a recent event-related potential (ERP) study, Steinbeis and Koelsch (2010) found that consonant (pleasant sounding) musical chords primed representations of "good" or "pleasant" concepts, whereas dissonant (unpleasant sounding) chords appeared to prime "bad" or "unpleasant" concepts. These priming effects emerged after 350 milliseconds (ms) and were similar in timing and topography to the classical N400 semantic effect (Kutas & Federmeier, 2011). These results suggest that emotionally charged stimuli — including nonlinguistic stimuli — can prime emotional representations. Moreover, emotion priming and conceptual–semantic priming appear to share some of the same underlying mechanisms according to this study.

Importantly, however, some ERP studies have failed to observe N400 effects in emotion priming (Herring, Taylor, White, & Crites, 2011; Hinojosa, Carretié, Méndez-Bértolo, Míguez, & Pozo, 2009). Instead, these studies showed that emotionally arousing stimuli led to increased late positivities, which were associated with attention allocation or updating of short-term memory, rather than conceptual processing per sé (Dien, Spencer, & Donchin, 2004). Other studies have reported N400 and LPP effects within the same paradigm (Aguado, Diegues-Risco, Mendez-Bertolo, Pozo, & Hinojosa, 2013; Zhang, Li, Gold, Jiang, 2010). Thus, these studies suggest that emotion priming and semantic priming might engage distinct patterns of brain activity. More generally, the existence of conflicting results suggests a need to better understand the cognitive and neural mechanisms of emotion priming.

A more specific question is how different psychological processes interact in real time to determine how laughter is processed and perceived. Although relatively little is known about the neurophysiology if laughter perception, we can draw some clues from studies of other affectively charged stimuli to make some predictions about the time dynamics. Like other affectively charged sounds (screams, moans, crying, etc.), laughter engages bodily arousal in an automatic, stimulus-driven fashion (Warren, Sauter, Eisner, Wiland, Dresner, et al., 2006). This early modulation may help allocate processing resources toward salient objects and events, enabling the listener to extract key information and to respond to objects that are desirable or threatening (or otherwise significant) quickly and efficiently (Kayser, Petkov, Lippert, & Logothetis, 2005). Less is known about how emotion and cognition interact during later stages of evaluation (i.e., 300 ms and later). In particular, the context in which laughter is experienced may point to engagement of higher cognitive and semantic processes, which support the evaluation or appraisal of the stimulus and are less automatic.

### 1.1 Laughter as a Socioemotional Cue

As suggested above, laughter can convey a range of meanings depending on the context in which it is produced and on the cognitive and emotional state of the listener (Provine, 1992, 1996; Provine & Yong, 1991; Gervais & Wilson, 2005; Meyer, Baumann, Wildgruber, & Alter, 2007). Some researchers have further suggested that the meaning (or message) of a laugh is embedded within the acoustic signal (DePaulo, 1992; Szameitat, Alter, Szameitat, Darwin, Wildgruber, et al., 2009; Szameitat, Alter, Szameitat, Wildgruber, Sterr, & Darwin, 2009). Others, however, have pointed out that the acoustic variability of laughter vocalizations is too great, which argues that an acoustic message could not reside in the signal itself (Owren & Bacharowski, 2003; Bachorowski, Smoski, & Owren, 2001). If the meaning of a laugh is not hardwired to the acoustic signal, then it must be the product of other factors, such as the context in which the laugh is produced or the emotional bias of the listener. If context is the key to laughter appraisal, then the same laugh may serve as a positive affect inducer in one context, and as a negative affect inducer in another context. For example, if laughter functions as an affective cue in a similar manner to musical primes, we might expect it to facilitate processing of pleasant versus unpleasant concepts, i.e., emotion priming. A primary aim of the present investigation is to test this hypothesis by examining the behavioral and neurocognitive effects of laughter as an emotional prime and to compare laughter priming with priming by other pleasant and unpleasant sounds.

### ***1.1.1 Multiple Meanings of Laughter***

A second goal is to determine whether laughter is perceived differently in different socioemotional contexts, and if so, whether these context effects lead to different patterns of priming and to distinct neural responses.

#### *1.1.1.1 Laughter and Social Acceptance*

Like other pre-linguistic vocalizations, such as infant cries, laughter has deep biological roots in mammalian evolution (Provine, 2004; Davila-Ross, Owren, & Zimmerman, 2009, Ruch & Ekman, 2001) and plays an important role in socio-emotional development by stimulating increased positive affect and bonding among caregiver and child (Owren & Bacharowski, 2003; Panksepp & Burgdorf, 2000). However, laughter produced and exchanged among group members served more complex social functions, as well. For example, laughter is an important cue to social status among adults. Generally, lower-status individuals show acquiescence to higher-status individuals by laughing and averting the eyes (Mehu & Dunbar, 2008). Ramachandran (1998) has suggested that laughter evolved precisely to signal that the vocalizer is not a threat, for example, after a physical altercation. Laughter may also signal “tension-release,” “satisfaction,” or “safety” (Rothbart, 1973; Hayworth, 1928), relaxation, or the absence of negative affect. The original function of laughter is thought to have served to establish and strengthen social bonds (Grammer & Eibl-Eibesfeldt, 1990; Mehu & Dunbar, 2008). Cooperating individuals may coordinate their positive mental states through laughter that lead to more cohesive social bonds that increase fitness for both.

Dunbar (1996, 2004) argued that as group sizes increased over the course of human evolutionary history, and social networks grew larger, physical grooming behaviors between individuals that had maintained social bonds were replaced by more efficient ways to create and maintain positive relationships. Since laughter signals positive affect with little effort, it could be the more efficient behavior that replaced grooming. Owren and Bachorowski (2003) suggested that cooperative and predictable behavior amongst related and unrelated group members increased fitness through laughter because it signaled cooperative intent, and facilitated friendly interactions and developing friendships (Smoski & Bachorowski, 2003a, b). If individuals who like each other associate one another’s laugh with their own positive state, the mutually experienced positive feelings reinforce and strengthen cooperation between those individuals.

#### *1.1.1.2 Laughter and Social Anxiety*

It seems apparent that laughter played an important role in the social lives of ancestral humans as it still does for contemporary humans. Its ability to efficiently foster cooperative relationships between group members established it as an important tool for achieving social acceptance. That is, the fit an individual who wishes to be included in a particular group experiences based on how other group members treat him or her. The desire for social acceptance affects how an individual behaves, particularly when amongst other group members.

An individual’s perception of their level of social acceptance in a group is modulated by overt and implied social pressures from group members of different ages, and the individual monitors his or her behavior to maintain a close and amicable relationship with other group members, ideally which is mutually beneficial between all members. Like other communicative gestures (facial expressions, groans, sighs, and other non-linguistic vocalizations) laughter was likely originally bound to a particular affective state (Panksepp, 2005) such as occur during play interactions where it served to strengthen social bonds. However, human laughs have come to be used to express a range of other meanings that bear on inclusion or exclusion from group membership (Szameitat, Alter, Szameitat, Darwin, Wildgruber, et al., 2009). A striking example of this flexibility is the use of laughter to express social judgment, such as the mocking laughs that accompany teasing (Panksepp, 2000). In a derisive or mocking context, the function of laughter is not to promote social bonding, but to achieve social dominance. The person who is laughed at is more likely to feel embarrassment, sadness, and shame than social safety. In short, laughter can be used to communicate social threat, as well as social acceptance.

A natural response to threat is increased anxiety, which involves increased attention to negative stimuli (Fox, Russo, Bowles, & Duncan, 2001). When anxiety is chronic, it can lead either to a diffuse bias towards any kind of negative stimulus, or to an object-centered phobia, such as fear of specific objects (spiders, heights, germs). Fear of social situations, or social phobia, is characterized by feelings of uneasiness or anxiety related to interactions with others. Such feelings are referred to collectively as social anxiety. Socially anxious persons often believe that other people are evaluating them or judging their behaviors in a negative manner. Different types of social anxiety exist and may be specific to an individual. For instance, some individuals may fear negative evaluation when giving speeches or performing in front of an audience, while others may find it difficult to interact with others who are viewed as having a higher social status (Beatty & Friedland, 1990).

As a defense mechanism, social phobics become hypervigilant, and routinely scan their environment for social threats. One variant of this condition that researchers view as a specific disorder is gelotophobia, the fear of being laughed at (Titze, 2009; Ruch, 2009; Platt, 2008; Ruch & Proyer, 2008; Carretero-Dias, Ruch, Agudelo, Platt, & Proyer, 2010). This disorder may be an extreme form of social anxiety that is focused on laughter as a social cue. However, it may prove on further research to be a symptom in common to many subtypes of social anxiety.

### 1.2 Observing the Neurodynamics of Laughter Perception

In order to understand the psychology and neurobiology of laughter perception, it is important to consider it within the context of other emotion processes. The word "emotion" can refer to both physiological and cognitive changes related to a significant event or situation. Emotion as a visceral experience can operate precognitively. Emotion representation that relies on symbolic (perhaps linguistic) features elicits a higher level cognitive representation of *good* versus *bad*. The distinction between more visceral experience and more symbolic cognitive components of emotion may only become apparent when the neurodynamics of processing are examined. The visceral and precognitive processes that take place are fast and automatic, often tied to a particular stimulus, and in some cases genetically coded. These processes can be viewed as emotional arousal and may emerge as early as 70 ms after the stimulus onset as reflected in by startle reflex (Lang, Bradley, & Cuthbert, 1990). By contrast, symbolic representation of a stimulus as good or bad engages later downstream cortical processes. Research suggests that these more symbolic and linguistic processes begin to become apparent at approximately 200 ms and engage polymodal regions of the cortex (Van Petten & Reinfelder, 1995; Kutas & Federmeier, 2000).

Panksepp (2005) describes a model of emotion that separates primary processes such as sensory experiences from secondary processes that involve thoughts about those experiences. For humans, the ability to generate symbolic and linguistic consideration of primary process experiences are a function of the greatly expanded neocortex compared to other animals. These symbolic interpretations of emotional information engage many areas of the brain including both subcortical and cortical regions that interact to bring about the fullness of an emotional feeling. Electroencephalography (EEG) is a neurodynamic research tool that is well suited for investigations of the dividing lines between fast acting processes within brain activity. EEG provides a view into the moment to moment changes in electrical activity ongoing in the brain and how the activity patterns change in relation to stimulation conditions and level of consciousness (Nunez, 2006). A particularly useful method of evaluating EEG signals involves capturing the portions of the signal bound to the occurrences of distinct stimulus event types. This procedure is discussed next.

### *1.2.1 The Event-related Potential Method*

When neuro-electric activity occurs in the brain, the changes in voltage can be detected at the scalp surface using EEG sensors. Typically, multiple sensors are located strategically over the scalp surface and reveal voltage fluctuations of each relative to a reference sensor. The sensors monitor ongoing voltage fluctuations, measured in microvolts (μV), associated with the scalp locations over time. This provides researchers with a window into the brain activity taking place the in brain over time. When stimuli are presented to a perceptual system of someone monitored using EEG, the distribution and magnitude of the EEG signal changes in response to the stimuli. These signal changes contain brain activity patterns that can be compared amongst different stimulus conditions to reveal the patterns unique to each at various scalp locations. The event-related potential (ERP) technique is the analysis procedure that looks at those specific portions of the ongoing EEG signal. Stimulus events evoke activity patterns unique to that particular stimulus, but they also contain patterns that are similar to other events within the same condition. By averaging together the voltage change signatures from many events of the same condition, the underlying pattern in common to those events is revealed as an ERP. In effect, an ERP waveform displays a static sequence of voltage fluctuations, usually over a period of about a second, that are in common to the stimuli of a specific condition. The sequence and magnitude of positive and negative components that constitute an ERP can be compared between different conditions of an experiment. Differences in the shape and timing of these waveform patterns amongst conditions suggest processing differences associated with the stimuli in different conditions which can be quantified in order to make inferences regarding the underlying cognitive mechanisms contributing to the pattern.

Physiological measures such as electrocardiography (ECG) and electrodermal activity (EDA), and brain imaging measures such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), have time-scales that sample physiological and brain activity over a period of seconds to minutes, which is too slow to capture moment-to-moment changes in cognitive processing. In contrast to these methods, EEG is a direct record of brain activity changes. Thus, ERPs computed from EEG recordings can reveal emotion related neural activity with millisecond time resolution. This temporal resolution allows for separation of bottom-up (stimulus-evoked) processes, such as emotional arousal, and processes that are under greater cognitive control, such as emotional appraisal. In addition, spatio-temporal components of the ERP are known to reflect specific neural and psychological stages of processing. Thus, ERPs provide a spatio-temporal profile of cognitive activity necessary to view multiple stages of processing and to reveal how different processes, such as emotional arousal, appraisal, and comprehension interact in real time.

### *1.2.2 The Emotion Priming Paradigm*

The emotion priming paradigm is used to determine how the emotional value, or valence, of a stimulus (the "prime") affects emotional responses to a subsequent stimulus (the "target"). When the emotional qualities of the prime and target are congruent (e.g., both are positively valenced), responses to the target stimulus are faster and more accurate. When the emotional qualities of both the prime and target stimulus are incongruent, target processing is impaired. Thus, the paradigm can be used to examine how context (the prime) modulates emotional responses to the target. Such findings inform theories about the emotion processing and may help identify mechanisms that are associated with emotional processing amongst ongoing mechanisms that are less pertinent to emotion processing.

Affective priming is likely to reflect both bottom-up, automatic spreading activation (Fazio, 2001) and top-down, cognitive appraisal. In addition, affective priming is influenced by a number of other factors. One factor is the task, that is, how participants are instructed to process and respond to the prime or target.  Usually, a simple valence judgment about the target stimulus is used, which allows the prime to exert its effects on the target unencumbered by active prime processing. However, when the prime is actively processed, such as when task instructions are to evaluate the congruence between the prime and target stimuli, the prime and target stimuli may be processed more deeply.  In addition, because emotion evaluation often requires identification of a stimulus, appraisal of a stimulus is likely to be affected by semantic as well as affective features, of a stimulus. When prime and target categories are closely associated in meaning or relationship to one another, accuracy is increased and reaction time reduced compared to prime-target categories that are not closely associated (Zajonc, 1980; Murphey & Zajonc, 1993).

The present investigation uses affective priming to determine if ERP patterns associated with laughter are consistent with patterns associated with other positive affect sounds and different from patterns associated with negative affective sounds. The ERP patterns evoked by the different stimuli provide a set of biomarkers that complement behavioral findings associated with the task. Another goal is to look for even stronger evidence of unique effects of laughter as a flexible cue. To this end, a manipulation of socioemotional context is conducted that brings to mind thoughts about laughter as a negative social signal. If the manipulation succeeds, socially anxious feelings may alter the emotional response to laughter, but not the response to other affective sounds. A final goal is to discern whether laughter affects the ERP patterns that reflect early emotional arousal or later patterns associated with emotion appraisal.

## 1.3 Overview of Thesis

Four research questions were addressed in this investigation. The first question was whether emotion priming would be elicited by a cross-modal priming paradigm that compared laughs to other affective sounds. The second question was whether behavioral and ERP results showed evidence of valence-specific effects evoked by the priming task. The third question was whether laugh primes evoked a distinct ERP pattern from other affective sounds. The fourth question was whether any laugh-specific priming effects in behavioral or ERP results varied depending on the social context (neutral versus socially anxious) in which the laughs were used as primes.

In the sections below, I describe the elements of the present investigation. In section two the background of the emotion model is provided, followed by a review of ERP findings related to emotion processing. In section three, the development of a laughter stimulus corpus is provided along with the subjective and psychophysiological measures used to validate the stimuli. In section four, the cross-modal affective priming task, based on a paradigm developed by Steinbeis and Koelsch (2008, 2010), is described and three behavioral experiments comparing laughter to positive, negative, and neutral IADS primes are presented. These experiments show that the paradigm developed did produce behavioral results that indicated emotion priming was present. In section five, the ERP experiment utilizing the cross-modal affective priming task is described along with the behavioral and neurocognitive effects associated with early and later processing stages. Additionally, the manipulation of socioemotional context is described along with the changes in behavioral and ERP effects related to laughter that resulted. Finally, a summary of results is presented along with discussion of the implications of the results for understanding the psychology and neurobiology of laughter as a meaningful, socioemotional cue. These include discussion of bottom-up and top-down modulation of laughter appraisal and possible implications the results offer toward understanding social anxiety.

# 2 BACKGROUND

## 2.1 Structure of Emotion and Emotion Representation

Charles Darwin (1872) theorized that emotions are biologically determined and are universal to human culture. Since then, many ideas have emerged about the underlying structure of emotions. Perhaps the most basic distinction drawn is between emotion at the visceral level (e.g., changes in heart-rate, body temperature, homeostatic function) and emotion at the cognitive level (e.g., self-concept, emotion appraisal) Panksepp (2003).

### *2.1.1 PA and NA: Affective Dimensions of Arousal*

According to one common view, emotion can be conceptualized in terms of the dimensions arousal and valence. The first dimension, ***arousal***, represents the level of reactivity to a stimulus, which comes into play early and may be sustained throughout the emotional experience. The second dimension, ***valence***, represents the pleasant or unpleasant quality of a stimulus. Emotional appraisal is a process that involves the evaluation of the representation of a stimulus. It is the evaluation of the stimulus that leads to its emotional meaning. One model holds that the base dimensions of emotion are organized according to *positive affect or arousal (PA)* and *negative affect or arousal (NA)* (Watson & Clark, 1994; Watson & Tellegen, 1985). According to this view, the emotional attributes of stimuli tend to cluster into two higher order factors, which reflect the two basic motivational or affective tendencies (PA and NA). Interestingly, PA and NA are the result of rotating the original factors valence and arousal (Watson & Tellegen, 1985).

The Tellegen–Watson model uses PA and NA to characterize emotions on two continua: *elation–depression* (high vs. low PA) and *anxiety–calmness* (high vs. low NA). High PA is characterized by feelings of alertness and vigor, a kind of feed-forward arousal. Psychologically, PA has been linked to enhanced creativity and receptiveness to novel objects and events (extroversion, or in the extreme, impulsivity). At the opposite end is low PA, which is characterized as depression in its purest form (Tucker & Williamson, 1984). Physiologically, positive emotion may relate to increased levels of norepinephrine (NE), which has been implicated in novelty-seeking (Garvey, Noyes, Cook, & Blum, 1996) and approach behavior

(Damasio, 1996). High NA is described as anxiety and vigilance towards perceived threats, and has been linked with dopaminergic (DA) systems (Tucker & Williamson, 1984), although the psychopharmacology is somewhat more complex (Gray, 1982). The opposite end of high NA, or anxiety, is relaxation or the absence of negative affect.

A complementary view of emotion has focused on two motivational biases that link feelings to actions. These biases lead an organism either toward (approach) or away (withdraw) from a stimulus depending on its adaptive significance. Our intrinsic biases are to move toward food and mates (appetitive), and to move away from dangerous environments and threatening pursuers (aversive). Eysenck (1967) posited that these systems may be linked to basic dimensions of personality, such as extraversion and emotionality, which reflect fundamental functions of the nervous system. Similarly, Gray (1990, 1994) has emphasized the neural correlates of impulsivity and anxiety. In this context, Gray proposed two motivational systems: a behavioral activation system (BAS), which leads to active pursuit of positive and negative reinforcement, and a behavioral inhibition system (BIS), which leads to inhibition of action and to narrowing of attention, in order to re-appraise a distant threat (Gray, 1994). The opposing BIS/BAS constructs have been considered to represent neurophysiological patterns of response to environmental cues (Fowles, 1987). The PA/NA and BIS/BAS models can be seen as two sides of one coin. While the PA/NA model focuses on perception of emotion, BIS/BAS focuses on the "motivational base of action" (Tucker, Luu, Desmond, Hartry-Speiser, Davey, & Flaisch, 2003).

### *2.1.2 Emotion and Meaning*

The extraction of meaning — i.e., semantic comprehension — is not a unitary or simplistic event. In fact, the interpretation of the meaning of a single word is influenced not only by linguistic (symbolic) factors — such as word length, frequency, part-of-speech, and phonological structure — but also by so-called extralinguistic factors, including internal (i.e., emotional) states (Fodor, 1981; cited in Shanon, 1988; Frishkoff, 2004, 2007). Thus, while classical theories of semantics have often emphasized meaning comprehension as an abstract, symbolic process, a more physiologically grounded view emphasizes that meaning evaluation is subject to motivational and affective processes, as well as cognitive constraints (Tucker, Frishkoff, & Luu, 2008).

In line with this view, Osgood, Suci, Tennenbaum (1978) found that valence (good versus bad) and arousal (strong versus weak) accounted for more than 60% of the variance in word meaning. They concluded that emotion evaluation or appraisal is in fact a fundamental, and perhaps inseparable, part of meaning (Osgood, 1962; Osgood, Suci, and Tennenbaum, 1978).

Following this logic, Bradley and Lang developed a method, known as the Self Assessment Manikin (SAM; Bradley & Lang, 1994), which is used to characterize stimulus valence (unpleasant to pleasant) and arousal (calm to excited). The SAM tools are sets of cartoon depictions of anthropomorphic figures experiencing graded magnitudes of each dimension, to which raters indicate their perception of individual stimuli. Bradley and Lang have used the SAM method to provide normative ratings of mean valence and arousal values associated with pictures (International Affective Picture System, IAPS), words (Affective Norms for English Words, ANEW), and sounds (International Affective Digitized Sounds, IADS). Over the past two decades, researchers have used these normative scores extensively to manipulate and control valence and arousal of experimental stimuli.

## 2.2 Dynamics of Emotion and Emotion Representation

### *2.2.1 Stages of Emotion Processing*

Emotion processing unfolds rapidly and engages distinct neuropsychological mechanisms (or brain “microstates”) every 10-100 ms. Thus, in order to understand the core structure of emotion, and the mechanisms that contribute to flexibility in emotion perception, it is necessary to consider how they unfold over time.

There are at least two phases of emotion processing (Vuillemier, 2005; Damasio, 2000; Clore & Ortony, 2000; LeDoux, 1995, 2000, Schupp, Flaisch, Stockburger, & Junghöfer, 2006), and it is important to consider how these two phases unfold psychologically and physiologically.

#### *2.2.1.1 Emotional Arousal*

In stage one, emotional arousal, stimuli evoke feelings that are not directed toward any particular object or event (Clore & Ortony, 2000). At this stage, the emotional response is relatively isolated from higher cognitive processes (i.e., semantic processing, context-specific evaluation). At the neural level, stage one is linked to brainstem (reticular formation), thalamic, and amygdalar activation (LeDoux, 1995) that directs allocation of processing resources (Adolphs, 1999), as well as modulation of early sensory processes in the thalamus and cortex (Sass, Heller, Stewart, Silton, Edgar, et al., 2010). LeDoux (1995, 2000) suggests that this early stage involves a rough and rapid estimate of the valence and intensity of a stimulus. This response engages what is sometimes called the “low road” to emotion evaluation (LeDoux & Phelps, 1993), because it does not involve the corticothalamic loops that are engaged during later, more “cognitive” stages of processing.

#### *2.2.1.2 Emotion Appraisal*

In stage two, emotion appraisal, feelings are directed towards a specific object, resulting in appraisal of the object as good or bad for the observer. Importantly, this appraisal is context-dependent. The affective meaning, or valence, of a stimulus can vary depending on the context in which it is experienced. For instance, the same person may interpret a laugh as positive when she is relaxed and happy, and as negative when the context triggers past associations of laughter with social ostracization. Stage two is supported by paralimbic regions, particularly orbito-frontal and medial frontal cortex (LeDoux, 1995; Clore & Ontony, 2000; Osgood, 1978; Adolphs, 1999). According to LeDoux (1995, 2000), it is during this later stage of stimulus evaluation that existing knowledge, dispositions, and associations develop a more refined (though not necessarily more accurate) appraisal of the stimulus. Because the cortical-subcortical pathways that are engaged during this stage involve top-down influences of memory and appraisal, it is sometimes referred to as the “high road” (LeDoux & Phelps, 1993).

### ***2.2.2 Proposed Model of ERPs in Emotion Processing***

Based on prior ERP studies of emotion, a model of the emotion processing time-course includes three stages: early sensory arousal (0-200 ms), early valence-specific processing (200-400 ms), and mid-latency to late processing (400-1000 ms) that involve interactions of motivational bias (e.g., high vs. low PA/NA), current context (e.g., positive or negative primes), and appraisals based on the comparison of past and present experience. This model is summarized in Figure 1.

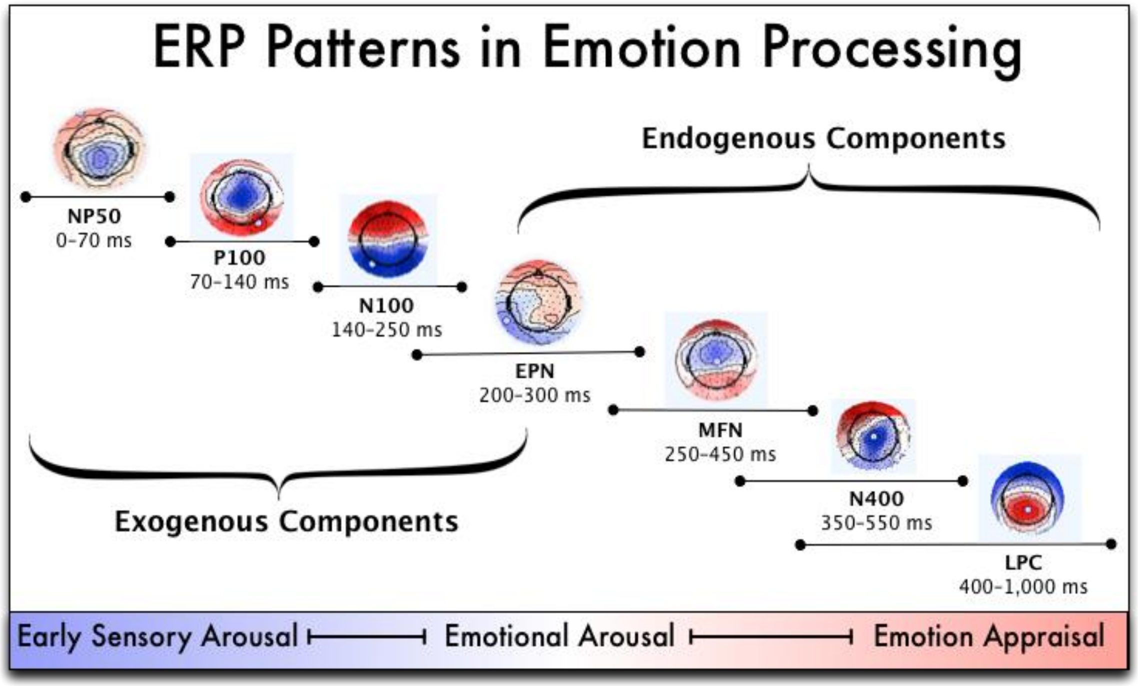

Figure 1. ERP patterns that reflect stages of emotion processing

### *2.2.3 ERPs and Emotion Processing*

Each of the three phases described above is associated with specific neurocognitive processes, which elicit characteristic patterns of neural activity. These patterns can be detected using ERP methods. ERP patterns are characterized by three criteria. These include a temporal criterion, a spatial criterion, and a functional criterion. The temporal criterion refers to when during the ERP time-course the pattern occurs (e.g., early, middle, or late). The spatial criterion refers to how the pattern is distributed on the scalp of the head, which is also referred to as its topography. The functional criterion refers to what underlying processes are occurring when the pattern is found. The nomenclature used to specify a pattern often uses polarity of the waveform (positive or negative) and its time-course as distinguishing features, which are tied to the event that evoke them. For example, the visual-evoked P100 pattern has a peak latency of approximately 100 ms and is positive over occipital areas of the scalp, that reflect generators in visual regions of the cerebral cortex. To simplify discussion of ERP pattern effects in this investigation they are classified below on the basis of the time period in which they are found and what processes have been found to be associated with them.

#### *2.2.3.1 Outline of Relevant ERP Patterns*

##### 2.2.3.1.1 Visual Evoked Potentials (VEP, 50-200 ms)

The earliest components of the ERP reflect very early sensory processing. They include "brainstem bumps" (0-20 ms), early corticothalamic responses (NP50: 50-150 ms), and early sensory-evoked potentials, such as the occipital P100 (70-140 ms) and N100 (140-200 ms) responses to visual stimuli. These so-called exogenous ERPs, evoked primarily by stimulus features, occur very early in the processing stream and can be modulated by positive or negative arousal, although they typically do not show valence-specific effects. The NP50 (also referred to as C1) reflects responses to visual stimulation, including contrast and spatial frequency, and is evident along the posterior midline. Its polarity may differ depending on the regions of stimulation in the visual field (Luck, 2005). It may merge with a larger wave around 100ms that occurs to visual stimulation.

The P100, which typically occurs between 70 and 140 ms is maximal over the occipital cortex. It is believed that the early portion of the waveforms is generated by dorsal extrastriate regions, whereas the later portion is generated by the more ventral fusiform gyrus. Features of the pattern vary with stimulus contrast and respond to the direction of spatial attention.

The N100, which appears between 140 and 200 ms is a negativity over occipito-temporal regions believed to be generated during visual stimulation by the parietal and lateral occipital cortices and is modulated of visuospatial attention. When evoked by auditory stimulation, the waveform has a fronto-central distribution and is thought to originate from auditory cortex located in the superior temporal gyrus of the temporal lobe. Like the P100, it too is sensitive to attention.

#### 2.2.3.1.2 Early Posterior Negativity (EPN, 200-300 ms)

The early posterior negativity (EPN) is a negative-going pattern that is maximal over temporo-occipital regions between 200 and 300 ms following stimulus presentation. Studies have localized the EPN to visual association areas, as well as to inferior parietal and posterior limbic cortex (Keuper, Zwanzger, Nordt, Eden, Laeger, et al., 2012). Schupp, Junghöfer, Weike, & Hamm (2003) have suggested that it is the result of amygdalar inputs to visual cortex. They speculate that the EPN reflects allocation of attention to stimuli that have immediate significance, i.e., coarse emotion detection as described by LeDoux (1995, 2000).

#### 2.2.3.1.3 Medial Frontal Negativity (MFN, 300-450 ms)

The medial frontal negativity (MFN) is defined as a relative increase in negativity between 300 and 450 ms over the frontocentral part of the head surface. The MFN has been localized to the anterior cingulate cortex and insula, regions that are commonly engaged in processing of novelty and pain (both physical pain and psychological distress). It is also known as a frontal N400 (fN4) in studies of episodic memory (Curran, 1999; Strekalova, 2006) In this context, the MFN is less negative in response to studied ("old") versus unstudied ("new") stimuli. It is unclear how the MFN, fN4, and N400 are related, and they are often confused with one another.

#### 2.2.3.1.4 N400 Effect (N400, 350-550 ms)

The N400 effect is defined as an increase in negativity between 300 and 500 ms over posterior regions of the scalp in response to meaningful stimuli that are semantically unexpected.

This effect is classically seen in semantic priming paradigms, where stimuli that have the same or similar meanings (related or congruent condition) are contrasted with unrelated stimuli (unrelated or incongruent condition). In this paradigm, the first stimulus (the prime) activates a set of meaning representations in memory, leading to expectancy of particular meanings or categories. When this expectancy is violated, there is a robust N400 effect, as described in hundreds of papers over the last several decades (Kutas & Federmeier, 2000, 2011; Lau, Phillips, Poeppel, 2008).

N400 priming effects have been found using different types of stimuli, such as words, pictures, movies, and facial expressions (Sitnikova, Holcomb, Kiyonaga, & Kuperberg, 2008; Aguado, Dieguez-Risco, Méndez-Bértolo, Pozo, & Hinojosa, 2013). In addition, prior work suggests that the N400 effect is not modality-specific. Similar effects were found for auditory and visual stimuli (Holcomb & Neville, 1990; Bentin, Kutas, & Hillyard, 1993; Van Petten & Rheinfelder, 1995). Importantly, environmental sounds have been shown to elicit N400 semantic effects, as well (Plante, Van Petten, & Senkfor, 2000; Orgs et al., 2006, 2007, 2008). This finding, among others, suggests that any meaningful stimulus, including nonlinguistic stimuli, can elicit an N400 semantic effect.

A more controversial question is whether affective priming is associated with the N400 effect. As described below, some studies have reported N400 effects of emotion priming (Zhang, Lawsom, Guo, & Jiang, 2006**;** Steinbeis & Koelsch, 2008, 2010**;** Goerlich, Witteman, Schiller, Van Heuven, Aleman, & Martens, 2012; Wu, Athanassiou, Dorjee, Roberts, & Thierry, 2011), and others have reported no differences within the N400 window (Herring, Taylor, White, & Crites, 2011). This suggests that emotion priming may be associated with a different ERP component. One such component is the late positive potential (LPP).

##### 2.2.3.1.5 Late Positive Potential (LPP, 400-1000 ms).

The LPP effect is defined as a positive-going waveform that is maximal at approximately 500 to 700 ms over posterior regions of the scalp. It may be related to other late positivities, such as the P3b or P300 (Polich, 2007), the P600 (Kaan, Harris, Gibson, & Holcomb, 2000), and the late positive complex (LPC; Dien, Spencer, & Donchin, 2004). The acronym "LPP" is especially common within the emotion ERP literature. As described below, it is typically larger, or more positive, for more intense or arousing stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000); Schupp et al., 2003).

#### *2.2.3.2 Prior Work on ERPs in Emotion Processing*

In the next four sections below, studies of ERP responses to emotional stimuli are reviewed, with focus where possible on positive and negative words and sounds. The sections provide an overview and summary of four kinds of contrasts between stimulus features that are relevant to this ERP investigation. The contrasts in these sections are: *Arousing vs. Less Arousing Stimuli* (summarized in Table 1); *Positively vs. Negatively Valenced Stimuli* (summarized in Table 2); *Emotionally Congruent vs. Emotionally Incongruent Stimuli* (summarized in Table 3); and *High vs. Low NA (i.e., Anxious vs. Non-Anxious) Participants* (summarized in Table 4). The contrasts between Tables 1 and 2 illustrate the sensitivity of ERP patterns to valence and arousal characteristics of the stimuli utilized. Contrasts within Table 3 focus on affective priming of emotional words, which informs expectations related to the paradigm employed in this investigation. Contrasts within Table 4 relate to studies that examined anxiety as a factor affecting ERPs.

#### 2.2.3.2.1 ERPs to Arousing vs. Less Arousing Stimuli

As discussed earlier, valence and arousal are often correlated. For this reason, it is important to consider whether ERPs that are putative markers of emotion — especially, valence-specific effects — are also influenced by arousal, regardless of valence.

Junghöfer, Bradley, Elbert, and Lang (2001) focused on differences in early ERP patterns evoked by stimulus arousal differences. The investigators presented high and low arousal IAPS in rapid succession alternating between arousal levels on trials. Valence differences between the stimuli were not a factor in the investigation and ERP patterns were reported for the posterior region of the scalp. No differences between arousal levels were found during the P100 (96-160 ms) time period. Differences emerged within the P200 (168-232 ms) period and demonstrated low arousal images evoked a more positive component pattern than high arousal images. During the N260 (232-296 ms) period, high arousal images evoked a more negative component than low arousal images. These time periods overlap with the EPN period and possibly represent activation differences of the same processing system. These results suggest the EPN modulation found in ERP patterns is possibly a marker of arousal differences and not valence differences.

Rozenkrantz and Polich (2008) used high and low arousal positive and negative IAPS presented in an oddball detection paradigm. High arousal positive and negative images were matched in arousal level, as were low arousal positive and negative images. They found that the patterns in the EPN window (220-300 ms) evoked by high arousal images were more positive than low arousing images. They also found that the LPP (which encompassed the LPP window: 300-450 ms, the early slow wave: 550-700 ms, and the late slow wave: 700-850 ms) was more positive to high arousing images than low arousing images. Both positive and negative images held this pattern related to arousal at frontal, central, and posterior sites. these results support a role of arousal in the EPN and LPP.

Hinojosa, Carretié, Valcárcel, Méndez-Bértolo, and Pozo (2009) conducted two experiments. One utilized words, and the other IAPS, in the same methodology. Positive and negative stimuli were matched on arousal (relaxing and neutral were not). For the word experiment, the EPN window (225-275 ms) showed no effects, however for the LPP window (350-425 ms) neutral words evoked more positive patterns than positive and negative words in occipital region and more negativity in frontal region. For the image experiment, the EPN window (175-275 ms) showed that positive images had greater negativity than negative in occipital region, supporting valence specificity in the EPN. The LPP window showed more negative patterns for positive and negative images compared to neutral images in the frontopolar region, and more positive patterns for positive and negative images compared to neutral images in mid-central and mid-parietal regions.

Leite, Carvalho, Galdo-Alvarez, Alves, Sampaio, and Conçalves (2012) used affective pictures that were high and low in arousal during passive viewing and a startle eye-blink task. Compared to neutral, the EPN was sensitive to early attentional allocation directed toward affective stimuli compared to neutral. They also reported an LPP that was larger to high arousing pleasant and unpleasant images compared to low arousal pleasant, unpleasant, and neutral images. The startle probe LPP amplitude was smallest to high arousing pleasant images compared to all other conditions.

Briggs and Martin (2009) selected high and low arousal IAPS that corresponded to positive, negative, neutral, and sexual categories to create eight comparison conditions. The LPP pattern 300-500 ms was evaluated between conditions. High and low neutral images, and high and low positive images did not differ in LPP amplitude. The LPPs for high arousal sexual and unpleasant images were significantly more positive than low arousal versions. The LPP for high arousal sexual images was significantly more positive than all other conditions. The LPP for high arousal unpleasant images was significantly more positive than for high arousing positive and neutral conditions. Low arousing sexual images evoked more positive patterns than low arousal neutral images. Despite a few exceptions between conditions high arousing stimuli yield larger amplitude patterns. Inferring that sexual and unpleasant stimuli motivate the greatest amount of cognitive resources, followed then by pleasant images, these results are consistent with the LPP indexing the amount of resources garnered for processing effort.

Lithari, Frantzidis, Papadelis, Vivas, Klados, et al. (2010) found the P100 less positive to high arousing images than low arousing images. The N100 showed greater negativity was evoked by high arousing images than low arousing images. The N200 had a shorter latency for high than low arousing images. Furthermore, the LPP evoked by high arousing images was more positive than when evoked by low arousing images.

In general, high arousal stimuli appear to evoke more positive ERP component patterns than lower arousal stimuli. This would be expected as more processing resources should be mobilized and allocated to processing highly arousing stimuli, which are more likely to signal significant events than low arousing stimuli in the environment. The EPN, thought to be an early marker of emotion, is less consistent than the LPP with regard to arousal. The LPP is larger to emotional than neutral stimuli in each of the studies reported, whereas the EPN varied between emotionally arousing and low arousing or neutral categories. These studies indicate that differences found in late ERP patterns attributed to valence differences between positive and negative stimuli must be considered along in light of their arousal differences. Therefore, these studies underscore the necessity to carefully control affective stimuli on the arousal dimension, or manipulate arousal in conjunction with valence systematically, when investigating affective influences on brain activity to ensure that valid inferences can be drawn about ERP effects. If valence differences are revealed after arousal variation was controlled, the role of emotion in modulating the waveform patterns is more reliably inferred. This methodological imperative applies equally to inferences about behavioral result differences.

Table 1. ERP Effects of Arousal

| **Paper** | **Stimulus Type** | **Modality** | **Task** | **P1** | **N1** | **EPN** | **MFN/N400** | **LPP** |
|---|---|---|---|---|---|---|---|---|
| Briggs (2009) | pictures | visual | distractor (oddball) | n.a. | n.a | n.a. | n.a. | High A > Low A |
| Hinojosa (2009) | words | visual | judge arousal | n.a. | n.a. | n.s. | n.a. | E > NEUT |
| Junghöfer (2001) | pictures | visual | passive | NS | n.a. | High A < Med A <Low A | n.a. | n.a. |
| Leite (2012) | pictures | visual | passive | n.a. | n.a. | High A/Low A < NEU | n.a. | High A > Low A |
| Lithari (2010) | pictures | visual | passive | High A > Low A | High A > Low A | n.a.[3] | n.a. | High A > Low A |
| Rozenkrantz (2008) | pictures | visual | distractor (oddball) | n.a. | NS | High A > Low A | n.a. | High A > Low A |
| Gianotti (2008) | words (Exp.1) | visual | passive | NS | NS | NS | NS | High A > Low A |
|  | pictures (Exp.2) | visual | passive | NS | NS | Low A > High A | NS | High A > Low A |

[1] POS > NEG/NEUT (not a pure effect of arousal)

[2] Note. "High A" and "Low A" denote high and low arousal, respectively. In these experiments, arousal was explicitly varied and orthogonal to valence. "E" and "N" denote emotional and neutral. In these experiments, positive and negative stimuli were contrasted with neutral stimuli.

[3] Note. Figure 2 shows an arousal effect within the EPN window: the ERP difference topography shows a stronger negativity over parietal region, and a greater positivity over inferior sites. Unfortunately, the direction of the contrast (high A - low A, or low A- high A) is not specified. Therefore, it is not possible to determine whether this effect corresponds with a typical EPN effect.

#### 2.2.3.2.2 Valence-Specific ERP Effects

The primary question of interest in this section concerns whether stimuli of different valence evoke distinct ERP patterns from one another. The secondary question addressed is whether differences found between valences in ERP patterns remain after stimulus arousal level is matched. Two sets of studies in this group are evaluated separately based on their level of control over arousal level in their stimuli. The first set of studies used stimuli that differed in arousal level between valence conditions. Typically, negative stimuli were the highest in arousal, positive stimuli were the next highest in arousal, and neutral stimuli were the lowest in arousal. The second set of studies used stimuli that were at least partially matched on arousal level. The majority of these matched arousal between positive and negative conditions, but not for neutral conditions. However, a few matched arousal across all conditions. Discussion of findings for each set of studies is also separated into sections that address effects in early emotional arousal period versus effects present in the later emotional appraisal period.

Many studies that used picture stimuli and reported differences in early ERP patterns amongst valence categories did not control for arousal level. Cuthbert, Schupp, Bradley, Birbaumer, and Lang (2000) presented IAPS images to participants for six seconds and found that during the 200-300 ms period, the EPN window, positive images evoked less negativity than neutral images, but there was no difference between negative and neutral images. Schupp, Junghöfer, Weike, & Hamm (2003) also used positive, negative, and neutral IAPS images, but presented them in continuous streams. The N1 period (160-224 ms) showed that positive and negative images evoked greater negativity in the temporo-occipital region than neutral images. Additionally, they found larger EPN (232-296 ms) amplitudes for positive and negative images compared to neutral images. Foti, Hajcak, and Dien (2009) used positive, negative, and neutral

IAPS images and found that the N1 (103 ms) was more negative for negative images than for both positive and neutral images at central sites. They also found an EPN (230 ms) that appeared to differentiate between valence categories. Positive images evoked a more negative pattern than negative images, and negative images a more negative pattern than neutral images at parietal sites. The researchers then employed a principal components analysis (PCA) to quantify ERP patterns without interference from adjacent wave components. Results of the PCA showed that the N1 (136 ms) and the EPN (241 ms) evoked by positive and negative images displayed negative amplitudes compared to neutral images at parietal midline.

ERPs obtained during a passive viewing experiment by Keil, Bradley, Hauk, Rockstroh, Elbert, and Lang (2002) showed differences between patterns evoked by positive and negative IAPS compared to neutral images. The N1 (120-150 ms) amplitude was more positive for positive images than either neutral or unpleasant images. Pastor, Bradley, Löw, Versace, Moltó, and Lang (2008) found that during the early time window (150-300 ms), which encompassed the EPN window, positive images were more positive than neutral and negative images over frontal and central regions. Positive images showed a less positive pattern than neutral and negative images over the occipital region. Carretié, Hinojosa, Martín-Loeches, Mercado, & Tapia (2004) used temporal principal components analysis (tPCA) to unveil ERP “component” patterns to positive, negative, and neutral images that deviated from a standard image. They focused on frontal sites and found that the P1 (105 ms and negative at frontal sites) was largest to negative stimuli. The P2 (180 ms) was larger for negative and positive images compared to neutral images. And, the subsequent N2 component (240 ms) amplitude was more negative for positive and neutral stimuli than negative. The N2 reported is within the EPN window and provides further support for its early sensitivity to emotional arousal. Without considering arousal, early components evoked by pictures appear to be valence specific.

Early emotion effects were found for other types of stimuli as well. A recent study by Rellecke, Palavoza, Sommer, and Schacht (2011) used positive, negative, and neutral facial expressions, as well as words of the same categories. They found that emotion effects appeared between 50 and 100 ms for faces. Happy expressions evoked a more positive pattern than neutral expressions in parietal regions, and both positive and negative words evoked more positive patterns compared to neutral words in posterior regions. Between 150 and 200 ms (the N1 period) angry expressions evoked greater negativity in temporo-occipital region than happy or neutral expressions. The authors did not examine the EPN window for faces or words. However, Scott, O'Donnell, Leuthold, and Sereno (2009) and Kissler, Herbert, Winkler, and Junghöfer (2009) found EPN was larger for emotionally arousing words compared to neutral words, particularly for negative words.

It is difficult to compare these early valence ERP pattern effects because different stimulus valence conditions were unmatched on arousal level. However, they do show evidence that valence-specific processing could emerge in the early emotional arousal stage of the proposed time-course of emotion processing. In general, as the stimulus processing time-course proceeds from the earliest components (N1 and P1) to the EPN period, valence-specific waveforms become more differentiated. However, none of these studies seemed to show definitively that the magnitude of the waveform in early patterns tracked the level of arousal or valence category. If neutral stimuli are conceptualized as intermediate in valence between negative and positive valences, the waveform pattern should reflect its position between positive and negative. Positive and negative valence stimuli may sit at opposite poles and neutral stimuli represent the absence of both arousal and valence.

Covariation of arousal and valence in these unmatched studies makes it difficult to attribute the differences in early pattern solely to valence differences. However, if arousal alone was the driving the effect and the EPN was a marker of arousal, it would be expected that the waveform pattern evoked by negative images, which are typically higher in arousal, would consistently evoke a pattern with the greatest disparity from the pattern evoked by neutral and positive images. Because this was not always the case, the EPN remains a potential valence marker.

In late ERP patterns evoked by picture stimuli that were not matched on arousal level, there is greater differentiation amongst valence conditions than in early patterns. Cuthbert et al. (2000) found that positive images evoked more positive patterns than negative and neutral images during the LPP window (300-400 ms). During the early LPP window (400-700 ms) positive images evoked a more positive pattern than negative images, and negative images evoked a more positive pattern than neutral images at posterior midline. The late LPP (700-1000 ms) showed that the patterns evoked by positive and negative images possessed similar amplitudes, and were lower in amplitude than neutral images. In a passive viewing paradigm used by Foti et al. (2009), the LPP of positive images was more positive than neutral images. However, the greatest positivity was to negative images, which was also distinct from positive images. A PCA showed that the LPP for positive and negative images was larger than for neutral images in the centro-parieto-occipital region. The LPP in the parieto-occipital region was more positive for negative images than for positive images, and neutral images evoked the least positive pattern. Keil et al. (2002) found that the LPP (300-440 ms) during passive viewing of images was greater for both positive and negative images than neutral. In the early LPP window (300-400 ms), positive images evoked greater positivity than both negative and neutral images. Pastor et al. (2008) found that the LPP pattern 400-700 ms showed that positive and negative images evoked a more positive LPP than neutral images in the fronto-central and centro-parietal regions. Briggs and Martin (2009), who used high and low arousal IAPS stimuli positive, negative, neutral, and sexual categories to create eight comparison conditions, collapsed over high and low arousal conditions. After which, they found that positive and negative images, which did not differ from each other, evoked larger LPP patterns 300-500 ms than the neutral condition. Although these studies did not control for arousal, in general they suggest emotional stimuli were more positive than neutral.

Other studies using picture stimuli that were not matched on arousal level show that the LPP has a relationship with metabolic signal change and is also modulated by effort. In Sabatinelli, Lang, Keil, and Bradley (2007), the LPP (400-900 ms) differed between pleasant and unpleasant IAPS images compared to neutral. They further assessed each stimulus category using fMRI. The magnitude of BOLD signal change followed a similar pattern as the LPP. The pattern evoked by positive images was slightly more positive than for negative images, and the BOLD change tracked this difference. Positive images had greater BOLD change than negative images, and changes for both positive and negative images were greater than for neutral images. Moser, Hajcak, Bukay, & Simons (2006) used negative and neutral IAPS images to see if the LPP was modulated by effort. Instructions in separate blocks of trials were, to simply view the images, to suppress their emotional response, or to enhance their emotional response. During the viewing block the LPP was larger for negative images than neutral images at parietal, central and frontal midline electrode sites. The LPP was significantly reduced in amplitude during the suppress condition (appeared closer to the neutral amplitude), whereas in the enhance emotion the pattern was not different from the view condition. These findings suggest effort to inhibit a reaction affects the LPP. Increased effort to inhibit a response reduces amplitude, whereas increased attention and difficulty may increase LPP amplitude.

In addition to early effects reported, Rellecke et al. (2011) found late emotion effects for facial expressions and words. Between 350 and 400 ms, neutral faces evoked more positivity than happy or angry faces in posterior parieto-occipital regions. These results are intriguing because they suggest that while facial expressions are obvious visual cues to positive, negative, and neutral affect, they are not be processed in a comparable way as other valenced images in which the emotional expression evoke greater positivity. Words showed early pattern effects, but did not show late pattern effects, and suggested that late patterns are less sensitive to valence differences amongst words.

Except for Rellecke et al. (2011), neutral stimuli evoked late ERP patterns that were always lowest in amplitude. However, positive and negative patterns could be higher or lower than each other in positivity. Therefore, conclusions drawn about consistent differences in LPP effects for positive and negative stimuli in studies that are unmatched on arousal are as unreliable as in early components. If high arousal stimuli evoke larger ERP patterns than lower arousal stimuli, negative stimuli should always show greatest positivity. Because this was not the case for the LPP, it is likely that several different processing mechanisms overlap during the emotional appraisal period and contribute to complex unpredictable patterns between emotion conditions. LPP patterns to neutral conditions usually differ from emotion conditions and likely reflect lower arousal activation of appraisal mechanisms.

In contrast to the studies discussed above, differences in early ERP patterns amongst valence categories were found in studies that did control the arousal level of stimuli. The majority of these matched arousal level between positive and negative stimuli, while neutral stimuli retained their inherent low-arousal characteristic. Studies that used images found valence effects in the early ERP patterns. Olofsson and Polich (2007) used negative, neutral, and positive IAPS in an oddball task. No effects were found for the P1 (80-120 ms), or for the N1 (120-160 ms). However, negative images evoked a larger pattern than neutral or positive in the P2 window (160-220 ms) in the parietal region. The EPN window (220-300 ms) showed greater negativity for neutral than negative or positive images in the parietal region. Flaisch, Junghöfer, Bradley, and Schupp (2008) used positive and negative IAPS images matched on the arousal level and found that positive and negative stimuli were significantly different from each other during the EPN window (248-288 ms) at both frontal and posterior regions. Leite et al. (2012) found the EPN was more negative to high and low arousal positive and negative IAPS images compared to neutral images.

Studies that used sounds also found valence effects in the early ERP patterns. Thierry and Roberts (2007) used environmental sounds that were negative, neutral (the standard), and loud neutral sounds to investigate ERP patterns. They discovered that the N1 between 70-130 ms (peak: 105 ms) was larger for loud neutral sounds than for both negative and neutral sounds of the same volume in fronto-central regions. This effect illustrated the sensitivity of this very early component to the intensity of the stimulus. The N2 between 260 and 310 ms (peak: 292 ms), showed that unpleasant sounds evoked a less negative pattern than both the neutral and louder neutral sound at frontal sites. Based on these findings, it appears that emotion effects for sounds begin to emerge in the 200-300 ms window consistent with the EPN period.

Effects in the early ERP patterns were found for word stimuli. Scott et al. (2009) used positive and negative words of high and low arousal compared to low arousal neutral words. Effects for the P1 (80-120 ms) were found only for high frequency occurring words. Negative words evoked a smaller P1 than both positive and neutral words. The EPN (200-300 ms) period showed that positive and negative words evoked larger EPN than neutral words, and negative words evoked a larger EPN than positive words. Kissler, Herbert, Peyk, and Junghöfer (2007) used pleasant and unpleasant words compared to neutral words. They found greater negativity at 250 ms for both pleasant and unpleasant words compared to neutral in the occipital region, although positive and negative words did not differ. In a later study, Kissler et al. (2009) used highly arousing positive and negative words compared to less arousing neutral words. No effects were found for the P1 or N1 patterns. However, the EPN window (240-300 ms) again revealed that both pleasant and unpleasant words evoked more negative amplitudes than neutral. Hinojosa, Méndez-Bértolo, and Pozo (2010) also compared positive and negative words to lower arousal neutral. They found that positive words evoked a more negative EPN than negative and neutral words. Comparing the tasks used in their study, the lexical decision task brings out effects, but during a simple word detection task the EPN is unresponsive.

The late ERP patterns for studies in which arousal was at least partially matched showed greater differentiation amongst valence conditions than did early patterns matched on arousal. Dolcos and Florin (2002) found that the LPP (500-800 ms) for high arousal positive and negative images did not differ from each other; however, they both had greater positivities than the low arousal neutral images in the parietal region. In the frontal region, positive images differed from negative and neutral images, which did not differ from each other. In Olofsson and Polich (2007), the LPP wave pattern (300-450 ms) was larger for negative and positive images than neutral images. Additionally, both the early LPP (550-700 ms) and the late LPP (700-850 ms) was larger for positive and negative images than neutral images. Conroy and Polich (2007) found the LPP pattern (300-600 ms) evoked by negative images was less positive than neutral images, but positive images did not differ from neutral. Pastor et al. (2008) found that the LPPs 400-700 ms evoked by positive and negative images, which did not differ from each other, were larger than the LPP evoked by neutral images in the centro-parietal region. Leite et al. (2012) found the LPP was larger to high arousing pleasant and unpleasant images compared to low arousal pleasant, unpleasant, and neutral images during a viewing experiment. .

Thierry and Roberts (2007) found the LPP pattern 310-360 ms (peak: 341 ms) was greater for both negative and loud neutral sound stimuli compared to neutral stimuli at frontal sites. This effect seems to implicate the LPP in emotional differentiation as cognitive resources are shifted toward important stimuli. In the silent reading task used by Kissler et al. (2009), the LPP (470-570 ms) was larger positive than negative words in the parietal region; however, in the word counting task the LPP (450-650 ms) was larger for positive than neutral words and negative words did not differ from positive or neutral words. Hinojosa et al. (2010) found the both positive and negative words evoked a larger LPP (550-650 ms) compared to neutral words during a lexical decision task. Wangelin, Bradley, Kastner, and Lang (2012) found that the LPP was enhanced, and the startle LPP (240-360 ms) attenuated, for both erotic and violent scenes compared to neutral. Finally, Cano et al. (2009) found LPP differences that showed amplitudes for positive pictures were greater than for negative and neutral in the frontal region. Additionally, amplitudes for negative and neutral pictures were larger than for positive pictures in the parietal region.

Olofsson, Nordin, Sequeira, and Polich (2008) provide an extensive review of ERPs to affective pictures. They suggest that ERP patterns 100-250 ms respond to stimulus valence characteristics, whereas, later patterns from 200-1000 ms respond more to stimulus arousal characteristics. This is supported by findings of Gianotti, Faber, Schuler, Pascual-Marqui, Kochi, and Lehmann (2008) who concluded based on microstate analysis that affective information is processed prior to arousal. This conclusion seems counterintuitive when we consider that intensity of a stimulus, which intuitively would bear on arousal, modulates very early components. Krolak-Salmon, Hénaff, Vighetto, Bertrand, and Mauguière (2007) found intracranial ERPs, measured at the cortical surface indicate the amygdala responded to fearful faces within the 200-300 ms EPN window. Affective stimuli, which are inherently more arousing, garner more attentional resources due to the salience of information, and the resulting ERP pattern shows protracted effects of motivation and encoding or translation over the course of late ERP patterns that are statistically detected as arousal difference between valence conditions. Thus, arousal differences in the late patterns may be a carry-over from earlier arousal activation processes put in motion by valence.

In general, affective stimuli tend to modify both the EPN and LPP such that emotionally meaningful stimuli differ from neutral. While emotional versus neutral stimuli modulate the EPN, positive and negative stimuli differ from neutral most often in the LPP. Differences in valence effects in ERP patterns occur at different locations of the scalp and are variable between studies. This makes it difficult to develop a consistent picture and interpretation of the processes associated with the patterns across studies difficult. These inconsistencies in valence findings and the complex interactions between valence and arousal were noted in Citron’s (2012) review of effects related to visually presented emotional words.

A question of interest regarding valenced stimuli studied using ERPs is whether or not there is evidence of valence-specific processing in the brain activity. The EPN and the LPP patterns are most often used as evidence of valence specificity. Some researchers who support the negativity bias argument have found that negative stimuli are preferentially processed (Bernat, Bunce, & Shevrin, 2001; Hajcak & Olvet, 2008; Carretie et al., 2004; Scott et al., 2009, Czigler et al, 2007). Other researchers support the argument that positive stimuli are preferentially processed in the brain (Briggs & Martin, 2009; Kissler & Hauswald, 2008; Schacter & Sommer, 2009). And there are still other researchers that support the position that there is no preferential processing for either valence, and that the effects found are related to arousal (Kissler et al., 2007, 2009; Hajcak & Olvet, 2007; Schupp, 2000; Flaisch et al, 2007). Therefore, it is important to note whether evidence of preferential processing of valence emerges in the present investigation and whether it aligns with prime or target valence categories.

Table 2. ERP Effects of Valence

| Paper | Stimulus Type | Modality | Valences Compared | Stimulus Arousal Match | Task | P1 | N1 | EPN | MFN/N400 | LPP |
|---|---|---|---|---|---|---|---|---|---|---|
| **Armhein (2004)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Passive viewing | *n.a.* | *n.a.* | *n.a.* | *n.a.* | E > NEU |
| **Briggs (2009)** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Distractor (Oddball) | *n.a.* | *n.a.* | *n.a.* | *n.a.* | E > NEU |
| **Cano (2009)** | pictures (Exp.1) | visual | POS, NEG, NEU | Matched: POS=NEG=NEU | Distractor (Oddball) | *n.a.* | *n.a.* | *n.a.* | *n.a.* | Frontal: POS > NEG & NEU |
| **Carretie (2004)**** | pictures | visual | POS, NEG, NEU* | Unmatched: NEG>POS>NEU | Distractor (Oddball) | Frontal P1: NEG < E | *n.a.* | *n.a.* | *n.a.* | *n.a.* |
| **Conroy (2007)** | pictures | visual | POS, NEG, NEU | Matched: POS=NEG=NEU | Distractor (Oddball) | *n.a.* | *n.a.* | *n.a.* | *n.a.* | NEG > NEU |
| **Cuthbert (2000)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Judge reaction | *NS* | *NS* | POS > NEU | *n.a.* | POS > NEG & NEU |
| **Czigler (2007)** | sounds | auditory | NEG, NEU | Not reported | Distractor (Oddball) | | | | | |
| **Dolcos (2002)** | pictures | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Attend | *n.a.* | *n.a.* | *n.a.* | *n.a.* | POS > NEG |
| **Flaisch (2008)** | pictures | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Passive view | *n.a.* | *n.a.* | E < NEU | *n.a.* | E > NEU |
| **Foti (2009)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Passive view | *n.a* | E < NEU | E < NEU | *n.a.* | NEG > POS > NEU |
| **Hinojosa (2009)** | words (Exp.1) | visual | POS, NEG, NEU* | Partial: POS=NEG>NEU | Lexical decision | *n.a.* | *n.a.* | *n.s.* | *n.a* | NEU > E |
| | pictures (Exp.2) | visual | POS, NEG, NEU* | Partial: POS=NEG>NEU | Detect image | *n.a.* | *n.a.* | POS < NEG/NEU | *n.a* | E > NEU |
| **Hinojosa (2010)** | words | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Lexical decision | *n.a.* | *n.a.* | POS < NEG/NEU | | E > NEU |
| **Keil (2002)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Passive view | *NS* | POS > NEG/ NEU | *n.a.* | *n.a.* | E > NEU |
| **Kissler (2007)** | words | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Read words | *n.a.* | *n.a.* | E < NEU | *n.a.* | *n.a.* |
| **Kissler (2009)** | words | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Read words | *n.a.* | *n.a.* | E > NEU | *n.a.* | POS > NEG |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Leite (2012)** | pictures | visual | POS, NEG, NEU | manipulated | Passive view | *n.a.* | *n.a.* | E < NEU | *n.a.* | E > NEU |
| **Moser (2006)** | pictures | visual | NEG, NEU | Unmatched: NEG>NEU | Active View | *n.a.* | *n.a.* | *n.a.* | *n.a.* | NEG > NEU |
| **Olofsson (2007)** | pictures | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Oddball | *NS* | *NS* | NEU < POS/ NEG | *n.a.* | E > NEU |
| **Rellecke (2011)** | faces | visual | POS, NEG, NEU | Partial: NEG>POS=NEU | Classify | POS > NEU | NEG < POS / NEU | *n.a.* | E < NEU | *n.a.* |
| | | | | | Classify | E > NEU | *n.a.* | *n.a.* | *n.a.* | *n.a.* |
| **Sabatinelli (2007)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Passive view | *n.a.* | *n.a.* | *n.a.* | *n.a.* | E > NEU |
| **Schupp (2003)**** | pictures | visual | POS, NEG, NEU | Unmatched: NEG>POS>NEU | Count checker-boards | *NS* | E < NEU | E > NEU | *n.a.* | *n.a.* |
| **Scott (2009)** | ANEW | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Lexical decision | NEG > POS > NEU | *NS* | E > NEU | *n.a.* | *NS* |
| **Smith (2003)** | pictures | visual | POS, NEG | Matched: POS=NEG | Judge valence | NEG > POS | *n.a.* | *n.a.* | *n.a.* | *n.a.* |
| **Wangelin (2012)** | pictures, faces | visual | POS, NEG, NEU | Partial: POS=NEG>NEU | Passive view | *n.a.* | *n.a.* | *n.a.* | *n.a.* | E > NEU |

POS means positive stimulus; NEG means negative stimulus; NEU mean neutral stimulus; E = Emotional (positive and negative);
NS = No Effect; n.a. = Not Analyzed; ** = Did not control for arousal

#### 2.2.3.2.3 ERPs Patterns in Emotion Priming

ERP patterns such as the N400 were found over recent years in emotion priming paradigms, as well as semantic priming paradigms (Frishkoff, Tucker, Davey, & Scherg, 2004). In these studies, emotionally incongruent prime-target pairs evoked more negative waveforms than emotionally congruent pairs during the N400 period (300-450 ms) of the ERP. In addition to word and picture stimuli, music and environmental sounds have also been investigated as primes and targets (Cummings, Čeponiene, Koyama, Saygin, & Townsend, 2006; Orgs, Lange, Dombrowski, & Heil, 2006, 2007, 2008).

In Morris, Squires, Taber, and Lodge (2003) positive and negative political object words were used as primes for positive and negative word targets. The authors collapsed across valence conditions of the priming task and compared emotionally congruent and incongruent stimulus pairs. They found an N400 effect (320-460 ms) that indicated incongruent prime-target pairs evoked a more negative N400 pattern than congruent prime-target pairs. The authors state that there were not enough trials to compare the congruency effects amongst positive and negative prime-target combinations, so it is not possible to see which combinations of primes and targets contributed most to the overall congruency effect. The LPP peak amplitude did not differ due to congruency.  Zhang, Lawsom, Guo, and Jiang (2006) used IAPS images and words as primes for word targets. They found that RT to incongruent trials was longer than to congruent trials, which is consistent with priming. For the word prime condition the N400 to incongruent trials was more negative than to congruent trials over posterior regions. They did not find the effect for picture prime condition.

Four studies found N400 effects using auditory primes. Steinbeis and Koelsch (2008, 2010) examined affective priming using musical chords as primes. The authors used consonant (pleasant sounding) and dissonant (unpleasant sounding) musical chords that were 800 ms in duration as prime stimuli. Visually displayed target words were categorized by participants as either pleasant or unpleasant. RT revealed that unpleasant chord primes paired with unpleasant word targets were more quickly evaluated than unpleasant chord primes paired with pleasant word targets. There was no difference in RT when pleasant prime chords were paired with either pleasant or unpleasant target words. However, there was a robust N400 effect (300-500 ms) in response to the incongruent conditions. It was greatest to pleasant chords paired with unpleasant word targets, and to unpleasant chord primes paired with pleasant target words, compared with conceptual matches (baseline). Additionally, similar effects were found for both musically trained and untrained participants, and for manipulations of major-minor mode and timbre to construct pleasant and unpleasant sounding chords. Goerlich, Witteman, Aleman, and Martens (2011) found that RT of participants to make a valence judgment about word targets primed by 600 ms happy and sad classical music piano excerpts displayed a trend that indicated responses on congruent trials were faster than incongruent trials. Reaction time to words primed by happy and sad pseudo-word prosody, however, was significantly faster to congruent words than incongruent targets. Despite the absence of behavioral effects for music primed word targets, the N400 waveform appeared to display greater negativity for incongruent than congruent combinations, however the difference also did not reach significance. Prosody primed word targets, which demonstrated a behavioral effect, showed a significant N400 effect as well. Incongruent primes-target combinations were more negative than congruent combinations in anterior and central regions. Consistent with their previous findings, Goerlich, Witteman, Schiller, Van Heuven, Aleman, and Martens (2012) replicated the paradigm and again found that congruent music primed word targets trended toward faster evaluation than incongruent pairs, and the N400 was more negative for incongruent than congruent pairs. Congruent prosody-word pairs were evaluated significantly faster than incongruent pairs, and the N400 for incongruent pairs were also more negative than for congruent pairs (N400 effect). When the task instructions were changed such that the participant made a non-affective judgment about word targets, the N400 effects did not occur. The authors suggested this is evidence that spreading activation may not be the only mechanism contributing to affective priming and that response conflict may play a role.

The N400 pattern is most often reported with regard to semantic evaluation, and has recently been purported to respond similarly to emotional evaluation. Differences in the LPP pattern have been found to emotional evaluation in the absence of semantic information processing. Therefore, an open question exists as to which component responds to what type of processing. Do the N400 effects to emotional priming result from *representation of emotion as meaning* similar to *representation of semantic information as meaning*. The results of the above studies suggest that the N400 may be sensitive to emotion congruence in a similar manner as semantic congruence. A further question is whether the effects are attributable to emotion congruence or to arousal confounds that may also have modulated amplitudes of particular conditions. Confounding arousal and valence characteristics could result in spurious or unpredictable findings about waveforms that are presumed to be due to valence differences alone.

In none of the studies above was the arousal level of either the prime or target stimuli reported to be matched across conditions. The studies discussed next did include at least some control over the arousal level of their stimuli. Zhang, Li, Gold, and Jiang (2010) used IAPS images, which differed on both valence and arousal level, as primes for positive and negative affective Chinese words that were matched on arousal level in a paradigm similar to their earlier study. Words were also matched on familiarity. They found that participants responded faster and more accurately to affectively congruent targets than incongruent targets. Additionally, participants were faster to respond to positive than negative word targets. An N400 effect was found in fronto-central regions in which incongruent prime-target affective combinations evoked a more negative pattern than congruent combinations. Additionally, they found an LPP effect in centro-parietal regions in which incongruent combinations were more positive than congruent combinations. While these effects support the expectation that affective priming can evoke an N400-like effect pattern, the arousal differences between prime stimuli present the same problem of interpretation as the earler studies in this section.

Wu, Athanassiou, Dorjee, Roberts, and Thierry (2012) conducted two experiments in which semantic and affective relatedness was manipulated. The first experiment required a decision about whether an adjective-noun dyad prime was semantically related to the target sound that followed. The second experiment used the same procedure except that the decision was whether the affective quality of the adjective-noun dyad prime was congruent with the affective quality of the sound target. For both experiments an N400 effect was found for congruency. Semantically unrelated prime-target combinations evoked more negative N400 patterns than related combinations, and affectively incongruent prime-target combinations evoked more negative N400 patterns than congruent combinations. Interestingly, for the first experiment about the symbolic meaning, the N2 and P2 for unrelated prime-target combinations were lower in amplitude than for semantically congruent combinations. However, these effects were not present for affectively incongruent versus congruent combinations. For the second experiment about the affective congruency between prime-target combinations the effects were not present at all. The semantic decision in the first experiment may be less difficult than the affective decision in the second experiment. Participants may have to inhibit an initial tendency to make a semantic decision, that was activated by cognitive processes related to prime associations, and must reconsider the target in terms of affective meaning before making a decision. Or, it is possible that instruction to make a semantic congruency decision about semantically unrelated targets magnifies the expectancy effect presumed to be indexed by the N400 effect.

The findings of these studies indicate that affective congruence contributes to the morphology of both the N400 and LPP ERP patterns and semantic congruence is not the only domain in which the these later components respond. It remains in question whether the N400 effects found for word target stimuli are the same as N400 effects for other types of target stimuli. The N400 period waveform may not solely reflect a response to either semantic or affective content of words, but may represent a more general mechanism sensitive to expectancy across multiple domains that process meaning. Such expectations may arise from mental representation activations stemming from semantic or affective consistency with primes, with arousal level of a stimulus presenting a further confounding factor.

The N400 effect was not always found in studies that employed an affective priming paradigm. For instance, Hinojosa et al. (2009) who used high and low arousal affective word pairs did not find effects in the N400 window between congruent and incongruent conditions. Zhang et al. (2006) only found an N400 effect when words were used as primes for target words. They did not find the N400 effect when pictures were primes for words.

Aguado, Dieguez-Risco, Méndez-Bértolo, Pozo, and Hinojosa (2013) used faces depicting happy and angry expressions as primes for positive and negative words. While target words were carefully matched on arousal level, and differed only in valence, face prime stimuli differed significantly on both valence and arousal. They did not find significant effects for behavioral measures, but did find effects related to the N400 and LPP ERP patterns. However, the variability in N400 patterns was complex and did not show a clear difference between incongruent and congruent patterns. The LPP pattern showed a target valence effect in which positive targets evoked more positive patterns than negative targets in frontal, central, parietal, and occipital (or anterior and posterior) regions, and a target valence by congruency interaction that showed incongruent positive targets evoked more positive patterns than incongruent negative targets. The mix of effects here does not create a consistent pattern of effects that would support expectations of affective priming.

Herring, Taylor, White, and Crites (2011) conducted several experiments to investigate affective priming. In their first two experiments using positive and negative IAPS that were carefully matched on arousal level, they found the expected priming effects in the behavioral data, faster and more accurate evaluation of congruent pairs, but did not find an N400 effect. They did find an effect for the LPP pattern in which incongruent pairs evoked a greater positivity than congruent pairs. In their third experiment, they utilized a paradigm in which prime and target words were combined to create pairs that crossed affective and semantic congruency. Their four conditions consisted of semantically matched and affectively matched; semantically matched, but affectively mismatched; semantically mismatched and affectively mismatched; semantically mismatched, but affectively matched. They found faster RT to congruent pairs than incongruent pairs, but they did not find the N400 effect. They did find LPP effects to between affectively congruent and incongruent target words. The LPP pattern showed significantly more positivity for incongruent trials than congruent over parietal regions. These results suggest that closer attention should be paid to the effect of priming on the LPP pattern window in affective priming studies. Additionally, given that IAPS arousal level was carefully controlled and no N400 effect emerged, it brings into question the N400 effects of other studies that did not match stimuli on arousal.

The evidence suggests that affective priming can lead to comparable effects as semantic priming. However, this is not always the case and it is possible that the arousal level of the stimuli used may bear on those effects. The findings in the studies above elucidate the need to control for complex interactions between valence and arousal stimulus factors in the present investigation. Without control over them, a clear picture of how affect specifically contributes to both priming behavior and electrophysiological responses may not be possible.

The affective priming tasks reviewed also point out that either the N400 or an LPP emerges, which differs on the basis of congruent and incongruent relationships between prime and targets. This discrepancy amongst findings suggests that at least two different types of processing may be taking place during the appraisal period of an affective priming task. The N400 effect is most often found when processing of semantic relationships between primes and targets is required. However, in emotion priming paradigms the semantic relationship is ignored, and evaluation of the emotional relationship is required. Both semantic and affective stimuli possess meaning, which overlap as cognitive concepts. Whichever meaning is dominant may determine which component is evoked. When processing of meaning is focused on semantic relationships between primes and targets the N400 is evoked, whereas the LPP is evoked when the emotional meaning between primes and targets is processed. Examination of Table 3 shows that when words are the target stimuli, the N400 is most often affected by the prime-target relationship. However, when pictures are targets the LPP is affected. Perhaps words, by virtue of being learned symbolic stimuli, possess a greater inherent semantic quality elicits semantic processing and leads to N400 effects in emotion paradigms.

To summarize, it is important for studies that use affective stimuli of any modality (words, images, vocalizations, music, or environmental sounds) to control for level of arousal. Arousal can vary amongst stimuli of different valence conditions, which complicates the inferences drawn about results related to valence differences. In addition, studies of affective priming should control for conceptual-semantic relationships between prime and target, which may obscure subtle effects due to affective relationships. As detailed below, many studies failed to control for these factors.

Table 3. ERP Effects of Emotion Priming

| Paper | Prime | Target | SOA | Task | P1 | N1 | EPN | MFN/N400 | LPP |
|---|---|---|---|---|---|---|---|---|---|
| **Aguado (2013)** | Faces (V) | Word (V) | 300ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | NEG CON < POS CON | NEG INC < POS INC |
| **Goerlich (2011)**** | Music (A) | Word (V) | 200ms | Affective Congruency | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
| **Goerlich (2012)**** | Music (A) | Word (V) | 200ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
|  | Prosody (A) | Word (V) | 200ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
| **Herring (2011)** Exp.1 | Pictures (V) | Pictures (V) | 300ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | *NS* | INC > CON |
| Exp.2 | Pictures (V) | Pictures (V) | 300ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | *NS* | INC > CON |
| Exp.3 | Words (V) | Words (V) | 300ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | *NS* | INC > CON |
| **Morris (2003)**** | Pictures (V) | Words (V) | 250ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
| **Steinbeis (2008)**** Exp. 1a | Chords (A) | Word (V) | 1000ms | Affective Congruency | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
| **Steinbeis (2010)**** Exp. 1, 2, 3 | Chords (A) | Word (V) | 200ms | Affective Congruency | *n.a.* | *n.a.* | *n.a.* | INC < CON | *n.a.* |
| **Wu (2011)**** Exp. 2 | Words (V) | Sounds (A) | 900, 1000, or 1100 ms | Judge Target Valence | *n.a.* | *NS* | *NS* | INC < CON | *n.a.* |
| **Zhang (2006)**** | Pictures (V) | Words (V) | 300ms | Judge Target Valence | *n.a.* | *n.a.* | *NS* | *n.a.* | *NS* |
|  | Words (V) | Words (V) | 200ms | Judge Target Valence | *n.a.* | *n.a.* | *NS* | INC < CON | *NS* |
| **Zhang (2010)** | Pictures (V) | Words (V) | 150ms & 250ms | Judge Target Valence | *n.a.* | *n.a.* | *n.a.* | INC < CON for both SOAs | INC > CON |

A means “auditory”, V means “visual”, CON means “congruent condition”, INC means “incongruent condition”, > means "more positive” or "less negative”, < means "more negative" or " less positive", ** means arousal not matched, *NS* = No Effect, *n.a.* = Not Analyzed

#### 2.2.3.2.4 Effects of State and Trait Anxiety

Li, Zinbarg, and Paller (2007) used words and found the P1 (100-160 ms) amplitude difference between threat and neutral words was positively correlated to BIS trait anxiety. The P1 “tended” to be larger for high trait anxiety participants. Low anxiety participants appeared to show neutral words evoked a larger P1 than threat words. The LPP (300-500 ms) showed a larger amplitude pattern to threat words than neutral words, which was greatest at central sites. It is expected that threat words had greater arousal quality than neutral words.

Li, Zinbarg, Boehm, and Paller (2008) did report differences in P1 (145-175 ms) amplitude for happy versus fearful faces. Fearful faces evoked larger amplitude P1 than happy faces at in occipital region. The magnitude of P1 differences between fearful and happy faces was positively correlated with trait anxiety score (formed as a composite of SPS and BIS measures). The LPP pattern (300-400 ms) showed that fearful faces evoked a lower amplitude pattern than happy faces in the central region. There was not a relationship found between the LPP and trait anxiety. The face stimuli used in this study were not matched on arousal.

Holmes, Nielsen, Tipper, and Green (2009) used fearful, happy, and neutral facial expressions to evaluate the P1, EPN, and LPP in high and low anxiety participants using a 1-back and 2-back task. These tasks required participants to indicate whether the current stimulus presented matched a previous stimulus that appeared one or two presentations in the past. In frontal regions the early LPP (180-400 ms) and the late LPP (400-700 ms) were analyzed. In posterior regions the P1 (124-164 ms) the EPN (208-280 ms) were analyzed. Fearful faces evoked the largest P1, which differed from neutral faces. Happy faces evoked an intermediate amplitude P1, which did not differ from fearful or neutral faces. In the EPN window, the low anxious group showed that fearful and happy faces differed from neutral faces, but did not differ from each other. For the early LPP window, fearful and happy faces differed from neutral, but fearful and happy did not differ from each other. The waveforms indicate the fearful and happy conditions had greater positivity than neutral faces. For the late LPP window, the 1-back task results showed that fearful faces evoked a significantly larger pattern than neutral, with happy faces again intermediate that did not differ from fearful or neutral. The 2-back task showed both fearful and happy faces evoked significantly larger patterns than neutral, but did not differ from each other.

Wangelin et al. (2012) found that the LPP (400-700 ms) was more positive for both high arousing positive and negative images (erotica, violence) than neutral scenes. Additionally, the startle LPP amplitude was lower in amplitude for these positive and negative scenes compared to neutral. There were no differences found for the LPP and LPP magnitude between high and low socially anxious groups classified using the LSAS.

Gibbons (2009) investigated subliminal priming using words presented at 17 ms to affect judgments of paintings and portrait images. The prime word varied valence (positive vs. negative) and arousal level (high vs. low). Individual differences in state and trait anxiety were measured because high anxiety has been found to increase priming effects on behavioral measures and P1 amplitude. Judgments of target images were more positive when primed by a positive word than by a negative word, and positive arousing prime words evoked more positive judgments than other conditions. In this study, high anxious participants were affected more than low anxious by the manipulation. ERP differences were not found in the early ERP patterns, however later components, such as the LPP, was more positive for positive arousing primes than negative arousing primes. The effects demonstrated that subliminal priming affected late versus early processing stages based on ERP results.

In general, when effects of anxiety were found in ERP patterns, they related to arousing positive and negative stimuli compared to neutral. A clear picture of how anxiety level affects ERP components is not apparent at this time. However, given the increased sensitivity to stimuli, especially negative stimuli, and growing interest in the neural mechanisms underlying anxiety I believe it is important to consider its role in emotional stimulus processing. It would not be surprising to find anxiety-specific effects as ERP components related to affective priming become more apparent.

Table 4. ERP Effects of Anxiety (NA)

| Paper | StimType | Modality | Task | P1 | N1 | EPN | MFN/N400 | LPP |
|---|---|---|---|---|---|---|---|---|
| **Sass (2010)** | words | visual | Stroop | Anxious arousal women > Anxious arousal men | *n.a.* | E < NEU | E > NEU | *NS* |
| **Gibbons (2009)** | words | visual | Rate liking of image | NS | NS | *n.a.* | *n.a.* | POS arousing > NEG arousing |
| **Li (2009)** | faces | visual | Judge affect | NEG > POS | *n.a.* | NS | *n.a.* | POS > NEG |
| **Wangelin (2012)** | scenes, faces | visual | Passive view | *n.a.* | *n.a.* | *n.a.* | | P3: NEU > E;<br>LPP: E > NEU |
| **Li (2008)** | faces | visual | Valence Judgment | NEG > POS | *n.a.* | *n.a.* | *n.a.* | POS > NEG |
| **Li (2007)** | words | visual | Stroop | NS | *n.a.* | *n.a.* | *n.a.* | NEG > NEU frontal in supraliminal, posterior in subliminal |
| **Holmes (2009)** | faces | visual | 1-back test | NEG > NEU | *n.a.* | | *n.a.* | POS & NEG > NEU |

> means "more positive” or "less negative”, < means "more negative" or " less positive",
** = Did not control POS, NEG for arousal , *NS* = No Effect, *n.a.* = Not Analyzed

## 2.3 Study Hypotheses

The main goal of this study was to examine behavioral and neural correlates of emotion priming. The function of laughter was of particular interest. That is, whether or not laughter functions as a positive prime and whether laughter-specific effects could be reversed under social anxiety. If so, this finding would provide evidence of flexibility in comprehending the meaning of laughter in different contexts and its effects at the neurocognitive level.

First, we hypothesized that emotionally charged (positive or negative) sounds would prime affectively congruent emotions and emotion representations **(Hypothesis 1: Emotion Priming).** To test this hypothesis we examined relatedness effects for the control (IADS) stimuli. We expected to see faster or more accurate responses (or both) to affectively related ("congruent") prime–target pairs in comparison with unrelated ("incongruent") stimuli. In addition, we expected to see ERP correlates of emotion priming. Based on previous findings (see **Table 3**), we expected that priming effects would modulate late ERP components (N400, LPP) that reflect higher cognitive processes. In particular, if the priming effect is due (in whole or in part) to semantic processing (i.e., more symbolic representation of meaning), then we would expect to see N400 effects of emotion priming. By contrast, if the priming effect involves non-semantic processes that contribute to emotion evaluation, then we would expect to see LPP effects.

It is important to note that emotion priming is expected to look different for positive and negative targets. For example, if emotion priming elicits N400 effects, there should be larger N400s (greater negativity over centroparietal regions at approximately 400 ms) in response to positive targets when preceded by negative sounds, because the positive targets are less expected. However, the same positive words should elicit smaller N400s when preceded by positive sounds, because they are more expected within this context. For this reason, it was important to examine valence-specific effects, to help disentangle effects of priming and effects of target valence (Hypothesis 2).

The second hypothesis addresses whether positive and negative stimuli elicit different behavioral or ERP responses and whether these differences reflect a negativity or a positivity bias **(Hypothesis 2: Valence-specific Effects)**. Furthermore, it is possible that target valence effects alter or obscure emotion priming effects. For this reason, it will be important to look at valence-specific responses to words, and to consider how these may impact behavioral and N400 measures of priming.

Based on previous findings (see Tables 1-2), stimuli of different valence categories show numerous effects on ERP patterns, primarily in the EPN and LPP pattern windows. The different stimulus valence categories compared were usually positive, negative, and neutral and suggest three possible ways valence specific effects could emerge. There could be a negativity bias, a positivity bias, or no bias toward a particular valence in the ERP patterns. It is hypothesized that ERP components such as the EPN and LPP will not differ in latency or amplitude when positive and negative stimuli have been matched on arousal.

Hypotheses 3 and 4 build on these first two questions. Question 3 focused on whether laughter-specific effects were found within the priming paradigm. Hypothesis 4 focused on the possibility that laughter-specific effects might differ under a social anxiety manipulation.

Hypothesis 3 addresses whether there are laughter-specific responses in the ERPs that are differentiated from ERPs evoked by other valenced primes **(Hypothesis 3: Laughter-specific Effects)**. Some researchers have reported that stimuli that are of high evolutionary significance, such as images of mutilation, erotica, and facial expressions, (Schupp et al. 2003; Aeschlimann et al., 2009; Meyer, Zysset, Von Cramon, & Alter, 2005; Hinojosa et al., 2009) are preferentially processed compared to stimuli that have learned emotional significance, such as words. In addition, there is evidence to suggest that human vocalizations are more effective at conveying affect than other sounds, and that positive sounds are more easily recognized than other environmental sounds (including negative human vocalizations) (Aeschlimann et al., 2008). If laughter primes are "special" in either of these two senses, we might expect to see laughter-specific ERP effects.

Because this is the first study of laughter priming and the first study to examine ERP responses to laughter, we do not have evidence to support a prediction about ERP responses to laughter. However, if laughter elicits qualitatively distinct neurocognitive processes, we expect to see ERP patterns that reflect these differences. If laughter is a qualitatively different (category-specific) positive prime, it is hypothesized that ERP patterns should reflect this difference.

Our last question was whether emotion priming with laughter was different in a context that promotes social anxiety **(Hypothesis 4)**. When the socioemotional context is altered to induce feelings and thoughts about social failure, the ERP patterns related to laughter primed stimuli should differ from those evoked in a neutral context. If the manipulation succeeds, laughs should serve as negative rather than positive affective primes. Therefore, it is hypothesized that laughter priming effects should be reversed following the social context manipulation, whereas effects of other prime sounds should show little or no difference from the neutral context.

# 3 DEVELOPMENT AND VALIDATION OF EXPERIMENT STIMULI

This present investigation involves an emotion priming task utilizing three types of stimuli: (1) short bouts of laughter, which function as primes, (2) positive and negative IADS sounds, and (3) positive and negative words, which function as targets. Described in this section are the procedures used to develop the set of sound stimuli for the priming task. Priming tasks in many previous studies used SOA lengths of 200-300 ms. This SOA range is often used primarily due to the expectation that the effect of the prime on the target was very short lived, and longer SOAs would not yield priming effects (Hermans, De Houwer, & Eelen, 2001; Hermans, Spruyt, & Eelen, 2003). However, the focus of this investigation is on laughter, which is a sound that unfolds over time. When laughs were truncated to shorter lengths than 500 ms, the resulting sound often ended abruptly and sounded unpleasant. However, when laughs were truncated at 500 ms, it allowed for sufficient vocal energy of the laugh to be transmitted for a laugh to be recognizable. Environmental sounds selected from the IADS were also truncated to 500 ms to control for prime duration.

## 3.1 Sound Stimuli (Primes)

### *3.1.1 Laughter Stimuli*

In order to study the effects of honest spontaneous laughter, a well controlled corpus of laughter vocalizations required development. These “honest” laughs were audio high-resolution recordings of laughs obtained from participants who freely laughed, rather than from actors or from a variety of sources such as the internet, other media including radio or television, or from happenstance social settings in which other sounds or acoustical noise are present. In short, a situation was set up in which participants felt comfortable enough to laugh spontaneously, while in a laboratory setting that maintained control over extraneous noise.

Participants (63 males, 92 females) 18-46 years of age ($M_{\text{age}}$ = 20.1 years) signed up for study sessions through an online recruitment system (SONA Systems) and watched humorous video clips on a 25 inch monitor in a dimly lit and sound attenuated testing room. High resolution stereo audio recordings of spontaneous laughter were obtained (44.1 kHz sampling rate; 24-bit resolution) using wireless microphones (Shure PG-2) while headphones (Sennheiser, HD 212Pro) delivered the video clip audio track to avoid cross-contamination with the laughter audio recording. Participants also tracked the video clip “funniness” in a continuous manner using a slider-style response box, which varied a voltage trace from 1 – 10 V. A dedicated computer (MS Windows XP) running DirectRT (Empirisoft Corporation, New York, NY) stimulus presentation software randomized video-clip order. The majority of participants produced spontaneous laughter during the video-clip viewing session. Audio recordings devoid of discernible laughs or which lacked variation were not utilized. This resulted in a 91 participant sample (38 Males, 53 Females). Because our sample of candidate laughers included more females than males, ratings of candidate laughers were made by laboratory members to arrive at 30 female and 30 male laughers whose recordings contained a variety of voiced laughs from which three intensity level categories (high, medium, low) could be constructed. The audio track for each laugher was extracted and down-sampled to 22.05 kHz with 16-bit resolution. The sampling rate was reduced for compatibility with Praat 5.1 software (Boersma & Weenink, University of Amsterdam, The Netherlands) which was then also used to identify candidate laugh bouts and extract them as individual stimuli. The highest intensity voiced laugh bouts, based on relative amplitude to other bouts in each recording, were located first. Low intensity voiced laugh bouts, which were of comparable duration to high intensity laughs when possible, were selected next. Low intensity laughs did not include vocalizations such as snickers and breathy unvoiced characteristics. Similar duration medium intensity bouts, which were approximately midway in amplitude between low and high intensity laugh bouts, were then located. All candidate bouts were preceded by a period of silence. After winnowing candidate laughs from each laugher to the best examples, 30 laughs per category (high, medium, low intensity) for each sex were selected for further examination.

In order to verify that the perception of laughs becomes more positive with increasing intensity, a listening study was conducted. Participants (14 males, 25 females) 18 - 26 years of age listened to laugh bouts and rated how positive each of the 180 laughs sounded to them. All laugh bouts were amplitude normalized. Participants were instructed to use their initial impression to:

> Please rate your immediate impression of how positive you find each laugh without contemplating it very long. Although reaction time is not a factor of interest, we do want you to respond quickly to get your initial impression. Try not to allow laughs you have heard on a previous trial influence your decision on the one you are rating; rate them as independently as possible.

A dedicated computer and auditory stimulus delivery system was used to present the laughs within a sound attenuated room to individual testing cubicles, which prevented participants from seeing ratings made by other participants. Each group of up to five participants heard a short set of orientation trials followed by two counterbalanced blocks of stimuli that were presented in randomized order within each block through high definition Sennheiser HD650 headphones. Participants made ratings on a scale of 1 to 7, which was counterbalanced (1-Neutral to 7-Very Positive, or 1-Very Positive to 7-Neutral). On each trial a green LED warning light was followed by a 500 ms pause that preceded the laugh bout presentation. Participants had eight seconds to respond before the next trial began. No participants failed to respond within the response period.

Ratings of positivity were analyzed using a repeated measures ANOVA. Figure 2 illustrates differences in ratings of positivity between female and male laughter for the three laugh intensity categories. A main effect for laugh intensity was present *F*(2, 74) = 306.37, p < .001, $\eta_p^2$ = .89 in which high intensity laughs (M = 5.20) were rated significantly more positive than medium intensity laughs (M = 4.35), and medium laughs were rated significantly more positive than low intensity laughs (M = 3.70).[1] As expected, listeners perceive the positivity of laughs to increase with increasing intensity.

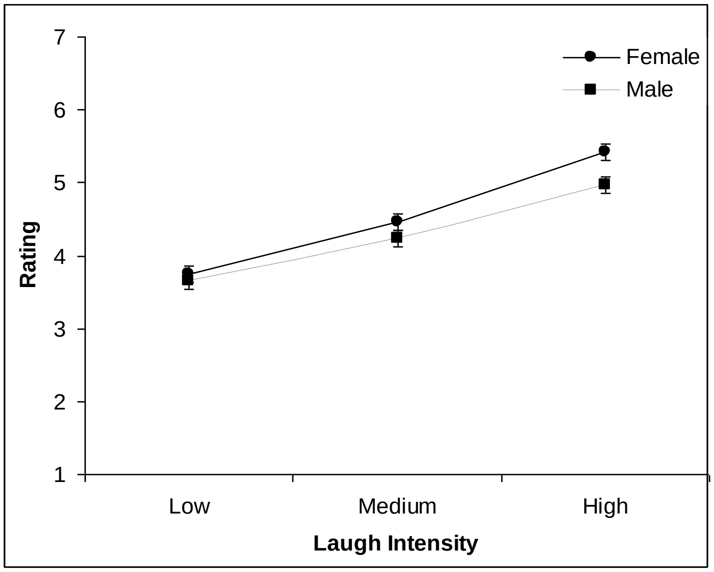

Figure 2. Ratings of positivity amongst laughter intensity categories.

### *3.1.2 Environmental Sound Stimuli*

The IADS data set consists of 167 sounds collected for use in affective research (Bradley & Lang, 2007). This database was used because of its wide variety of sounds, which permit results to be more generalizable than studies using homogeneous sound types. Each sound is six seconds long and has been rated on the dimensions of valence and arousal with respect to how

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[1] A main effect for laugher sex was present *F*(1, 74) = 32.37, *p* < .001, $\eta^2$ = .47 in which female laughs (*M* = 4.54) are rated as more positive than male laughs (*M* = 4.28). A laugher sex by intensity category interaction was also present *F*(2, 74) = 16.69, *p* < .001, $\eta^2$ = .31. This disparity between positivity ratings of female and male laughs decreased as intensity level decreased. High intensity female (*M* = 5.42) laughs were significantly more positive than high intensity male laughs (*M* = 4.97). Medium intensity female laughs (*M* = 4.46) were significantly more positive than male laughs (*M* = 4.23). However, low intensity female laughs (*M* = 3.75) were not significantly more positive that male laughs (*M* = 3.65).

they make listeners feel while they are listening to it. The majority of the sounds contain complex acoustical content, which in my view would result in high variability in ratings because different participants may focus on different periods of the six-second sound. Furthermore, for the ERP priming paradigm the original sounds are too long. Using Praat software, each six-second long sound was dissected into as many meaningful 500 ms excerpts of non-overlapping sounds as possible. This resulted in 454 sound excerpts. The process of breaking up each six second IADS was expected to change the valence and arousal tone compared to the original ratings in the IADS manual. Because of this, new normative data on both dimensions were needed before assigning each excerpt to valence categories. A description of the normative procedure follows.

### *3.1.3 Validation of All Sound Stimuli*

The SAM method described above was used to obtain ratings in response to 500 ms excerpts of both laughs and IADS. Thirty-five female participants listened to all 634 sounds presented randomly using E-prime software through headphones. Immediately following each sound the valence SAM appeared to which participants selected the cartoon figure with keyboard keys 1 through 9 corresponding to how happy or unhappy the sound made them feel when they listened to it. The arousal SAM appeared next, to which participants selected the cartoon figure with the keyboard corresponding to how excited or calm the sound made the feel when they were listening to it. After making both selections the next sound was presented. SAM ratings were used to guide the selection of stimuli for each of the four prime types that were used in subsequent experiments: positive IADS, negative IADS, neutral IADS, and laughs. In the final stimulus set, laughs and positive IADS were equated on mean ratings of valence. Laughs ($M$ = 5.70, $SD$ = .46) and positive IADS ($M$ = 5.64, $SD$ = .24) did not differ in valence rating, $t$(154) =

.98, *p* = .33. Laughs did differ from neutral IADS, *t*(154) = 15.92, *p* < .001, and negative IADS (*M* = 3.75, *SD* = .64), *t*(154) = 21.87, *p* < .001, on valence rating. Positive IADS differed from neutral IADS, *t*(154) = 21.00, *p* < .001, and from negative IADS, *t*(154) = 24.45, *p* < .001, in valence rating. Neutral IADS differed from negative IADS, *t*(154) = 11.65, *p* < .001, in valence rating. Stimuli in all prime categories were equated on arousal. Laughs (*M* = 4.60, *SD* = .23), positive IADS (*M* = 4.61, *SD* = .65), neutral IADS (*M* = 4.62, *SD* = .26), and negative IADS (*M* = 4.67, *SD* = .72) did not differ significantly from each other in arousal level. All *t*-test comparisons of arousal level amongst prime categories resulted in *p*-values were non-significant and were thus matched on this dimension.

Table 5. Valence and Arousal Means for Auditory Primes

| **Prime Type** | **Valence** | **Arousal** |
|---|---|---|
| **Positive IADS** | 5.64 (.24) | 4.61 (.65) |
| **Neutral IADS** | 4.69 (.32) | 4.62 (.26) |
| **Negative IADS** | 3.75 (.64) | 4.67 (.72) |
| **Laughs** | 5.70 (.46) | 4.60 (.23) |

### 3.2 Word Stimuli (Targets)

As mentioned previously, Bradley and Lang have used the SAM procedure (Bradley & Lang, 1994) to provide mean ratings along the three Osgood dimensions —valence and intensity (arousal) — for words, as well as for sounds. Their Affective Norms for English Words (ANEW) database includes means and standard deviations for each of these dimensions for approximately 2500 English words (Bradley & Lang, 2010). A subset of 156 words (78 positive, 78 negative) was selected for use as targets in the ERP emotion priming task. Table 6 shows mean valence and arousal ratings computed from data in the ANEW database for the positive and negative target word categories. There was a large and statistically significant difference in valence for positive versus negative words (p < .001). The two target word categories were matched on arousal (p > .5) and did not differ in length (restricted to four and six characters), written word frequency, or concreteness based on norms for the MRC (Medical Research Council) Psycholinguistics database. Appendix B contains a list of the sound excerpts used and their associated valence, arousal, and psycholinguistic characteristics.

Table 6. Valence and Arousal Means for ANEW Targets

| **Target Type** | **Valence** | **Arousal** | **Length** | **Frequency** | **Concreteness** |
|---|---|---|---|---|---|
| **Negative ANEW** | 2.07 (.44) | 6.29 (.79) | 5.08 (.79) | 34.07 (50.60) | 416.15 (98.62) |
| **Positive ANEW** | 7.90 (.45) | 6.30 (.82) | 5.14 (.78) | 35.96 (33.09) | 436.61 (112.40) |

Independent samples *t* test revealed that target word valence was significantly different between positive words and negative words; $t(154) = 82.13$, $p < .001$. Positive and negative words did not differ on level of arousal; $t(154) = .05$, $p = .96$. Furthermore, the two valence categories of words did not differ in length; $t(154) = .51$, $p = .61$; nor did they differ in written word frequency; $t(146) = .27$, $p = .79$; or in concreteness; $t(111) = 1.03$, $p = .31$.

## 4 BEHAVIORAL EXPERIMENTS

### 4.1 Behavioral Experiments Method

Three behavioral data collection experiments were conducted to first support the behavioral performance pattern obtained during the ERP experiment and to better understand how changes to the task affected the pattern of priming effects within the same prime-target-response timing structure. The ERP session involved collection of self-report data from many measurement tools, including social anxiety and affect scales, along with priming task performance and brain electrophysiological correlates of performance measures. These additional elements of the ERP session may affect performance in the priming task by changing the participants' expectations about the task. Additionally, the ERP methodology involved wearing an EEG sensor net during the priming task, which is a novel and somewhat unpleasant experience for participants. The behavioral experiments were employed to both check for differences in performance between the task performed with and without the additional elements of the ERP session and test for changes to effects based on a change in stimuli and in task instruction.

### *4.1.1 Cross-modal Priming Paradigm*

The cross-modal affective priming paradigm used in these experiments differed from that of Steinbeis and Koelsch (2008, 2010) in several ways. First, instead of musical chords serving as prime stimuli, the present task used excerpts from laughs, positive, neutral, and negative affective sounds to prime affect in listeners. Additionally, the affective sound excerpts were 500 ms in duration compared to the 800 ms music chords used by Steinbeis and Koelsch. Finally, the affective word stimuli used as targets in the present experiment were selected from the ANEW database and were carefully selected to maximize valence differences while matching on arousal level across valence categories. The valence of affective words used in the Steinbeis and Koelsch experiments were rated with their own norming procedure and did not address arousal level.

The paradigm was developed using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). Each trial began with a green fixation crosshair appearing in the center of the screen, which cued the participant to begin a trial by pressing a key on a keyboard or response box, depending on the experiment. Following a key-press, the crosshair turned gray and remained on the screen until the target appeared. The duration between initiating a trial and the presentation of an auditory prime varied randomly from 500-1000 ms, to minimize predictability. The participant was presented with a prime sound (positive IADS, negative IADS, Neutral IADS, or laugh) binaurally. Each sound was presented for 500 ms, which was its full duration. Following the offset of the prime sound, the fixation crosshair was immediately replaced by an ANEW word presented in the center of a LCD monitor in white (sans serif font, lower case, 24 dpi) against a black background. Words subtended 2-5 degree visual angle. There was a small amount of variability across subjects because head position varied with respect to the computer monitor. Figure 3 summarizes the event timing for each trial. The task of the participants varied depending on the goal of each experiment; however, their evaluation was always to make their decision as quickly and as accurately as possible in under a second (900 ms response window). Figure 3 illustrates the timing of events in the paradigm. Reaction time and accuracy data were recorded for offline analysis.

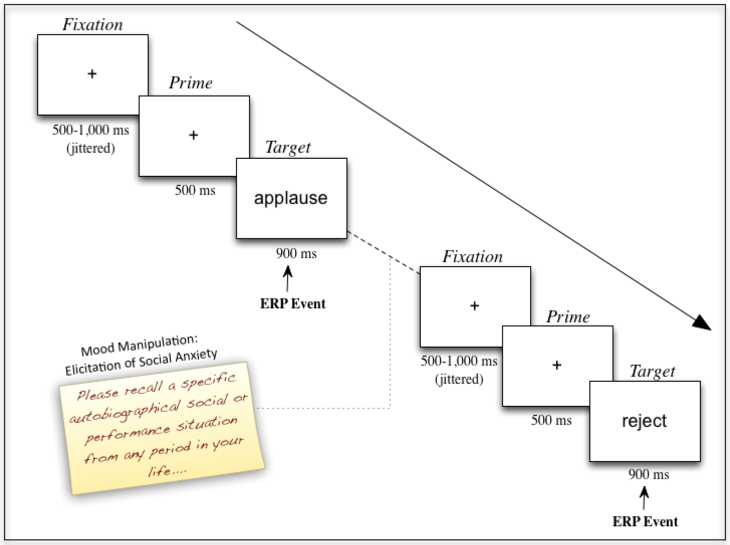

Figure 3. ERP experiment event sequence

## 4.2 Experiment 1

In this experiment I investigated the affective priming influence of positive and negative IADS excerpts, and laugh excerpts, on the evaluation of the pleasantness or unpleasantness of ANEW target words.

### *4.2.1 Study Design*

The factors in the analysis of behavioral data in the experiment included Prime Type and Target Valence.

### *4.2.2 Participants*

Twenty-eight undergraduate students participated in the experiment. Results from four male participants were excluded.

### *4.2.3 Stimuli*

The stimuli used in the cross-modal paradigm were 468 randomly assigned combinations of affective sound primes that were paired with affective word targets. Six combinations of primes and targets served as the conditions in the experiment: Laugh primes paired with positive target words, laugh primes paired with negative target words, positive IADS excerpts paired with positive target words, positive IADS excerpts paired with negative target words, negative IADS excerpts paired with positive target words, and negative IADS excerpts paired with negative target words. Prime and target combinations were checked to confirm that semantic relationships did not occur between the randomized pairing of primes to targets.

### *4.2.4 Procedure*

Participants arrived in small groups (up to 9) to a multi-station computer laboratory. Participants were seated at least one station apart from each other to minimize distraction by their neighbors. After they read and signed the informed consent form and completed a questionnaire that asks about presence of normal vision, normal hearing, age, sex, and handedness, they were given oral instructions about the task they were to perform by an experimenter. The description of the task was read to the group of participants and a demonstration of the first 5 practice trials was performed. Participants then put on Sony MDR-ZX100 stereo headphones and began the E-Prime experiment onscreen. The experiment program reiterated the instructions for the task and presented 20 practice trials that were not included in the experiment task with onscreen feedback to ensure they understood the procedure and responded within the time allotted. The task consisted of six randomized blocks of 78 randomized trials with a break between each block. Participants rested their index fingers on the "V" and the "M" key of the computer keyboard and initiated each trial by pressing one of them. Once a key was pressed, the time between initiating the trial and the presentation of the prime sound was jittered between 500 and 1000 ms. Each prime stimulus was presented for 500 ms and the fixation crosshair remained in the center of the screen throughout the prime presentation. Thus, the SOA was 500 ms for all trials. Auditory prime stimuli were positive and negative IADS excerpts and laughs presented binaurally. Immediately following the prime sound a positive or negative ANEW target word was presented visually for 1000 ms in the location where the fixation crosshair had been. The instructions to participants were to decide as quickly and accurately as possible whether the meaning of the word was pleasant (e.g. "praise," "reward") or unpleasant (e.g. "venom," "agony") by pressing the corresponding key on the keyboard. The assignment of the V and the M keys as pleasant or unpleasant was counterbalanced across groups of participants.

### *4.2.5 Data Analysis*

Responses to target-word categorization with reaction times less than 300 ms and greater than 900 ms were excluded. Participants with accuracy below two standard deviations of the mean or RT above two standard deviations of the mean were excluded (Scott et al., 2009). One participant was excluded for low performance which brought the sample size to 23. The minimum number of correct trials was 49 out of 78 (63%). The minimum accuracy for each prime-target category was 65 percent[2].

Mean accuracy and mean reaction time for correct trials for each participant and each condition were entered into a 3 x 2 Prime Type (laugh, positive, negative) x Target Valence (positive, negative) repeated-measures analysis of variance (ANOVA). Greenhouse-Geisser corrected degrees of freedom, *F*-ratios, and *p*-values and are reported where Mauchly's test of sphericity was significant. Post hoc (pairwise) comparisons were computed using paired samples *t*-tests. (Post hoc *t*-tests that were relevant to affective priming focus on the comparison between positive and negative target words within each of the prime type categories. Other post-hoc comparisons were not reported.)

### *4.2.6 Results*

The analysis of participant accuracy revealed a main effect of Prime Type, $F(2, 44) = 14.77$, $p < .001$, $\eta_p^2 = .40$. Post-hoc comparisons indicated that the accuracy of target word evaluation when primed by laughs was significantly greater than when target words were primed by positive IADS, $t(22) = 4.109$, $p < .001$. Additionally, the accuracy of target word evaluation when primed by negative IADS was significantly greater than when target words were primed by positive IADS, $t(22) = 4.90$, $p < .001$. The accuracy of target word evaluation between laugh and

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[2] Two participants had 65% accuracy in one of the prime-target categories. The rest of the participants' accuracy was 70% or greater in all categories.

negative IADS primed words did not differ. There was no main effect of Target Valence, *F*(1, 22) = .35, $p$ = .56, $\eta_p^2$ = .02. A significant interaction between Prime Type and Target Valence was found, *F*(2, 44) = 4.49, $p$ < .02, $\eta_p^2$ = .17. Post-hoc comparisons of differences among prime-target categories relevant to affective priming were not significant.

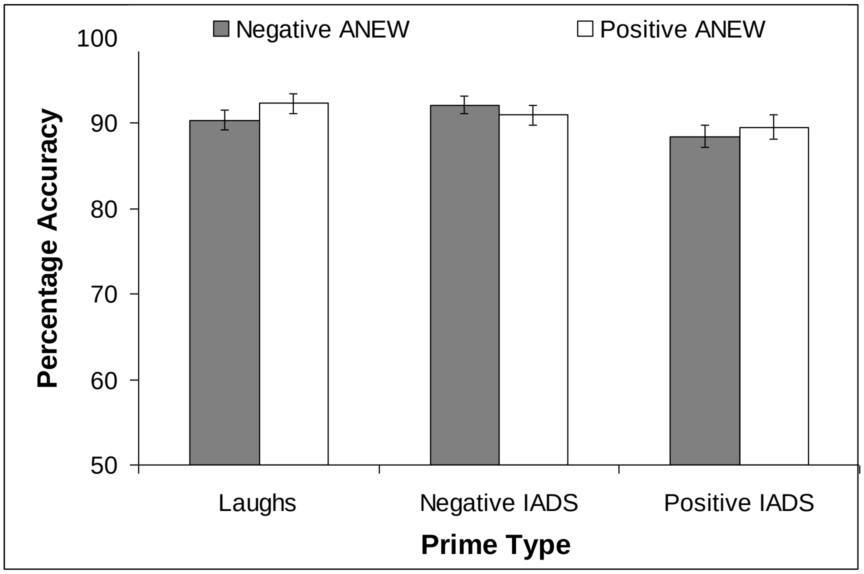

Figure 4. Accuracy results for Experiment 1

The analysis of participant reaction time for accurate trials to target word evaluation revealed no main effect of Prime Type, *F*(2, 44) = 1.73, $p$ = .32, $\eta_p^2$ = .05. However, a main effect of Target Valence was present, *F*(1, 22) = 7.86, $p$ = .01, $\eta_p^2$ = .26. Reaction time was significantly faster for positive than negative target words, *t*(22) = 2.80, $p$ < .01. No interaction was present between Prime Type and Target Valence, *F*(2, 44) = .86, $p$ = .43, $\eta_p^2$ = .04. For the post-hoc comparisons of interest to affective priming, positive target words primed by positive IADS were evaluated significantly faster than negative target words primed by positive IADS, *t*(22) = 3.98, *p* = .001. Evaluation of positive and negative target words when primed by negative IADS or laughs were not different.

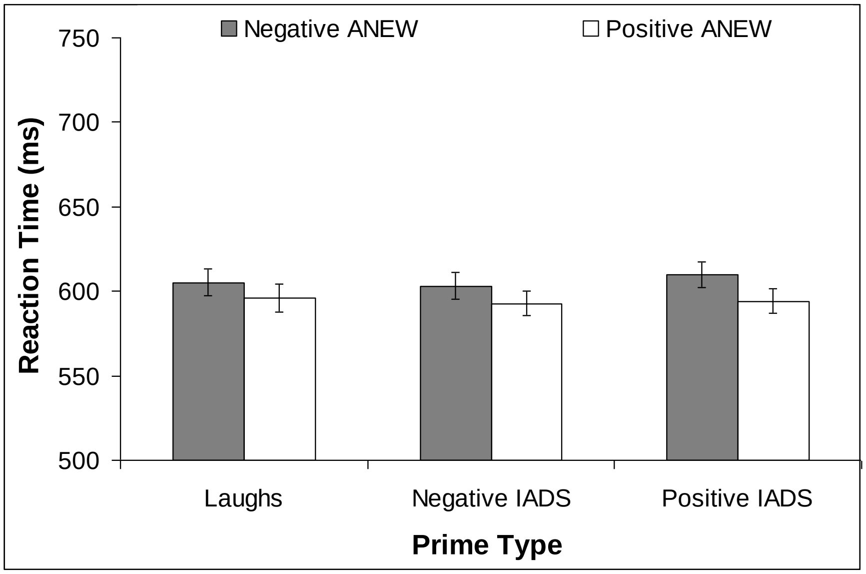

Figure 5. Reaction time results for Experiment 1

### *4.2.7 Summary*

The goal for Experiment 1 was to investigate whether affective sound-word combinations in a cross-modal paradigm could demonstrate affective priming effects. Figure 4 displays percent accuracy results for experiment conditions. The accuracy of target valence evaluation was greater for laugh primes than positive sound primes. However, target evaluation accuracy was also higher for negative than positive sound primes. It is possible that the affective content of laughs and negative sounds are quickly and easily processed and interfere less with target evaluation than positive sounds. Positive environmental sounds may possess greater ambiguity that prompted interpretive and reclassification processes that interfered with target evaluation. Accuracy results show that affectively congruent prime-target pairs were more accurately evaluated than incongruent pairs, which is consistent with priming. However, the lack of significance suggests it affective priming is difficult to detect in accuracy measures for a relatively easy target discrimination task without a large sample. Participants may simply have ignored the prime sounds and concentrated only on the target word decision. Inspection of Figure 5 suggests that affective priming, as viewed through RT, may be present for words primed by positive IADS and (to a lesser extent) for words primed by laughs, but there were no significant differences. The effect of target valence was consistent across prime categories, such that RT was significantly faster for positive than negative target words. This is a somewhat puzzling finding given that negative words are generally more quickly classified (Dijksterhuis & Aarts, 2003); however, faster responses to pleasant pictures have also been reported (Kissler & Hauswald, 2008). When considering the results of Experiment 1 overall, it appears that affective priming is present, but its effects are subtle compared to expectations. Nevertheless, affective priming experiments that include ERP measures have been found to show ERP patterns that respond to priming effects in the absence of behavioral effects (Aguado et al., 2013; Goerlich et al., 2012).

## 4.3 Experiment 2

This experiment investigates the affective priming influence of positive, negative, and neutral IADS excerpts on the evaluation of the pleasantness or unpleasantness of ANEW target words. The purpose of the stimulus change was to see whether target words were affected by neutral prime IADS, which have an intermediate position between positive and negative IADS on the SAM valence dimension.

### *4.3.1 Study Design*

The factors in the analysis of behavioral data in the experiment include Prime Type and Target Valence.

### *4.3.2 Participants*

Thirty-nine undergraduate students participated in the experiment. Results from 11 male participants were excluded.

### *4.3.3 Stimuli*

The same positive and negative IADS excerpt sound prime stimuli used in Experiment 1 were used. However, the laugh primes were replaced by neutral IADS primes.

### *4.3.4 Procedure*

The experimental procedure was the same as used in Experiment 1.

### *4.3.5 Data Analysis*

Responses to target-word categorization with reaction times less than 300 ms and greater than 900 ms were excluded. Participants with accuracy below two standard deviations of the mean or RT above two standard deviations of the mean were excluded. Seven participants were excluded for low performance. The 21 remaining participants had a minimum of 40 (51%) correct trials per condition and an accuracy of greater than 50% per condition.

Mean accuracy and reaction time for each participant and each condition were entered into a 3 x 2 Prime Type (neutral, positive, negative) x Target Valence (positive, negative) repeated-measures analysis of variance (ANOVA). Greenhouse-Geisser corrected degrees of freedom, *F*-ratios, and *p*-values and are reported where Mauchly’s test of sphericity was significant. Post hoc (pairwise) comparisons were computed using paired samples *t*-tests. As in

Experiment 1, the *t*-test comparisons that were relevant to affective priming in the interaction were between positive and negative target words within each of the prime type categories.

### *4.3.6 Results*

The analysis of participant accuracy revealed a main effect of Prime Type, $F(2, 40) = 7.52$, $p = .002$, $\eta_p^2 = .28$. Positive IADS primes elicited less accurate evaluation of target words compared with negative, $t(20) = 4.30$, $p < .001$, and neutral IADS, $t(20) = 2.60$, $p < .02$. Target evaluations when primed by negative and neutral IADS did not differ. There was no main effect of Target Valence, $F(1, 20) = 1.0$, $p = .33$, $\eta_p^2 = .05$. The interaction between Prime Type and Target Valence approached significance, $F(1.53, 40) = 3.16$, $p = .07$, $\eta_p^2 =.14$. For the post-hoc comparisons of interest to affective priming, evaluation of negative target words primed by negative IADS was significantly more accurate than evaluation of positive target words primed by negative IADS $t(20) = 3.34$, $p = .003$. Evaluation of positive and negative target words was not significantly different when primed by neutral IADS or laughs.

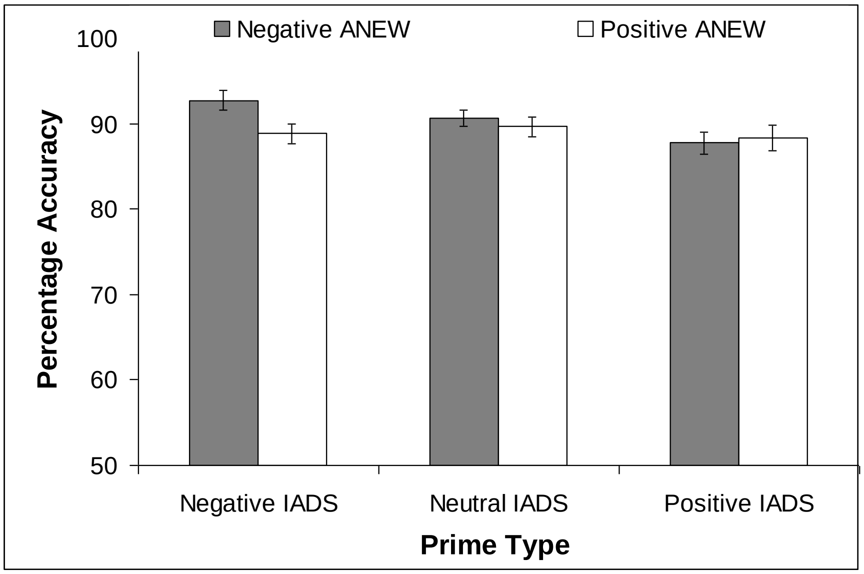

Figure 6. Accuracy results for Experiment 2

Analysis of reaction time of accurate response to target words showed no main effect for Prime Type, $F(2, 40) = .97$, $p > .39$, $\eta_p^2 = .05$. Additionally, no main effect was found for Target Valence, $F(1, 20) = 0.42$, $p > .52$, $\eta_p^2 = .02$. There was however, a significant interaction, $F(2, 40) = 4.98$, $p < .02$, $\eta_p^2 = .20$. For the comparisons of interest to affective priming, there were no significant differences between evaluation of positive and negative target words for any prime type.

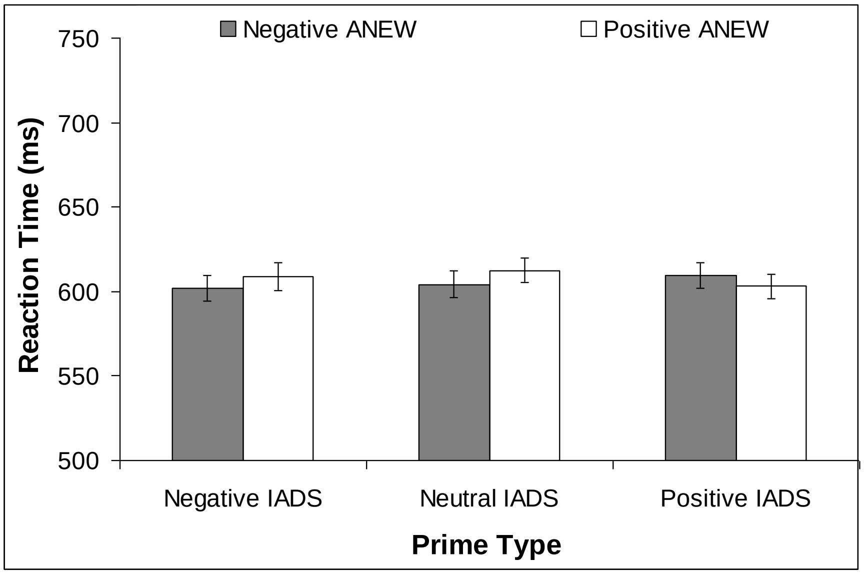

Figure 7. Reaction time results for Experiment 2

### *4.3.7 Summary*

The accuracy results of Experiment 2 show that neutral IADS sounds did not prime negative target words. The accuracy of positive and negative target evaluation was similar when neutral IADS served as primes. There was also no priming effect found for positive IADS. Negative words primed by negative IADS were evaluated significantly more accurately than positive words primed by negative IADS, which indicated priming effects associated with negative stimuli. The overall lower accuracy associated with positive IADS primes is consistent with Experiment 1 and is intriguing. As mentioned in that discussion, positive sounds may be more ambiguous than other sounds. However, the ambiguity of meaning would also be expected of neutral sounds, which makes that argument less plausible. Nevertheless, congruent prime-target combinations for both positive and negative IADS were more accurately and quickly evaluated than incongruent combinations. While differences between congruent and incongruent conditions were not significant, the pattern of values in the data suggested that affective priming may be present, albeit subtly, and that neutral IADS have a pattern that resembles the pattern produced by negative IADS.

## 4.4 Experiment 3

This experiment investigates the affective priming influence of positive and negative IADS excerpts, and laugh excerpts, on the evaluation of emotional congruity between the prime sound and target word stimuli.

### *4.4.1 Study Design*

The factors in the analysis of behavioral data in the experiment include Prime Type and Target Valence.

### *4.4.2 Participants*

Thirty-eight undergraduate students participated in the experiment. Results from 7 male participants were excluded.

### *4.4.3 Stimuli*

The same sound prime stimuli and targets used in Experiment 1 were used in this experiment.

### *4.4.4 Procedure*

The experimental procedure was the same as used in Experiments 1 and 2 with a modification to task instructions. Participants were instructed to decide as quickly and accurately as possible whether the emotional quality of the prime sound matched the emotional quality of the word target. They were informed not to attempt to match the symbolic meaning of the sounds and words, but to only consider the emotional meaning when making their judgment.

### *4.4.5 Data Analysis*

Responses to target-word categorization with reaction times less than 300 ms and greater than 1000 ms were excluded. Participants with accuracy below two standard deviations of the mean or RT above two standard deviations of the mean were excluded. Seven participants were excluded for having low performance. The remaining 24 participants had a minimum accuracy of 38% per condition. Accuracy was widely variable within individuals for different conditions. The minimum number of correct trials was 25 (32%).

Mean accuracy and reaction time for each participant and each condition were entered into a 3 (Prime Type) x 2 (Target Valence) repeated-measures analysis of variance (ANOVA). Greenhouse-Geisser corrected degrees of freedom, $F$-ratios, and $p$-values and are reported where Mauchly’s test of sphericity was significant. Post hoc (pairwise) comparisons were computed using paired samples $t$-tests.

### *4.4.6 Results*

Accuracy of word target categorization revealed a main effect of Prime Type, $F(1.54, 46) = 32.74$, $p < .001$, $\eta_p^2 = .59$. The accuracy of target word evaluation when primed by laughs was significantly greater than target words primed by positive IADS, $t(23) = 4.16$, $p < .001$ and negative IADS, $t(23) = 7.64$, $p < .001$. Additionally, the accuracy to target word evaluation when primed by positive IADS was significantly greater than target words primed by negative IADS, *t*(23) = 4.27, $p < .001$. There was no main effect of Target Valence, *F*(1, 23) = 0.50, $p = .49$, $\eta_p^2 = .02$. A significant interaction between Prime Type and Target Valence was found, *F*(1.15, 46) = 5.23, $p = .03$, $\eta_p^2 = .19$. For comparisons related to affective priming, post hoc tests indicated that there was no significant difference between positive and negative targets when primed by laughs. There was also no difference between positive and negative targets when primed by positive IADS. However, negative target words primed by negative IADS were significantly less accurate than positive target words primed by negative IADS ($p = .004$).

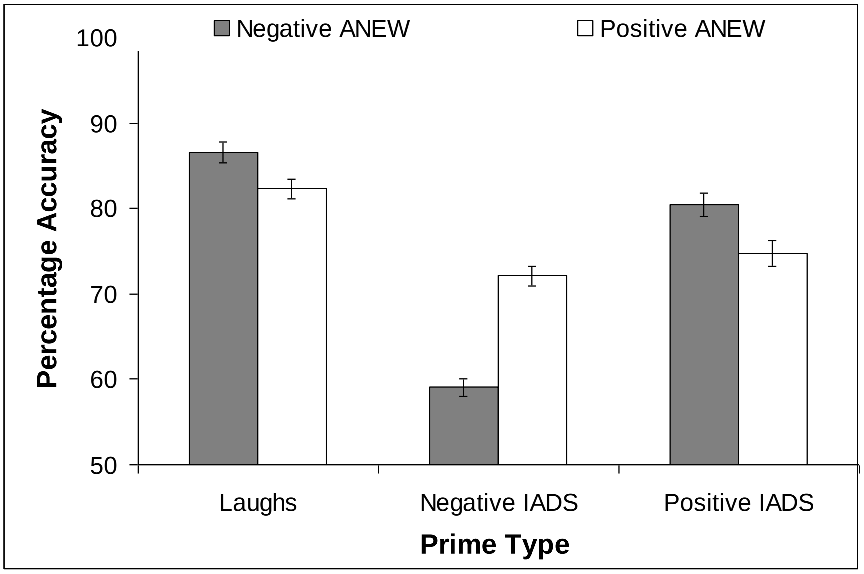

Figure 8. Accuracy results for Experiment 3

Reaction time of accurate responses revealed a main effect of Prime Type, *F*(1.411, 46) = 51.25, $p < .001$, $\eta_p^2 = .69$. RT was faster for target words primed by laughs than positive IADS, *t*(23) = 2.15, $p<.05$ and negative IADS, *t*(23) = 8.03, $p < .001$. RT was also faster when target words were primed by positive IADS than negative IADS, *t*(23) = 7.09, $p < .001$. A main effect of Target Valence was found, $F(1, 23) = 36.30$, $p < .001$, $\eta_p^2 = .61$. RT to positive target words was significantly faster than negative target words, $t(23) = 6.03$, $p < .001$. There was no significant interaction, $F(1.27, 46) = .30$, $p = .64$, $\eta_p^2 = .01$. For comparisons of interest to affective priming, post hoc tests indicated that positive target words primed by laughs were evaluated significantly faster than negative words primed by laughs, $t(23) = 3.97$, $p = .001$. Positive target words primed by negative IADS were evaluated significantly faster than negative target words primed by negative IADS $t(23) = 3.18$, $p = .004$. Positive target words primed by positive IADS were evaluated significantly faster than negative target words primed by positive IADS $t(23) = 3.78$, $p = .001$.

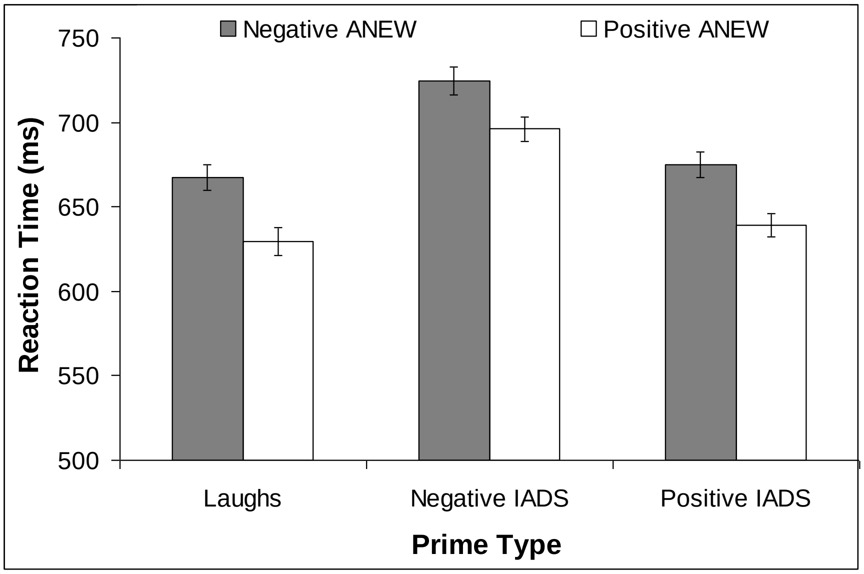

Figure 9. Reaction time results for Experiment 3

### *4.4.7 Summary*

The results of Experiment 3 demonstrate that the change in instruction from a simple valence judgment about the target word to a prime-target emotion congruency judgment made the priming task more difficult. This is evidenced by an overall decrease in accuracy and increase in reaction time compared to Experiments 1 and 2. Target words primed by laughs displayed greater accuracy than other prime categories. Target words primed by negative IADS showed a deficit in accuracy compared to positive IADS primes and laughs, especially for the congruent condition in which evaluation of negative target words primed by negative IADS approached chance level. It appears that for a task involving a prime-target congruency judgment, accuracy effects are present. However, they are in the reverse direction of what was expected to result from affective priming. For all prime categories, incongruent prime-target pairs had greater accuracy than congruent pairs. The change of task instruction to a prime-target congruency judgment increased the demand on cognitive resources, particularly attention. Such a reduction in resources may also have led participants to adopt a simple prime-target discrimination strategy. Such a strategy would make incongruent prime-target combinations easier to recognize than congruent combinations. The especially large decrement in accuracy for negative IADS primes suggests that negative stimuli may receive preferential processing which consumes attentional resources and increases error in the discrimination strategy. Dijksteruis and Aarts (2003) suggest that negative stimuli undergo more elaborate processing than positive stimuli, and that this processing consumes attention resources that interferences with other information processing.

With regard to reaction time, target words primed by laughs were more quickly evaluated than other prime categories. Overall, participants were slower to respond to negative than positive target words. They were also slower to respond to words primed with negative than positive sounds. Positive affect primes (laughs and positive IADS) appear to produce priming effects in the expected direction (congruent faster than incongruent). However, negative primes produced the reverse effect (congruent slower than incongruent). The reason for the reversed priming effects associated with accuracy for negative primes when measured by RT could again be related to the preferential processing of negative stimuli proposed above. Pratto and John (1991) found that negative stimuli consumed attentional resources dedicated to a color naming task that consistently resulted in longer RTs than positive stimuli. Presentation of negative stimuli during the task consume more of an already reduced pool of attention resources that were tapped by the more difficult congruency judgment task instruction, as compared to judgments made in Experiments 1 and 2. And when both the prime and the target stimuli are negative, the decrement in RT is greatest. The apparent reversal of the priming effect for negative primes in the congruency judgment task might be due to cognitive processing resource limitations rather than a reversed priming effect.

### 4.5 Behavioral Experiments Meta Analysis

Priming effects in the valence judgment experiments were small, which made them difficult to detect in the behavioral experiments. Many studies examine priming differences between congruent and incongruent conditions of the priming task to increase power. Therefore, data from Experiments 1 and 2, which involved a target valence evaluation on behalf of the participants, were combined. The conditions that were combined to form the congruent prime-target combination condition included positive IADS primes paired with positive target words, and negative IADS primes paired with negative target words. The conditions that were combined to form the incongruent prime-target combination condition included positive IADS primes paired with negative target words and negative IADS primes paired with positive target words. A paired samples *t*-test performed on accuracy measures showed that congruent conditions were evaluated significantly more accurately than incongruent conditions, $t(43) = 2.16$, $p < .04$. Figure

10 illustrates that the difference in accuracy between congruent and incongruent conditions. The difference in accuracy is small, but with the increased statistical power gained by combining Experiments 1 and 2 the subtle priming effect was revealed. A paired samples *t*-test on reaction time showed that congruent conditions were evaluated significantly faster than incongruent conditions, $t(43) = 2.53$, $p < .02$. Figure 11 illustrates the difference in RT between congruent and incongruent conditions. Similar to accuracy the increased statistical power gained by combining Experiments 1 and 2 revealed the small but significant priming effect. These results suggest that emotional priming using positive and negative affective sounds is present in these behavioral experiments; however, they are not robust, as they require increased statistical power to be detected in behavioral data.

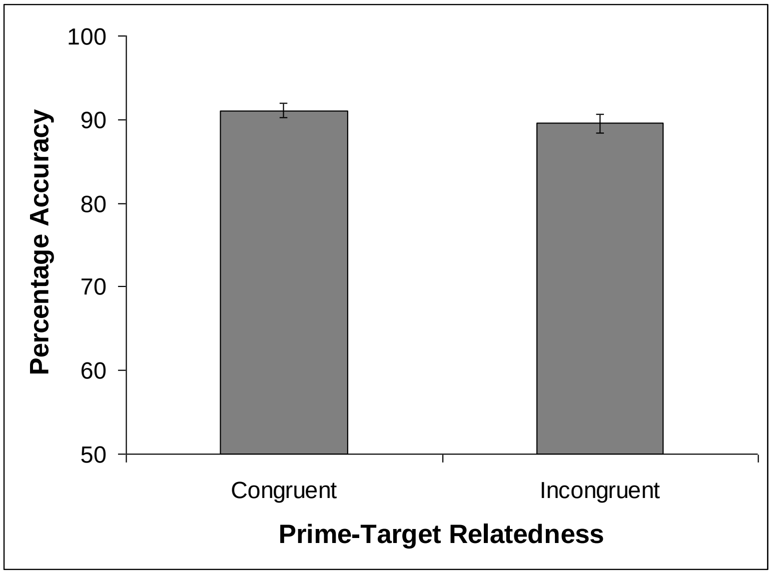

Figure 10. Accuracy for congruent and incongruent conditions in Experiments 1 and 2

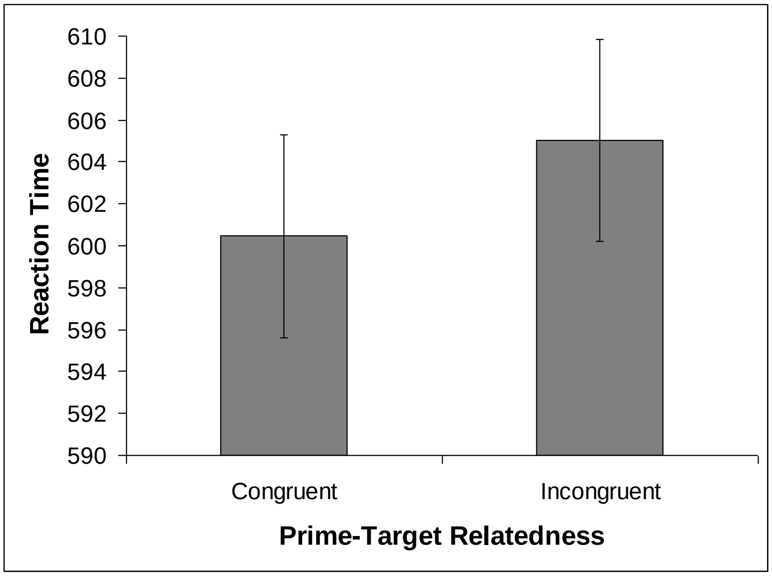

Figure 11. RT of congruent and incongruent conditions in Experiments 1 and 2

### 4.6 Interim General Discussion

The goal of the behavioral experiments above was to test the priming effects associated with the newly developed cross-modal paradigm. While the results did not show robust and significant priming effects, Experiments 1 and 2 showed that affectively congruent IADS prime and word target combinations were associated with faster and more accurate responses than incongruent combinations. Additionally, laughs did appear to operate as positive primes in Experiment 1, and produce a similar accuracy and RT pattern to positive IADS primes. An intriguing finding was the reversal of the priming effect for negative primes. When all three experiments are compared the pattern of priming effects seems consistent with regard to direction of priming. Additionally, the fact that different groups of participants performed the different tasks suggests that the effects of affective priming, although subtle, are reliable.

# 5 ERP EXPERIMENT

The ERP experiment was designed to address the four research questions of interest. The first question was whether emotion priming was present in the affective priming paradigm. The second question was whether evidence of valence-specific effects was present in the ERP patterns evoked during the priming task. The third question was whether laughs evoked a distinct ERP pattern from other affective sounds. And the fourth question was whether any effects related to laughs varied under different social contexts.

## 5.1 ERP Experiment Method

### *5.1.1 Study Design*

The overall design of Experiment 4 included two parts, which were separated by a mood manipulation. Both parts utilized the same priming task used in Experiment 1. The factors in the analysis of behavioral data in the ERP experiment include Prime Type and Target Valence. The factors in the analysis of ERP component patterns include Prime Type, Target Valence, Caudality, and Laterality. This analysis was conducted separately for Parts 1 and 2.

### *5.1.2 Participants*

Forty-eight right-handed female native English speakers (ages 18-29) were recruited to participate in the study. All participants had normal hearing and normal or corrected-to-normal vision, no history of neurological impairment, learning disabilities, or diagnosis of epilepsy.

### *5.1.3 Materials*

#### *5.1.3.1 Stimuli*

The same sound prime stimuli and targets used in Experiment 1 and 3 were used.

#### *5.1.3.2 Mood Manipulation*

The mood manipulation adapted experiment materials from Anderson et al. (2008). The form used for this manipulation is provided in Appendix C. See Section 5.1.4 (Procedure) for details regarding implementation of the mood manipulation protocol.

#### *5.1.3.3 Psychological Assessments*

The Positive and Negative Affective Scale (PANAS; Watson et al., 1988) was used to measure both trait and state affect of the participant. At the beginning of the experiment session trait affect was be measured using the PANAS under instructions to rate each of the affective adjectives indicating "to what extent you have felt this way during the past few weeks." Each of the 20 adjectives were rated on a five point scale (1-Very slightly or Not at all, 2 – A little, 3 - Moderately, 4 – Quite a bit, 5 – Extremely) resulting in a score range of 10 to 50 for PA and NA. State affect was measured over the course of the experiment under instructions to indicate "to what extent you feel this way right now" on the same scale. State affect was measured immediately before beginning experimental trials, again following the mood manipulation, and at the end of the experiment. The three instances in which the state PANAS was administered to participants was analyzed using separate repeated-measures ANOVAs for changes in PA and NA.

Measures of social anxiety were collected at the beginning of the experiment session using the Liebowitz Social Anxiety Scale-self report (LSAS; Leibowitz, 1987), the Social Phobia Scale (SPS) and the Social Interaction Anxiety Scale (SIAS) of Mattick and Clarke (1998). The LSAS is a 24 item scale that assesses the degree of fear (none, mild, moderate, severe) and avoidance (never, occasionally, often, usually) of different social situations over the past week. The SPS is a 20 item scale that measures the amount someone fears being viewed negatively by others when doing everyday things. (For example: I feel awkward and tense if I know people are watching me.) The SIAS is a 19 item scale that measures the amount of fear someone experiences specific to interacting in a social exchange. (For example: I have difficulty talking with other people.) This information was collected to control for social anxiety sensitivity in follow-up analyses. These scales are based on self-report and can be conducted without a clinician present. The SPS and SIAS were used in previous ERP paradigms (Li et al. 2008, cite) to investigate the strength of priming effects.

The PhoPhiKat-45 questionnaire (See Appendix C) developed by Ruch and Proyer (2009) was collected following the mood manipulation during the break for two purposes. First, the questionnaire assesses participant sensitivity to laughter on 3 subscales composed of 15-item each. The subscales measure sensitivity to fear of being laughed at (Pho-, gelotophobia), enjoyment of being laughed at (Phi-, gelotophilia), and enjoyment of laughing at others (Kat, katagelasticism). Individual differences in perception of laughter indicated by the subscales may be informative during follow-up analyses of experimental data. Second, administering the questionnaire during the mood manipulation procedure may bring to mind the significance of laughter following a mood manipulation.

### *5.1.4 Procedure*

When the participants arrived in the laboratory they read and signed the informed consent form and then completed preliminary questionnaires. They first completed a questionnaire that asked about presence of head trauma, epilepsy, migraines, normal vision, normal hearing, learning disorders, other cognitive impairments, and English as their native language. They then completed the Edinburgh Handedness Inventory (EHI), LSAS, SAIS, SPS, and the trait version of the PANAS. The geodesic sensor net was applied using standard techniques by trained personnel. High-fidelity ear-insert headphones (Etymōtic ER-2, Etymōtic Research Inc, Elk Grove Village, IL) were used to deliver sounds to the participant. The experimental session consisted of two parts which were separated by a mood manipulation procedure. Part 1 began with a practice session, followed by six blocks of 78 prime-target trials each (468 total trials). Part 2 was structured in the same way, but used a re-randomized delivery order of experiment stimuli.

Between Parts 1 and 2, we conducted a socioemotional manipulation, using a procedure adapted from Anderson et al. (2008). Participants were instructed to think of a time when they experienced intense humiliation, embarrassment, or shame in public and to compose a written narrative about their personal experience in order to bring to mind negative feelings and thoughts. The procedure was intended to activate memories of social rejection, with the goal of associating laughs in the task with social anxiety. At the end of the mood manipulation the participants completed the PhoPhiKat-45 questionnaire, which was intended to orient the focus of the mood manipulation toward laughter as a negative social cue.

At the end of the experiment session, EEG sensor net was removed and cleaned according to standard EGI procedures. The participant was debriefed and provided with a copy of their informed consent form, and asked not to reveal the purpose to other potential participants. Each experimental session lasted between 2 and 2.5 hours and was conducted by two or more trained personnel.

#### *5.1.4.1 Experiment Protocol*

Following completion of the initial questionnaires and the application of the geodesic sensor net, the participant filled out the state PANAS. The participant was also shown the EEG artifacts that occur as a result of eyeblinks, eye movements, head movements, brow, jaw and neck muscle tension and given instructions about how to avoid or minimize them. They were instructed to make their eyeblinks quick, to keep their face relaxed, and to wait for 10 seconds before continuing that task after making any significant movement. Next they were shown the behavioral task and performed 20 practice trials to confirm they understood the task and how to minimize artifacts. Participants rested the index finger of each hand on the two response box buttons they were to use to make their evaluation of the target word. A green fixation crosshair was present in the center of the screen, during which time the participant could make eyeblinks and movement. As described in Section 4.1.1, each trial of the task was initiated by the participant by pressing one of the two buttons, which then turned the fixation crosshair gray to signify the trial was underway. After a variable 500-1000 ms pause, the prime sound was presented binaurally for 500 ms. Immediately following the sound offset, the target word replaced the gray fixation crosshair in the center of the screen. The participant was instructed to make the evaluation as quickly and accurately as possible within less than a second of it appearing on the screen. The green fixation crosshair then reappeared in the center of the screen. In between each of the six experimental blocks of the task a rest period was provided so that the participant could move and research staff could make adjustments to sensors to eliminate any noise. After completing the six blocks of the task, experiment staff gave the participants the state PANAS a second time and gave instructions for completing the social anxiety event narrative that served as the mood manipulation. Participants were given up to 10 minutes to write a short narrative describing a humiliating situation that they remembered well and describe the negative thoughts the situation led them to believe about themselves. After completing the narrative, they were asked to complete the PhoPhiKat-45 questionnaire about laughter. During this time all EEG sensors were rewet with electrolyte and impedances were confirmed to be within limits before second task was begun. The mood manipulation materials were left visible to the participant on the table by their response box as a reminder while they performed the second ERP task. After completing the six blocks of trials in the second task, they completed the state PANAS a final time. Participants were thanked for their participation and excused.

### *5.1.4.2 Data Acquisition*

#### 5.1.4.2.1 Behavioral Data Acquisition

E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) was used to record accuracy and timing of behavioral responses the same as in Experiments 1-3.

#### 5.1.4.2.2 EEG Data Acquisition

Whole-head neurophysiological (EEG) activity was measured using a HydroCel Geodesic Sensor Net (HCGSN, Electrical Geodesics, Inc.) and digitized at a sampling rate of 250 Hz. HCGSN sensors are arranged in a 256-channel array of silver/silver chloride (Ag/AgCl) electrodes, which are enclosed in injection-molded plastic housing and embedded in surgical sponges. The electrode array is dipped in electrolyte (salt water) prior to application. Application and adjustment of the sensors takes approximately 30 minutes. The Net is disinfected according to FDA guidelines between uses.

### *5.1.4.3 Data Analysis*

#### 5.1.4.3.1 Behavioral Data Analysis

Responses to target-word categorization with reaction times less than 300 ms and greater than 900 ms were excluded. Participants with accuracy below two standard deviations of the mean or RT above two standard deviations of the mean were also excluded. Mean accuracy and reaction time for each participant and each condition were entered into a 3 (Prime Type) x 2 (Target Valence) repeated-measures analysis of variance (ANOVA). Greenhouse-Geisser corrected degrees of freedom, *F*-ratios, and *p*-values and are reported where Mauchly's test of sphericity was significant. Post hoc (pairwise) comparisons were computed using pair samples *t*-tests.

#### 5.1.4.3.2 EEG Preprocessing

Raw EEG data recordings were filtered offline using a bandpass of 0.1 to 30 Hz. Each recording was segmented into 1,300 ms epochs, beginning 300 ms before onset of the target word and extending to 1,000 ms after word onset. Each segment was checked for artifact contamination (eyeblinks and eyeblink recovery, alpha, and EMG). Contaminated channels were marked bad if trials contained blinks or eye movement amplitudes greater than 150 μV, if differential average amplitude (i.e., change in slope) is greater than 75 μV, if the channel was flat (had zero variance), or if manual inspection suggests noise specific to that channel (i.e., not affecting surrounding channels) was present. Any channel marked bad for more than 20% of the total trials was interpolated (replaced) using NetStation 4.6.4 (Electrical Geodesics, Inc.) bad channel replacement function.

After artifact correction, EEG segments were averaged across trials (within subjects and within condition) to create stimulus-locked ERPs. The ERPs were referenced from Cz to the average of the 256 channels using a weighted average that corrects for polar average reference effect. The ERPs were then baseline corrected by subtracting the baseline (average amplitude over pre-baseline window) from each sample.

Following ERP preprocessing and artifact correction procedures, a sample of 25 participants were used in the final dataset to evaluate the effects of the cross-modal paradigm on neurocognitive activity. The reasons for exclusion from the final ERP analysis include: presence of excessive eyeblink or eye recovery artifact, excessive EMG activity or alpha waveband contamination, excessive 60 Hz line noise, pre-baseline offset differences, or because they did not complete both parts of the Experiment 4, displayed low performance, or because of computer crashes.

#### 5.1.4.3.3 ERP Statistical Analysis

NetStation software was used to extract the mean amplitude of waveform patterns for each component time window and experiment conditions. Separate analyses of differences between conditions were performed using a repeated measures ANOVAs to test for effects four variables: Prime Type (Laugh, Positive IADS, Negative IADS), Target Valence (Positive ANEW, Negative ANEW), Caudality (varied by component of interest), and Laterality (Middle, Left, Right). Table 7 shows the analysis time window and analysis locations for each of the four ERP components of interest.

Table 7. ERP Component Analysis Windows and Scalp Distribution

| Component (Effect) | Time Window | Caudality | Laterality |
|---|---|---|---|
| EPN | 200-300 ms | Parietal, Occipital | Middle, Left, Right |
| MFN | 250-450 ms | Frontal, Central | Middle, Left, Right |
| N400 | 300-450 ms | Central, Parietal | Middle, Left, Right |
| LPP | 450-700ms | Central, Parietal, Occipital | Middle, Left, Right |

Table 8 provides a list of sites included in regions of interest (ROIs) defined by caudality and laterality and Figure 12 displays their positions on the scalp surface. Different levels of caudality and laterality were selected for ERP components based on their expected topographical distribution. Refer to Figure 1 for headmaps of known ERP effect topographies that guided ROI caudality and laterality variable level foci. Greenhouse-Geisser corrected degrees of freedom, *F*-ratios, and *p*-values and are reported where Mauchly’s test of sphericity was significant. Post hoc (pairwise) comparisons were computed using paired samples *t*-tests.

Table 8. Scalp EEG Electrode Locations in Regions of Interest (ROI)

| Regions of Interest (ROI) | | 10-20 | 10-10 (incl. 10-20) |
|---|---|---|---|
| **frontal** | mid frontal | Fz, Fpz | Fz, Af1, Afz, Fpz, Af2, F1, F2 |
| | left frontal | F3 | F3, Af3, Af5, F5 |
| | right frontal | F4 | F4, Af4, Af6, F6 |
| | left frontotemporal | F7, Fp1 | F7, Af7, Fp1, F9 |
| | right frontotemporal | F8, Fp2 | F8, Af8, Fp2, F10 |
| **central** | mid central | Cz | Cz, C1, C2, Fcz, Fc1, Fc2 |
| | left central | C3 | C3, C5, Fc3, FC5 |
| | right central | C4 | C4, C6, Fc4, FC6 |
| | left centrotemporal | T7 | T7, T9, FT7, FT9 |
| | right centrotemporal | T8 | T8, T10, FT8, FT10 |
| **parietal** | mid parietal | Pz | Pz, P1, P2, Cpz, Cp1, Cp2 |
| | left parietal | P3 | P3, P5, Cp3, Cp5 |
| | right parietal | P4 | P4, P6, Cp4, Cp6 |
| | left posterotemporal | P7 | P7, P9, TP7, TP9 |
| | right posterotemporal | P8 | P8, P10, TP8, TP10 |
| **occipital** | mid occipital | Oz | Oz, POz, PO1, PO2, Iz |
| | left occipital | O1 | O1, PO3, PO5 |
| | right occipital | O2 | O2, PO4, PO6 |
| | left occipitotemporal | — | PO7, PO9, I1 |
| | right occipitotemporal | — | PO8, PO10, I2 |

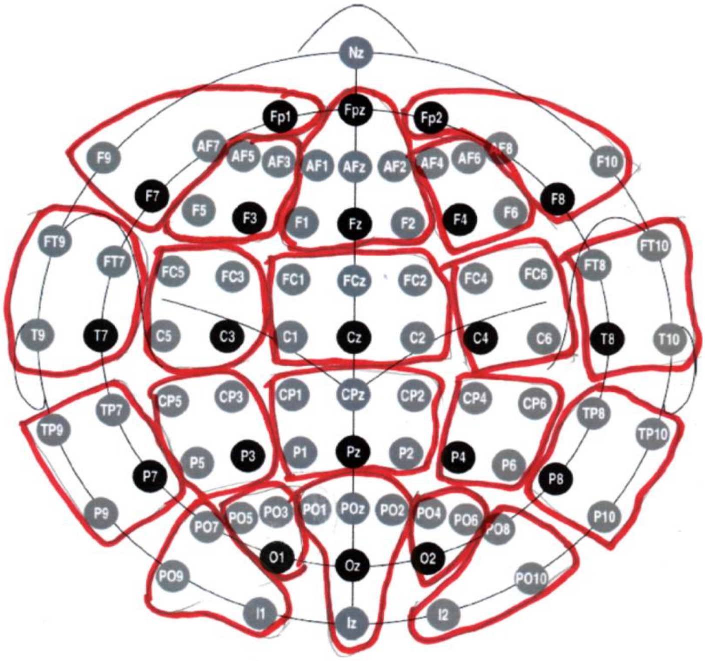

Figure 12. Scalp regions-of-interest for ERP topographic analysis

In order to examine ERP patterns with respect to relatedness between prime and target stimuli congruent and incongruent conditions were computed from data associated with positive IADS and negative IADS primes paired with positive and negative ANEW target words for each of the ERP pattern windows. Specifically, data for positive IADS primes paired with positive ANEW targets was combined with data for negative IADS primes paired with negative ANEW targets to derive the congruent condition. Data for positive IADS primes paired with negative ANEW targets was combined with data from negative IADS primes paired with positive ANEW targets to derive the incongruent condition. This process was performed for each of the ERP components (EPN, MFN, LPP). Laugh primes were not included and data following the mood manipulation was not included.

## 5.2 Results

### *5.2.1 Psychological Assessment Results*

The results of psychological assessments collected including the trait PANAS, LSAS, SAIS, SPS, GELOPH-45 that are descriptive of the participant sample are included in Table 8.

Table 9. Psychological Assessment Data Results

| Measure | *M* (ERP Ps) | *SD* (ERP Ps) | *M* (excluded Ps) | *SD* (excluded Ps) |
|---|---|---|---|---|
| Trait Positive Affect (past few weeks) | 33.64 | 7.30 | 29.43 | 7.62 |
| Trait Negative Affect (past few weeks) | 19.64 | 6.30 | 21.57 | 6.73 |
| Gelotophobia | 28.56 | 6.84 | 32.14 | 8.17 |
| Gelotophilia | 39.76 | 8.01 | 34.91 | 10.94 |
| Katagelasticism | 27.72 | 7.14 | 27.66 | 9.15 |
| LSAS Total Fear | 18.63 | 11.16 | 21.67 | 11.08 |
| LSAS Fear of Social Interaction | 8.50 | 5.47 | 10.35 | 5.79 |
| LSAS Fear of Performance | 10.57 | 5.73 | 11.98 | 5.63 |
| LSAS Total Avoidance | 20.63 | 11.87 | 24.91 | 15.52 |
| LSAS Avoidance of Social Interaction | 10.17 | 6.16 | 12.45 | 7.61 |
| LSAS Avoidance of Performance | 10.46 | 6.02 | 12.45 | 8.61 |
| SAIS | 20.21 | 10.74 | 22.91 | 12.86 |
| SPS | 15.08 | 11.52 | 17.80 | 19.69 |

Results of one-way ANOVAs comparing participants included in the ERP computations to participants not included revealed no significant differences amongst psychological assessment measures. Mattick and Clark (1998) report mean SAIS (*M* = 18.5, *SD* = 10.0) and SPS (*M* = 14.2, *SD* = 10.2) for 324 undergraduate females which are similar to the present sample. Fresco, Coles, Heimberg, Liebowitz, Hami et al. (2001) measured 53 non-anxious (28 men and 25 women) participants for comparison to an anxious sample. They report LSAS (self-report version) measures of total fear (*M* = 7.49, *SD* = 7.21), fear of social interaction (*M* = 3.29, *SD* = 3.43), fear of performance (*M* = 4.20, *SD* = 4.10), total avoidance (*M* = 6.00, *SD* = 6.16), avoidance of social interaction (*M* = 2.86, *SD* = 3.39), and avoidance of performance (*M* = 3.14, *SD* = 3.32). The scores for each scale are approximately twice as large in the present sample. This suggests that the present sample was composed of relatively high anxious participants.

#### *5.2.1.1 State PANAS Assessment Results*

Positive affect declined significantly over the course of the experiment, $F(2, 48) = 10.54$, $p < .001$, $\eta_p^2 = .31$. Before beginning the first part of the ERP experiment, PA was significantly higher ($M = 26.56$) than after completing the first ERP task ($M = 23.20$). Positive affect did not decline significantly from the second administration of the PANAS and the final assessment at the end of second ERP task ($M = 23.72$). A repeated-measures ANOVA conducted on state NA showed that negative affect did not change significantly over the course of the three assessment periods, $F(2, 48) = 1.23$, $p = .30$, $\eta_p^2 = .05$. Before beginning the first part of the ERP experiment ($M = 12.40$), NA was similar to the second administration ($M = 13.28$) and final administration ($M = 12.88$).

### ***5.2.2 Behavioral Results***

Prior to mood manipulation, Part 1, behavioral data collected from the 25 participants was suitable for analysis. As in the previous behavioral experiments, responses to target word categorization with reaction times less than 300 ms were excluded. One participant was excluded due to low number of correct responses and accuracy. Participants had a minimum accuracy of 61%; however performance was greater than 70% for the vast majority of participants. The minimum number of correct trials was 48. Degrees of freedom and probability statistics are reported using Greenhouse-Geisser adjusted values where Mauchley’s test of sphericity was significant.

Accuracy of target word categorization revealed a main effect of Prime Type, $F(2, 48) = 5.75$, $p = .006$, $\eta_p^2 = .19$. Evaluation of target words primed by laughs were significantly more accurate than when primed by positive IADS, $t(24) = 2.96$, $p = .007$. Evaluation of target words primed by negative IADS was also significantly more accurate than when primed by positive

IADS, *t*(24) = 2.49, $p < .03$. There was no main effect found for Target Valence, *F*(1, 24) = .27, $p = .61$, $\eta_p^2 = .01$. A significant interaction was found, *F*(2, 48) = 3.63, $p < .04$, $\eta_p^2 = .13$. For post-hoc comparisons related to affective priming, there were no differences between positive words and negative words that were primed laughs, positive IADS, or negative IADS.

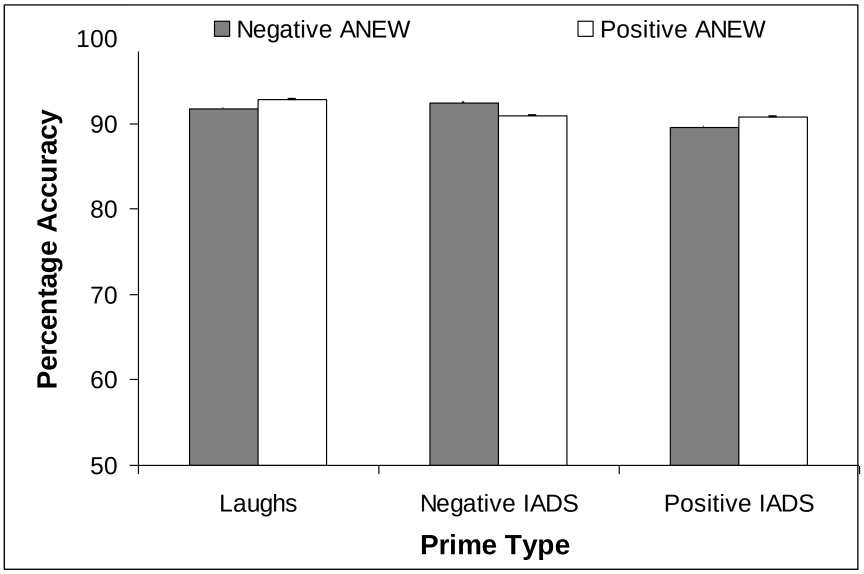

Figure 13. Mean accuracy for target word evaluation in Experiment 4 prior to mood manipulation

Reaction time to target word evaluation did not reveal a main effect of Prime Type, *F*(1.49, 48) = 2.38, $p = .12$, $\eta_p^2 = .09$. There was also no main effect of Target Valence, *F*(1, 24) = .20, $p = .66$, $\eta_p^2 = .01$. Nor was there a significant interaction, *F*(2, 48) = .72, $p = .49$, $\eta_p^2 = .03$.

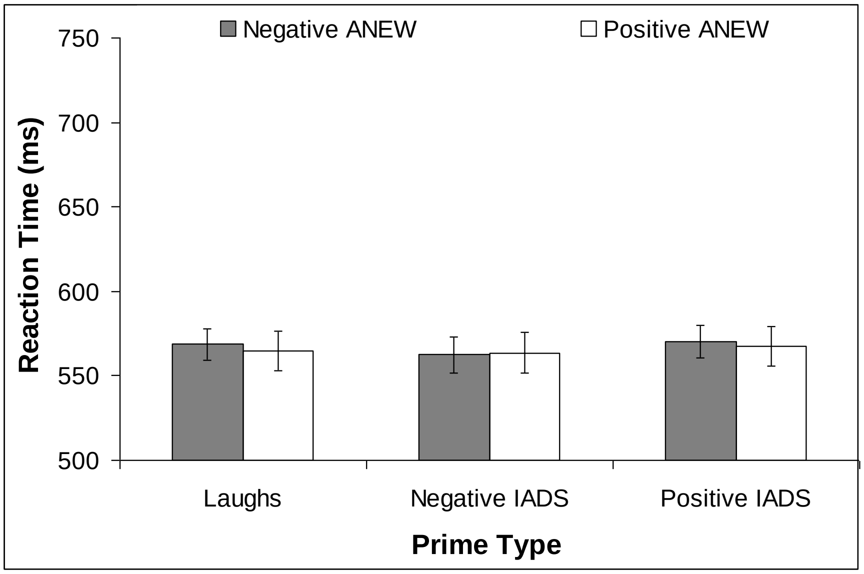

Figure 14. Mean reaction time for target word evaluation in Experiment 4 prior to mood manipulation

Following the mood manipulation, Part 2, behavioral data collected from the 25 participants were suitable for analysis. As in the previous behavioral experiments, responses to target word categorization with reaction times less than 300 ms were excluded. The minimum accuracy was 70%, and the minimum number of correct trials was 51.

Accuracy of target word categorization revealed a main effect of Prime Type, $F(2, 48) = 6.66$, $p = .003$, $\eta_p^2 = .22$. Target words primed by laughs were evaluated significantly more accurately than words primed by positive IADS, $t(24) = 2.19$, $p < .04$. Target words primed by negative IADS were evaluated significantly more accurately than words primed by positive IADS, $t(24) = 3.76$, $p = .001$. There was no main effect of Target Valence, $F(1, 24) = 1.72$, $p = .20$ $\eta_p^2 = .07$. However, there was a significant interaction, $F(2, 48) = 6.58$, $p = .003$, $\eta_p^2 = .22$. For the comparisons relevant to affective priming positive target words primed by positive IADS were evaluated more accurately than negative words primed by positive IADS, *t*(24) = 3.05, *p* = .006.

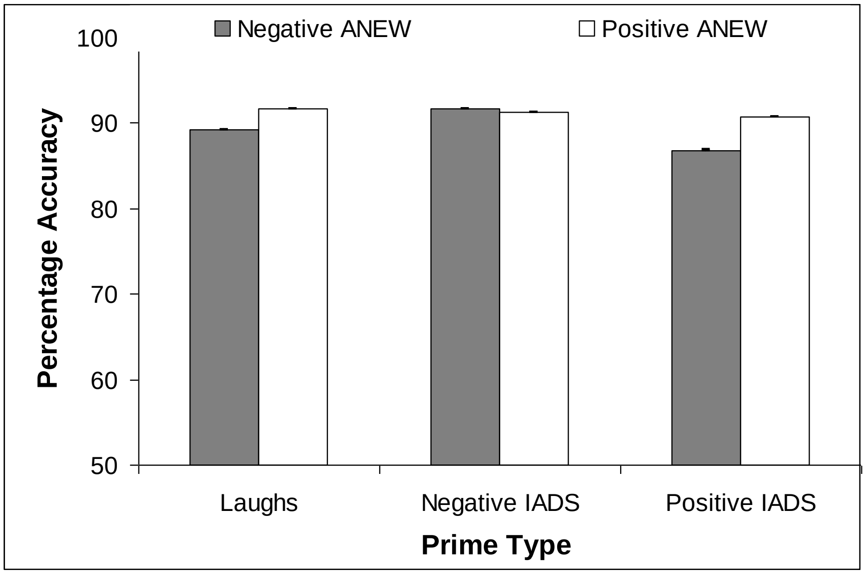

Figure 15. Mean accuracy for target word evaluation in Experiment 4 following mood manipulation

Reaction time to target words did not reveal a main effect of Prime Type, *F*(2, 48) = 1.11, *p* = .34, $\eta_p^2$ = .04. No main effect of Target Valence was present, *F*(1, 24) = .60, *p* = .45, $\eta_p^2$ = .02. Nor was there a significant interaction: *F*(2, 48) = 2.39, *p* = .10, $\eta_p^2$ = .09. None of the post hoc comparisons relevant to affective priming were significant.

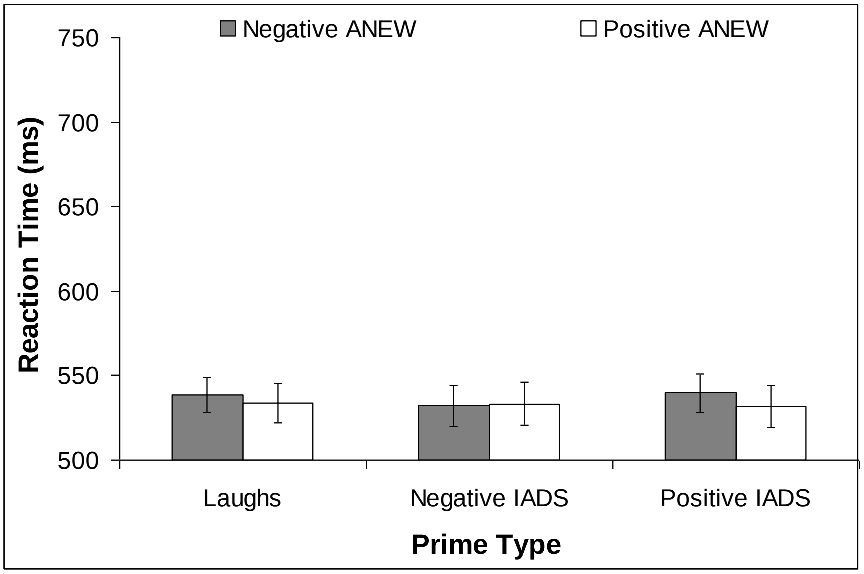

Figure 16. Mean reaction time for target word evaluation in for Experiment 4 following mood manipulation

### *5.2.3 Emotion Relatedness Comparisons in Behavioral Data*

Comparisons of behavioral conditions in previous studies often examined whether the congruence and incongruence between prime and target stimuli showed priming effects, regardless of valence differences (i.e. collapsing over valence). To examine the behavioral data from the ERP experiment in a similar manner, positive IADS and negative IADS paired with positive and negative ANEW target words were used to compare effects of relatedness between prime and target. Specifically, data for positive IADS primes paired with positive ANEW targets was combined with data for negative IADS primes paired with negative ANEW targets to derive the congruent condition. Data for positive IADS primes paired with negative ANEW targets was combined with data from negative IADS primes paired with positive ANEW targets to derive the incongruent condition. This process was performed separately for both accuracy and RT data.

Laugh primes were not included as positive primes in this analysis to be consistent with the behavioral data meta analysis of Experiments 1 and 2.

The results of the relatedness comparisons using data combined from both Part 1 and Part 2 of Experiment 4 showed that responses to congruent conditions were significantly more accurate than incongruent conditions, *t*(49) = 4.13, *p* < .001 (See Figure 17.)

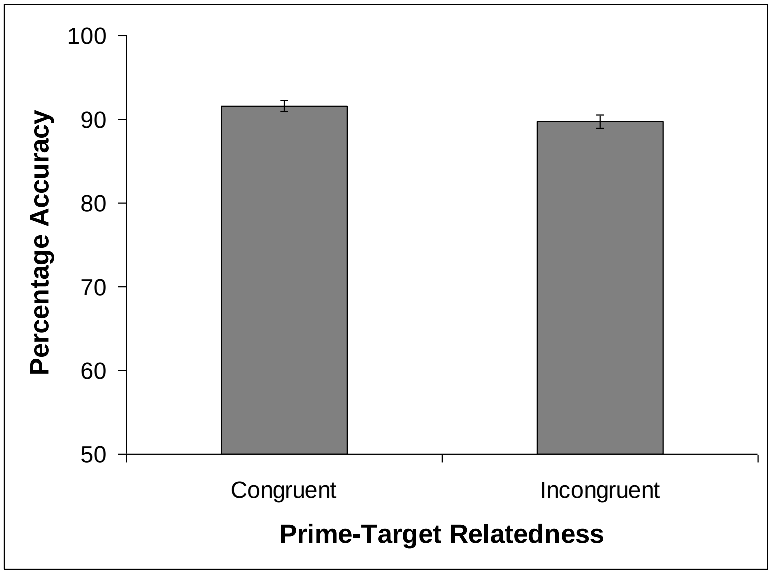

Figure 17. Accuracy of congruent and incongruent conditions in Experiment 4

The results of the relatedness comparisons for RT showed that congruent conditions were evaluated significantly faster than incongruent conditions, *t*(49) = 2.21, *p* < .03. (See Figure 18.)

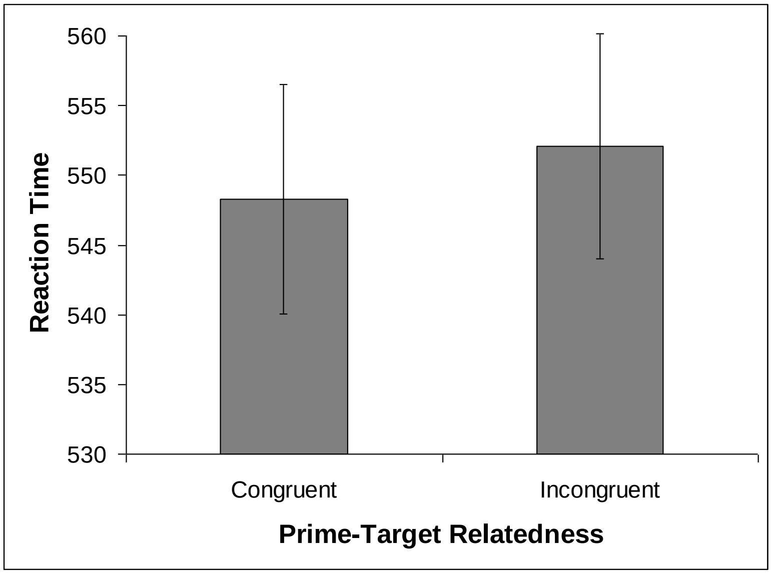

Figure 18. RT of congruent and incongruent prime-target combinations in Experiment 4

### *5.2.4 ERP Results*

For each of the four hypotheses, expected condition differences in four ERP patterns were investigated: the EPN (200-300 ms; Posterior ROI), the MFN (250-450 ms; Frontal ROI), N400 (350-500 ms; Posterior ROI), and LPP (400-700 ms; Posterior ROI).

#### *5.2.4.1 Summary of ERP Patterns*

ERP patterns evoked by the target stimulus are plotted in Figure 19. The left side of the figure displays the topographic (spatial) distribution of the ERP at the time of peak amplitude (positive or negative) for each pattern of interest (EPN, MFN, LPP). From left to right, the topographic maps represent the ERP response to positively valenced words, negatively valenced words, and the difference between negative and positive words. The waveform displayed on the right side shows the voltage change of the ERP for the electrode marked by an arrow in the difference topography. It is plotted over approximately one second following presentation of the target. Visual examination of the topographic maps shows that during the time window associated with an N400 (350-550 ms) there is a negativity that is medial and frontally distributed, which is characteristic of the MFN (250-450 ms) component. Therefore, results will be reported for MFN and not for the N400. The EPN effect shown in panel A is seen in the difference wave as negativity difference evoked by targets in the occipitotemporal region at approximately 275 ms. The MFN component in panel B shows a frontocentral negativity at approximately 330 ms. The LPP component in panel C shows a parietal positivity that peaks at approximately 600 ms.

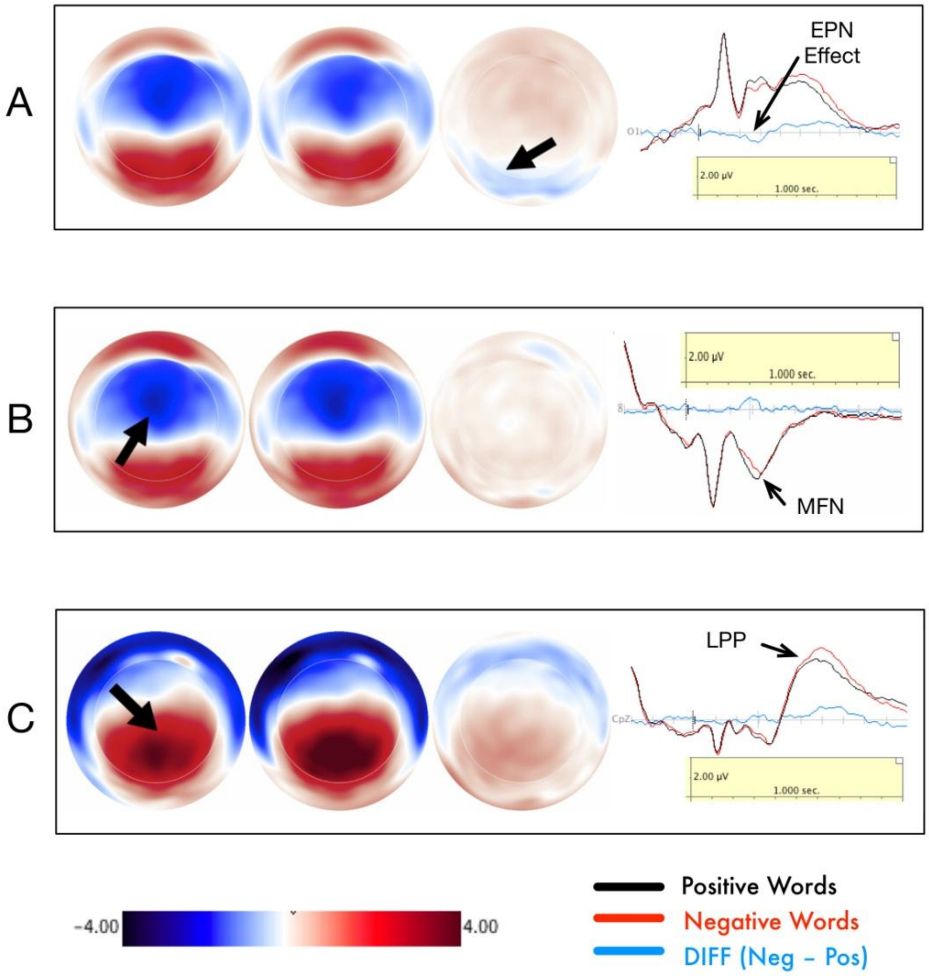

Figure 19. The EPN effect (A), the MFN component (B), and LPP component (C) found in Experiment 4

#### *5.2.4.2 ERP Results for Hypothesis 1 (Emotion Priming)*

Consistent with relatedness conditions computed for the behavioral data above, positive IADS and negative IADS paired with positive and negative ANEW target words were used to compare effects of relatedness between prime and target. Laugh primes were not included. There was no effect of relatedness found for any of the ERP patterns investigated with the restricted ROI-based *a priori* pattern definitions (EPN, MFN, LPP). However, visual inspection of additional regions suggested a relatedness effect at orbitofrontal locations (FP1, FPz, FP2, FP3, and FP4) at approximately 400-600 ms in the first half of the experiment (Neutral Context; Figure 20). Post hoc (exploratory) analyses confirmed that there was a small orbitofrontal relatedness effect. The unrelated condition was more negative than the related condition from at right orbitofrontal electrode Fp2, $t(24) = 2.04$, $p = .053$. There was no effect at the corresponding electrode, Fp1, in the left orbitofrontal region. The orbitofrontal effect was absent in the second half of the experiment.

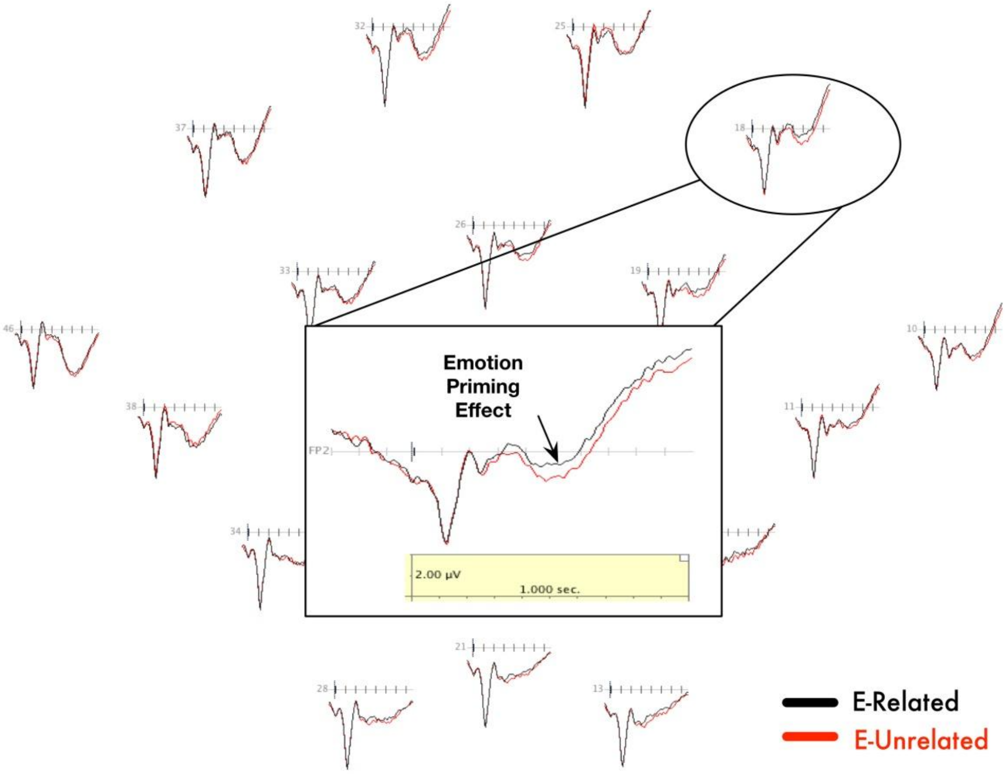

Figure 20. Orbitofrontal relatedness effect at Fp2 400-600 ms after onset of target word

### *5.2.4.3 ERP Results for Hypothesis 2 (Valence Effects)*

#### 5.2.4.3.1 EPN Effects

In the first half of the experiment (Neutral Context), the EPN showed a main effect of Target Valence $F(1, 24) = 10.06$, $p = .004$, $\eta_p^2 = .30$. Post-hoc analysis revealed that the EPN was more negative for unpleasant than pleasant words, $t(24) = 3.17$, $p = .004$. The EPN Target Valence effect was clarified by a two-way interaction, Target Valence X Caudality $F(1, 24) = 8.60$, $p = .007$, $\eta_p^2 = .26$. As illustrated in Figure 21, the EPN Target effect was stronger at occipital versus parietal sites.

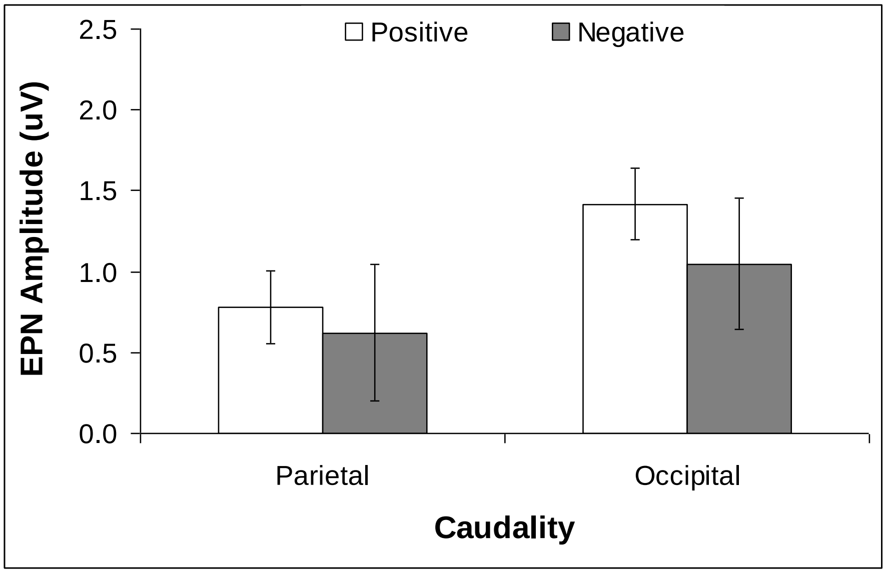

Figure 21. EPN Target Valence by Caudality Interaction

5.2.4.3.2 LPP Effects

A main effect of target valence was found for the LPP, *F*(1, 24) = 5.40, *p* = .029, $\eta_p^2$ = .18. Post-hoc comparisons showed that negative targets evoked a more positive pattern over posterior electrodes (i.e., a greater LPP response) than positive targets *t*(24) = 2.32, *p* = .029. The timing and topography of this effect are illustrated in Figure 22.

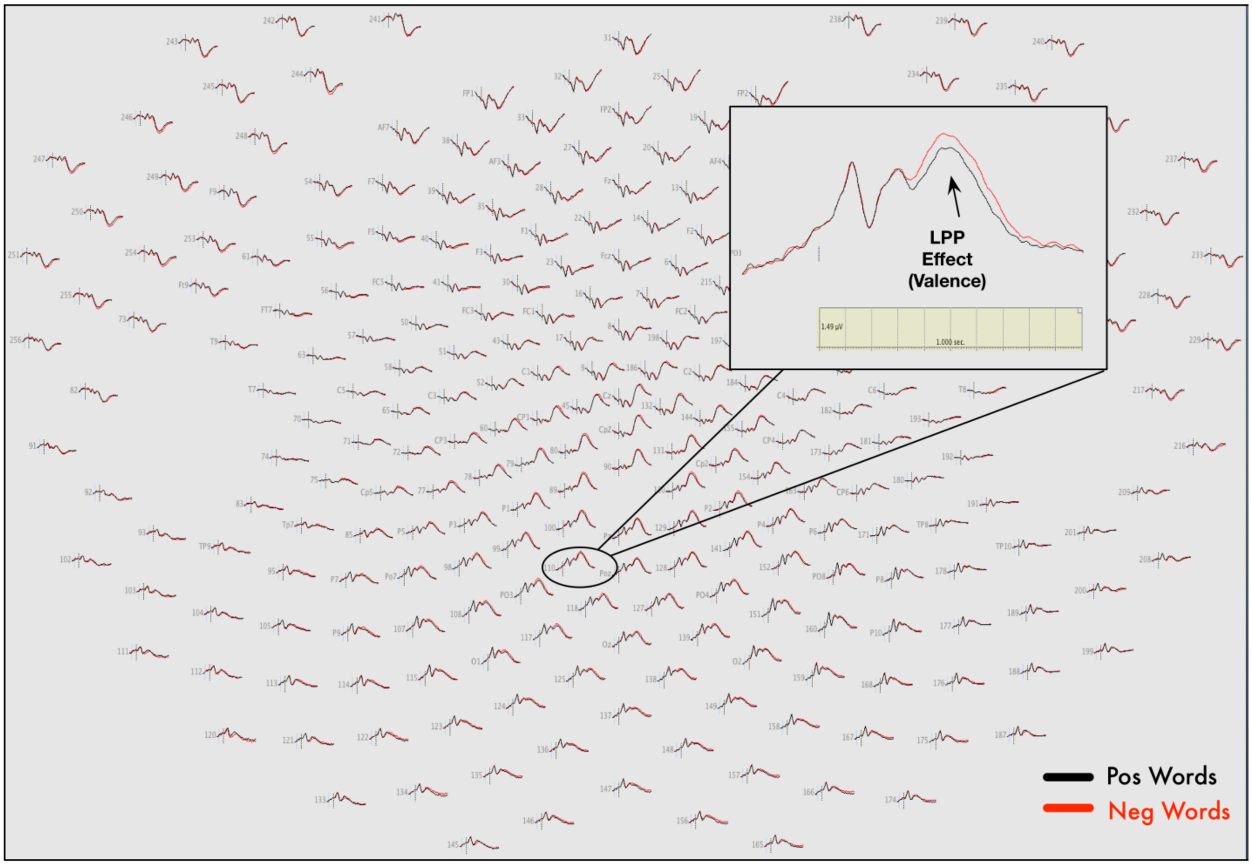

Figure 22. LPP Target valence effect

### *5.2.4.4 ERP Results for Hypothesis 3 (Laughter-Specific Effects)*

#### 5.2.4.4.1 EPN (Laugh) Effects

In the first half of the experiment (neutral context), the EPN showed a main effect of Prime Type $F(2, 48) = 5.44$, $p = .007$, $\eta_p^2 = .19$. Post-hoc comparisons showed that there was a stronger negativity in response to laughs versus positive IADS, $t(24) = 2.88$, $p = .008$ and in response to laughs versus negative IADS, $t(24) = 2.38$, $p < .03$. EPN mean amplitudes were not statistically different for positive and negative IADS primes. The EPN Prime Type effect was clarified by a 3-way interaction, Prime Type X Caudality X Laterality $F(8, 192) = 3.40$, $p = .014$, $\eta_p^2 = .12$. Post-hoc comparisons revealed that laughs were more negative than positive IADS at left, *t*(24) = 2.75, *p* = .011, and right, *t*(24) = 3.86, *p* = .001, parietal locations. Laughs were also more negative than positive IADS at left, *t*(24) = 2.24, *p* = .035, and right, *t*(24) = 3.30, *p* = .003, occipital locations. Compared to negative IADS, laughs were more negative over left, *t*(24) = 2.26, *p* = .033, and right parietal locations, *t*(24) = 3.62, *p* < .001, as well as right occipital locations, *t*(24) = 2.67, *p* < .013. The EPN of positive and negative IADS did not differ.

The EPN during the second half of the experiment revealed a significant main effect for Prime Type, *F*(2, 48) = 13.55, *p* < .001, $\eta_p^2$ = .36. Negative primes evoked a significantly more positive EPN than laugh primes, *t*(24) = 4.45, *p* < .001. Positive primes also evoked a significantly more positive EPN than laugh primes, *t*(24) = 4.20, *p* < .001. Positive and negative primes did not differ from each other with respect to EPN amplitude. The EPN Prime Type effect was clarified by a significant interaction with Caudality, *F*(2, 48) = 3.82, *p* = .029, $\eta_p^2$ = .14. The main effect for Prime Type showed that EPN amplitude for negative IADS primes was significantly more positive than for laugh primes, *t*(24) = 4.54, *p* < .001. Additionally, the EPN mean amplitude for positive IADS primes was significantly more positive than for laugh primes, *t*(24) = 4.20, *p* < .001. The EPN mean amplitude between positive IADS primes and negative IADS primes did not differ. The EPN also showed a significant interaction between Prime Type, Caudality, and Laterality, *F*(4.10, 192) = 4.71, *p* = .001, $\eta_p^2$ = .16.

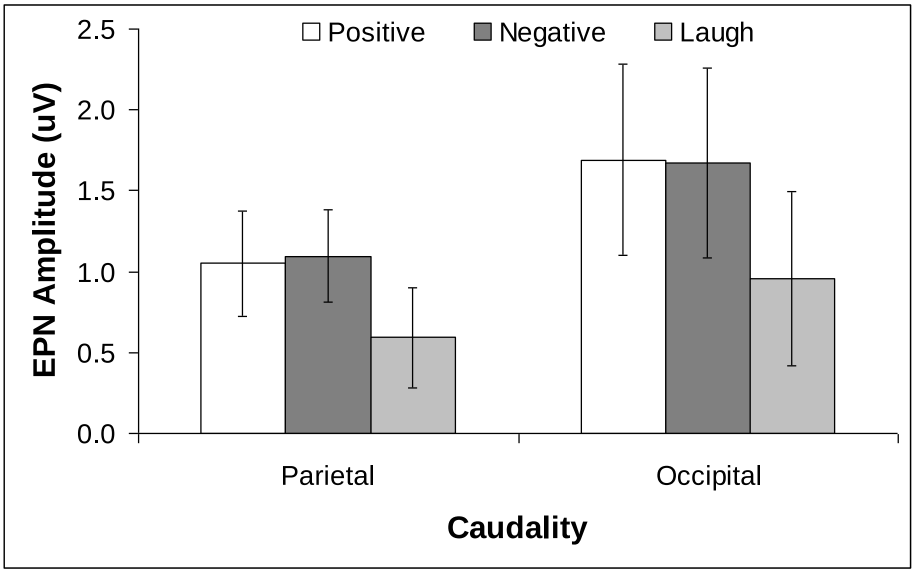

Figure 23. EPN Prime Type X Caudality Interaction

5.2.4.4.2 Orbitofrontal (Laugh) Effects

The medial frontal negativity (MFN) window showed a main effect of Prime Type, $F(2, 48) = 9.34$, $p < .001$, $\eta_p^2 = .28$. Post-hoc comparisons showed that the MFN was more positive in response to laughs than positive IADS, $t(24) = 3.39$, $p = .002$, and negative IADS, $t(24) = 3.51$, $p = .002$. MFN mean amplitudes were not statistically different between positive and negative IADS primes. The differences between the Prime Type conditions are displayed in Figure 24 and show the sustained positivity (or less negativity) beginning approximately 200 ms for laughs compared to IADS over frontal electrodes.

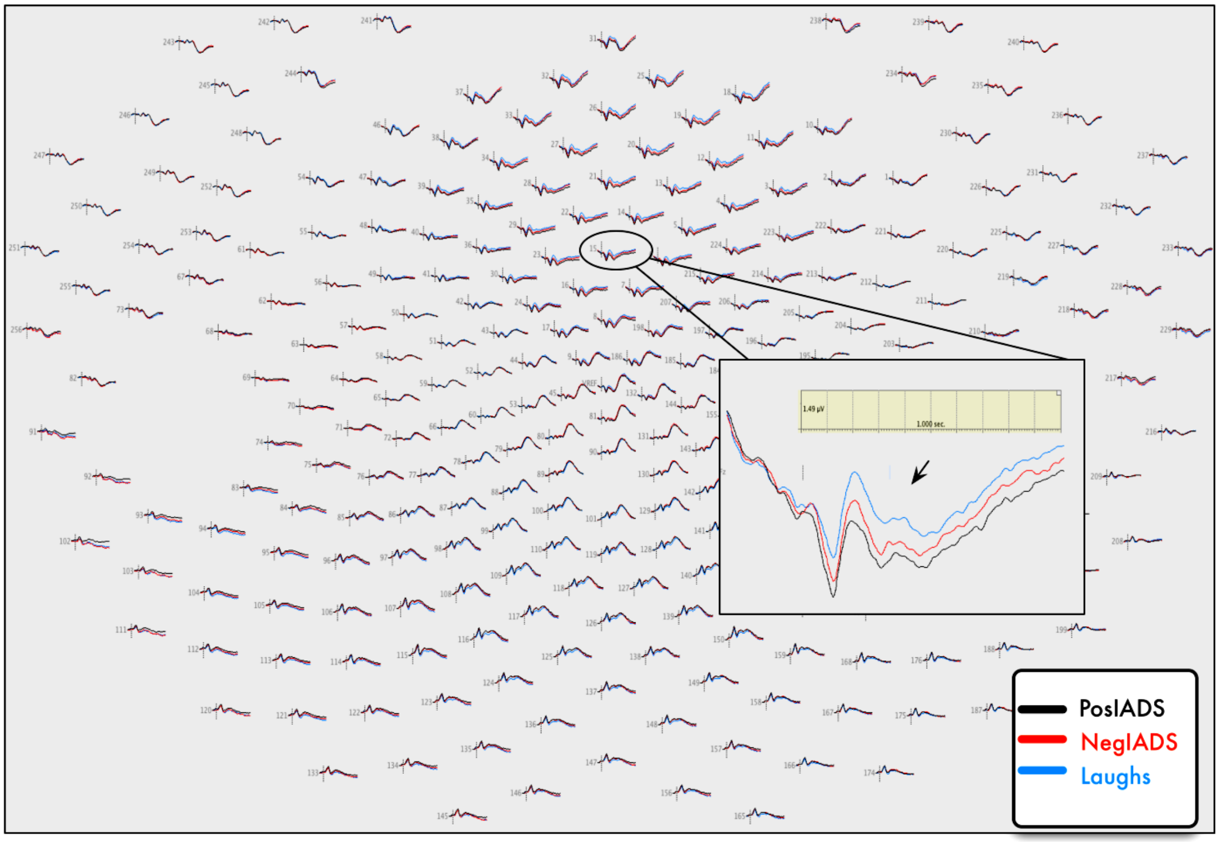

Figure 24. Prime Type effect between laughs and IADS over frontal sites

This Prime Type effect was clarified by a significant 2-way interaction with Caudality, $F(2, 48) = 14.36$, $p < .001$, $\eta_p^2 = .37$. As illustrated in Figure 25, the MFN window effect was strongest over frontal sites. Post-hoc analyses confirmed that laughs elicited a greater positivity than positive IADS primes over frontal sites, $t(24) = 4.81$, $p < .001$. Similarly laughs elicited a greater positivity than negative IADS primes over frontal sites, $t(24) = 3.69$, $p < .001$. By contrast, there was a small difference over the central ROI for laughs versus negative IADS, $t(24) = 2.40$, $p < .03$. No difference emerged over central electrodes for laughs versus positive IADS

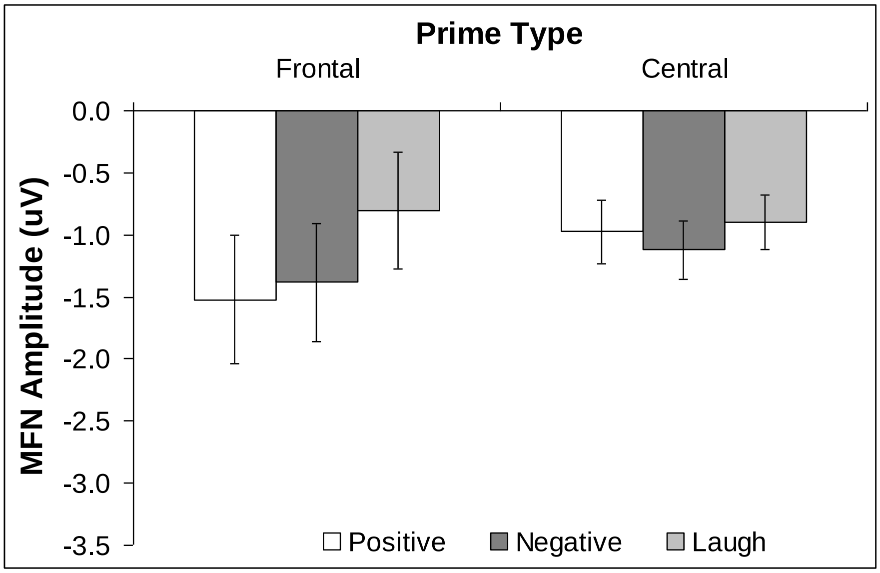

Figure 25. MFN Prime by Caudality Interaction Prior to Mood Manipulation

The MFN window Prime Type effect also showed an interaction with Laterality, *F*(4, 96) = 7.32, *p* = .001, $\eta_p^2$ = .23. Figure 26 shows that overall, the strongest differences were seen over the midline (Middle ROI). Post-hoc comparisons showed that laughs were significantly more positive than positive IADS over the midline, *t*(24) = 4.60, *p* < .001. Similarly, laughs were more positive than negative IADS over midline electrodes, *t*(24) = 3.96, *p* < .001. Smaller effects were seen over the left-lateralized ROI. Laughs were slightly more positive than positive IADS, *t*(24) = 2.63, *p* = .015 and were more also more positive than negative IADS over the left-lateral ROI, *t*(24) = 2.51, *p* = .019. Over the right-lateral ROI, there was a small Prime Type effect for laughs versus negative IADS, *t*(24) = 2.73, *p* = .012. The difference between laughs and positive IADS did not approach significance.

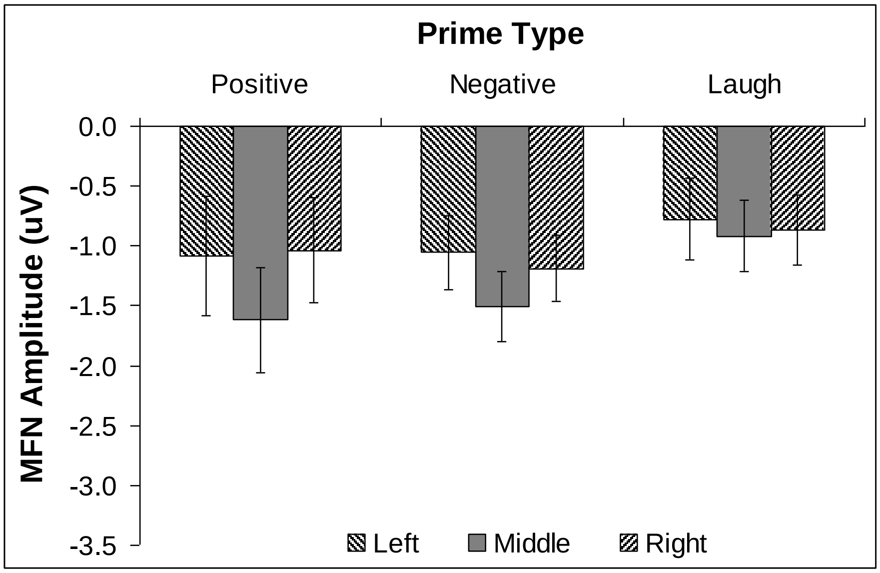

Figure 26. MFN Prime by Laterality Interaction Prior to Mood Manipulation

The MFN window also showed a significant 3-way interaction of between Prime Type, Caudality, and Laterality, *F*(3.13, 96) = 3.17, *p* = .027, $\eta_p^2$ = .12, suggesting further localization of the Prime Type effect. The MFN of negative IADS was more negative than positive IADS only at right central locations, *t*(24) = 2.70, *p* = .012. The MFN of positive IADS were more negative than laughs at middle frontal, *t*(24) = 5.26, *p* < .001, left frontal, *t*(24) = 4.58, *p* < .001, right frontal, *t*(24) = 2.84, *p* < .002, and middle central locations, *t*(24) = 2.84, *p* < .009. The MFN of negative IADS was more negative than laughs at middle frontal, *t*(24) = 3.63, *p* = .001, left frontal, *t*(24) = 3.01, *p* = .006, right frontal, *t*(24) = 3.64, *p* = .001, and middle central locations, *t*(24) = 3.53, *p* = .002.

The MFN window during the second half of the experiment showed a significant main effect for Prime Type, *F*(2, 48) = 16.31, *p* = .001, $\eta_p^2$ = .41. The pattern for positive IADS was significantly more negative than for laughs, *t*(24) = 4.86, *p* < .001. Additionally, the pattern for negative IADS was significantly more negative than for laughs, *t*(24) = 4.16, *p* < .001. An interaction between Prime Type and Caudality clarified the effects and is illustrated in Figure 27. The Prime type effect was largest at frontal locations compared to central locations. At frontal sites, the pattern for positive IADS was more negative than for laughs, *t*(24) = 5.17, *p* < .001. The pattern was also more negative for negative IADS than for laughs, *t*(24) = 4.50, *p* < .001. A smaller, but similar relationship was found at central locations. The pattern for positive IADS was more negative than for laughs, *t*(24) = 3.04, *p* = .006. Likewise, the pattern for negative IADS was more negative than for laughs, *t*(24) = 2.79, *p* = .01.

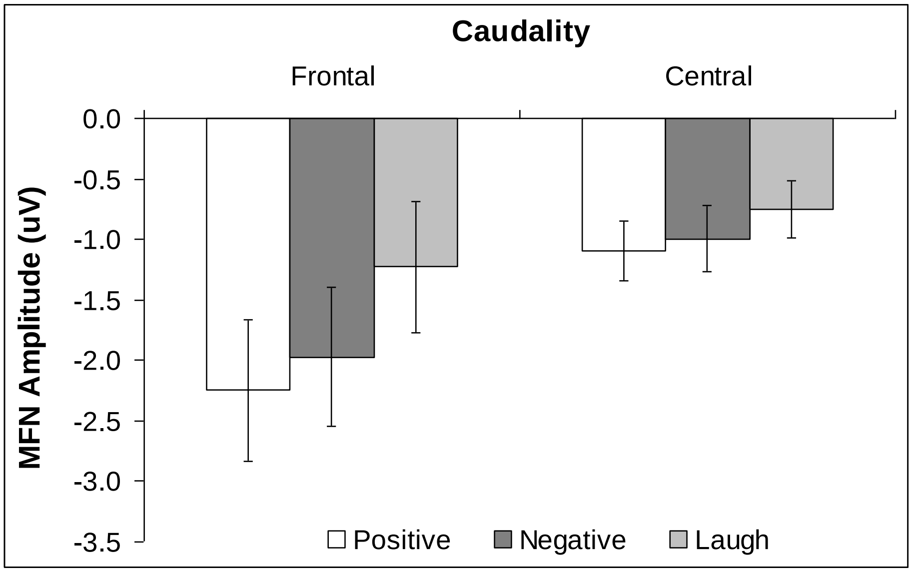

Figure 27. MFN Prime by Caudality Interaction Following Mood Manipulation

The MFN window also showed a significant interaction between Prime Type, Caudality, and Laterality, *F*(4, 96) = 2.83, *p* < .03, $\eta_p^2$ = .11. The pattern for positive IADS were significantly more negative than for negative IADS at middle central locations, *t*(25) = 2.71, *p* = .012. Positive IADS primes were significantly more negative than laugh primes at middle frontal locations, *t*(24) = 5.14, *p* < .001, left frontal locations, *t*(24) = 4.37, *p* < .001, right frontal locations, *t*(24) = 5.14, *p* < .001, and middle central locations, *t*(24) = 4.16, *p* < .001. Negative IADS evoked significantly more negative patterns than laugh primes at middle frontal locations, *t*(24) = 4.28, *p* < .001, at left frontal locations, *t*(24) = 3.58, *p* = .002, at right frontal locations, *t*(24) = 4.95, *p* < .001, and at middle central locations, *t*(24) = 3.63, *p* = .001.

#### 5.2.4.4.3 LPP (Laugh) Effects

Lastly, the LPP component showed a significant 2-way interaction between Prime Type and Laterality, *F*(4, 96) = 3.36, *p* = .013, $\eta_p^2$ = .12. Post-hoc comparisons showed that laugh primes evoked a more positive pattern at middle locations than at left locations, *t*(24) = 2.40, *p* = .025. See Figure 28.

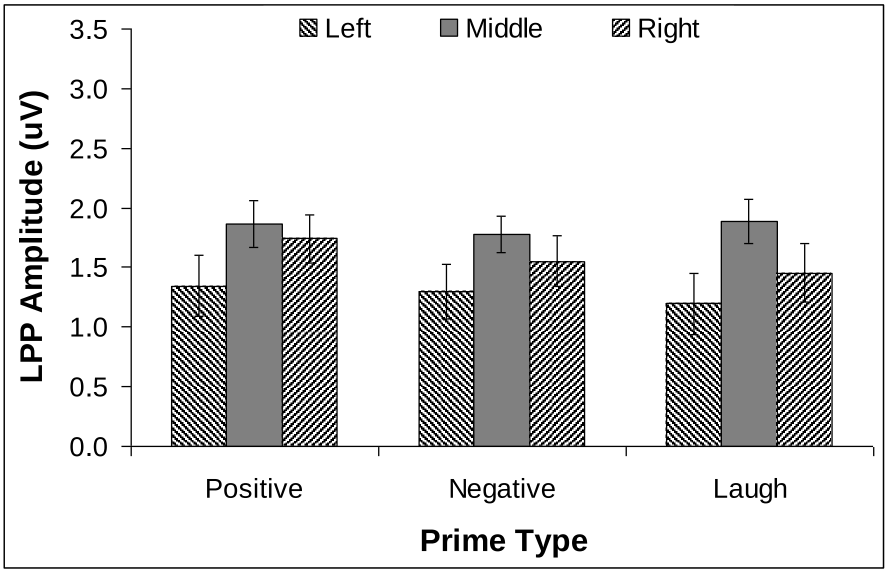

Figure 28. LPP Prime by Laterality Interaction Prior to Mood Manipulation

The LPP also showed a 3-way interaction of Prime Type X Caudality X Laterality, *F*(4.21, 96) = 3.92, *p* = .005, $\eta_p^2$ = .15. Post hoc comparisons revealed that positive IADS primes evoked significantly more positive patterns than negative IADS primes at right central locations,

$t(24) = 2.35$, $p = .027$. Positive IADS primes evoked more negative patterns than laugh primes at middle central locations, $t(24) = 2.12$, $p = .044$. Positive IADS primes evoked more positive patterns than laughs at right central locations, $t(24) = 2.44$, $p = .023$, and right parietal locations, $t(24) = 2.15$, $p = .042$. Negative IADS primes evoked more negative patterns than laugh primes at middle central locations, $t(24) = 2.57$, $p = .017$.

The LPP showed a significant interaction between Prime Type and Caudality during the second half of the experiment, $F(2.37, 96) = 5.83$, $p = .003$, $\eta_p^2 = .20$. Post-hoc comparisons revealed that the LPP for each prime type evoked the most positive pattern at parietal locations. Positive IADS were more positive at parietal locations than at occipital locations, $t(24) = 2.48$, $p = .021$, and central locations, $t(24) = 6.09$, $p < .001$. Positive IADS were more positive at occipital than at central locations, $t(24) = 2.12$, $p = .045$. Negative IADS were more positive at parietal locations than at occipital locations, $t(24) = 2.52$, $p = .019$, and central locations, $t(24) = 5.71$, $p < .001$. Laugh primes were more positive at parietal locations than at occipital locations, $t(24) = 3.07$, $p = .005$, and central locations, $t(24) = 5.33$, $p < .001$.

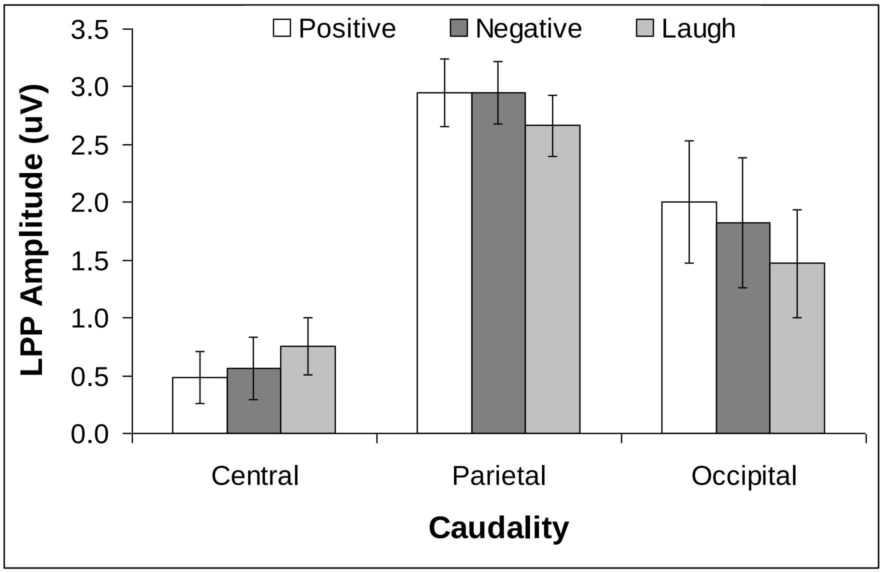

Figure 29. LPP Prime by Caudality Interaction Following Mood Manipulation

The LPP showed a significant interaction between Prime Type and Laterality, *F*(4, 96) = 5.96, $p < .001$, $\eta_p^2 = .20$. Post-hoc comparisons revealed that negative IADS were more positive at middle locations than at left locations, *t*(24) = 2.91, *p* = .008. Laugh primes were also more positive at middle locations than at left locations, *t*(24) = 3.22, *p* = .004.

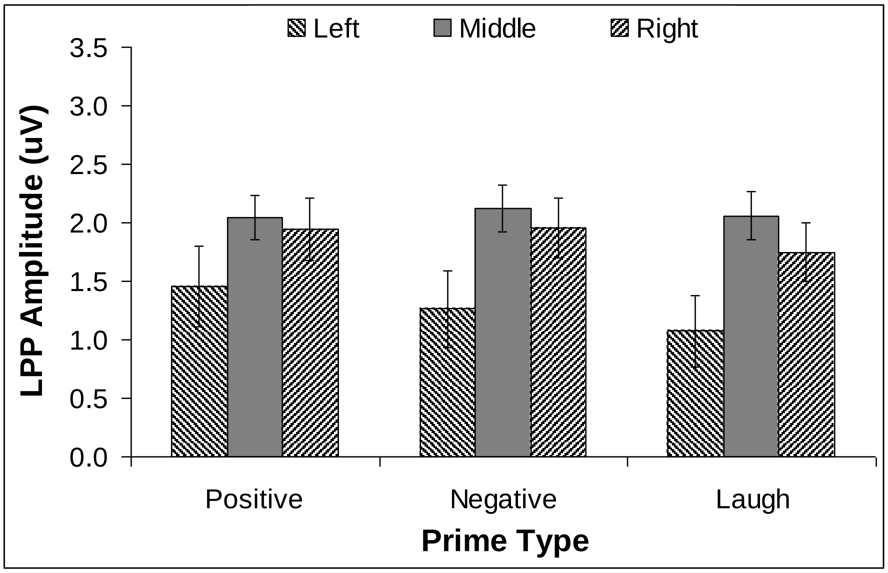

Figure 30. LPP Prime by Laterality Interaction Following Mood Manipulation

Finally, the LPP showed a significant interaction between Prime Type, Caudality, and Laterality, *F*(8, 192) = 3.20, *p* = .018, $\eta_p^2$ = .12. Post-hoc comparisons showed that laughs were significantly more positive at middle central locations than positive IADS, *t*(24) = 3.38, *p* < .002. Positive IADS were significantly more positive than laughs at left parietal locations, *t*(24) = 2.72, *p* = .012. Positive IADS were significantly more positive than laughs at middle occipital locations, *t*(24) = 2.69, *p* < .013, left occipital locations, *t*(24) = 3.45, *p* < .002, and right occipital locations, *t*(24) = 2.25, *p* = .034. Laughs were significantly more positive than negative IADS at middle central locations, *t*(24) = 2.91, *p* = .008. Negative IADS significantly more positive than laughs at left parietal locations, *t*(24) = 2.35, *p* = .028, and right parietal locations, *t*(24) = 2.82, *p* = .01.

### *5.2.4.5 ERP Results for Hypothesis 4 (Socioemotional Context Effects)*

The orbitofrontal region, where the relatedness effect was found for related- versus unrelated-IADS conditions, and the centroparietal region were examined to compare ERP relatedness patterns of Part 1 to patterns of Part 2 in the experiment. Orbitofrontal patterns evoked during Part 1 of the experiment are displayed in Figure 31. Electrode sites FP1, FP2, AF3, and AF4 were examined in the statistical analysis. Laughs paired with positive targets (laugh-related condition) showed a less negative pattern 450-550 ms than laughs paired with negative targets (laugh-unrelated condition). This laughter relatedness effect approached significance at electrode site AF3, *t*(24) = 1.77, *p* = .09. These laughter associated responses were distinct from patterns evoked by related and unrelated IADS primes, which did not differ from each other.

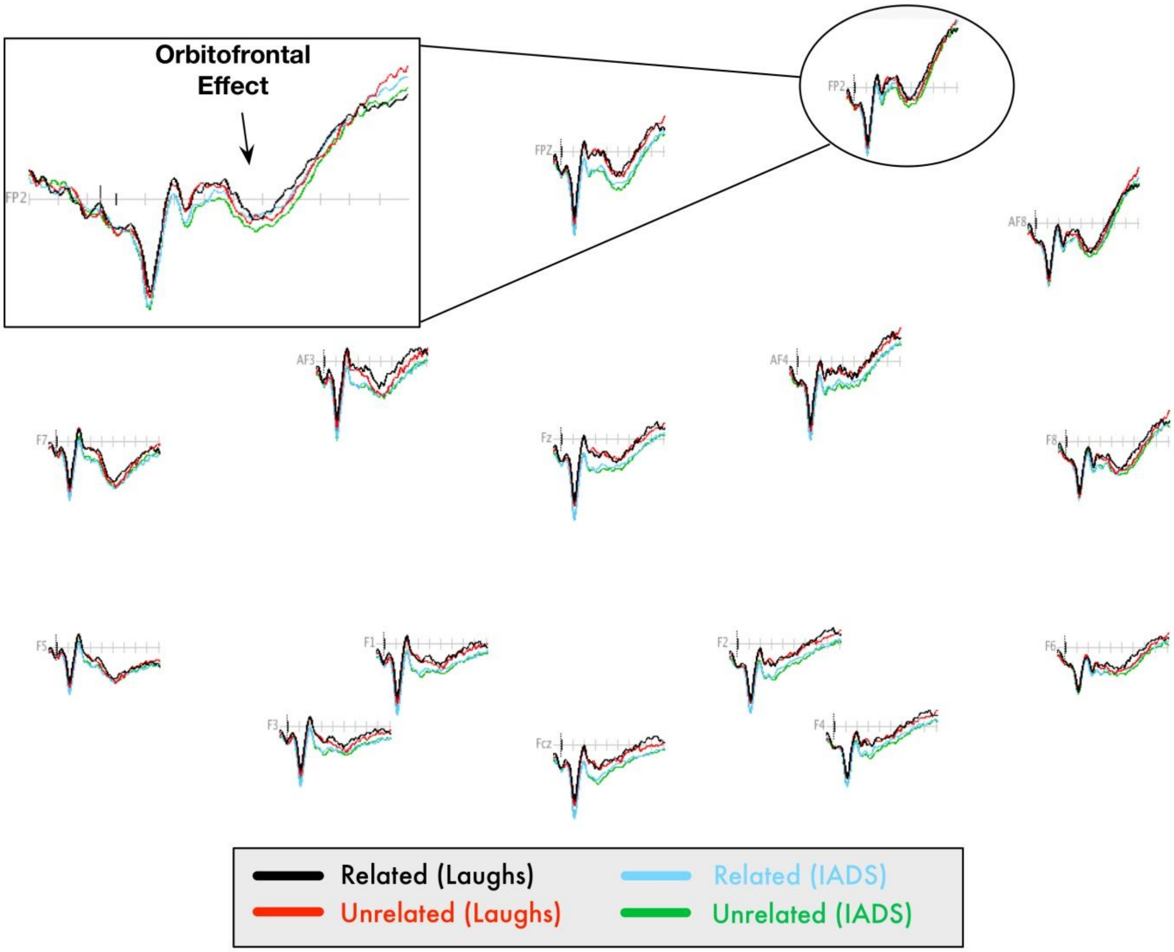

Figure 31. Orbitofrontal relatedness effect in Part 1 for laughs versus IADS

The orbitofrontal patterns in Part 2 of the experiment are displayed in Figure 32. The laugh-related condition again showed a less negative pattern 450-550 ms than the laugh-unrelated condition. In Part 2 the laughter relatedness effect reached significance at electrode site FP2, *t*(24) = 2.31, *p* = .03. It also approached significance at site AF4, *t*(24) = 1.85, *p* = .077 and FP1, *t*(24) = 1.76, *p* = .091. As was seen in Part 1, patterns evoked by related- and unrelated-IADS condition did not differ from each other.

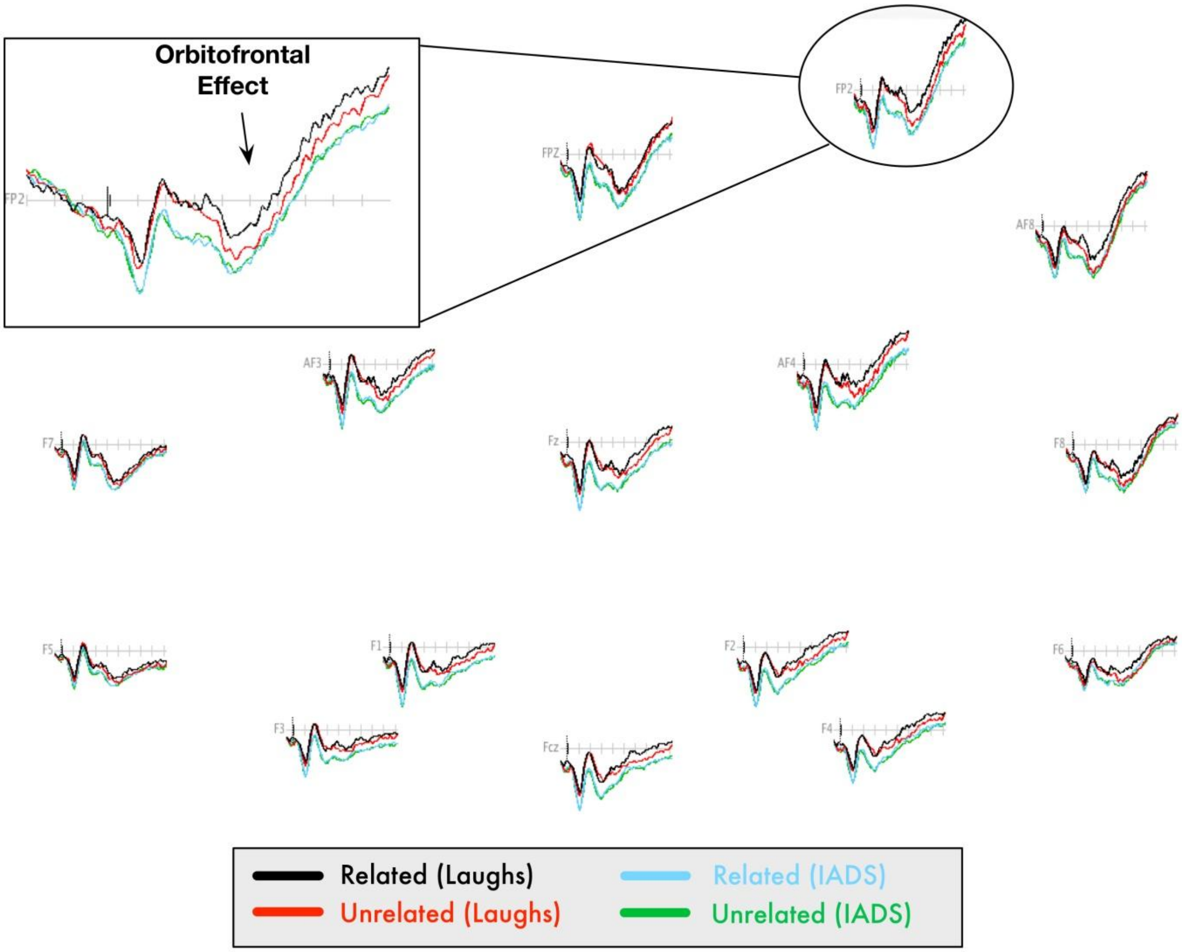

Figure 32. Orbitofrontal relatedness effect in Part 2 for laughs versus IADS

The LPP window of 450-700 ms in Part 1 of the ERP experiment showed a distinct pattern associated with laugh primes compared to IADS primes. Figure 33 shows centroparietal electrode sites (CP1, CP2, P1, and P2) examined in the analysis. Laugh primes paired with negative targets to form a laugh-unrelated condition evoked more positivity than laugh primes paired with positive targets to form a laugh-related condition, *t*(24) = 2.24, *p* = .035, at electrode site P1. IADS primes used to form related and unrelated conditions did not differ from each other in the LPP window.

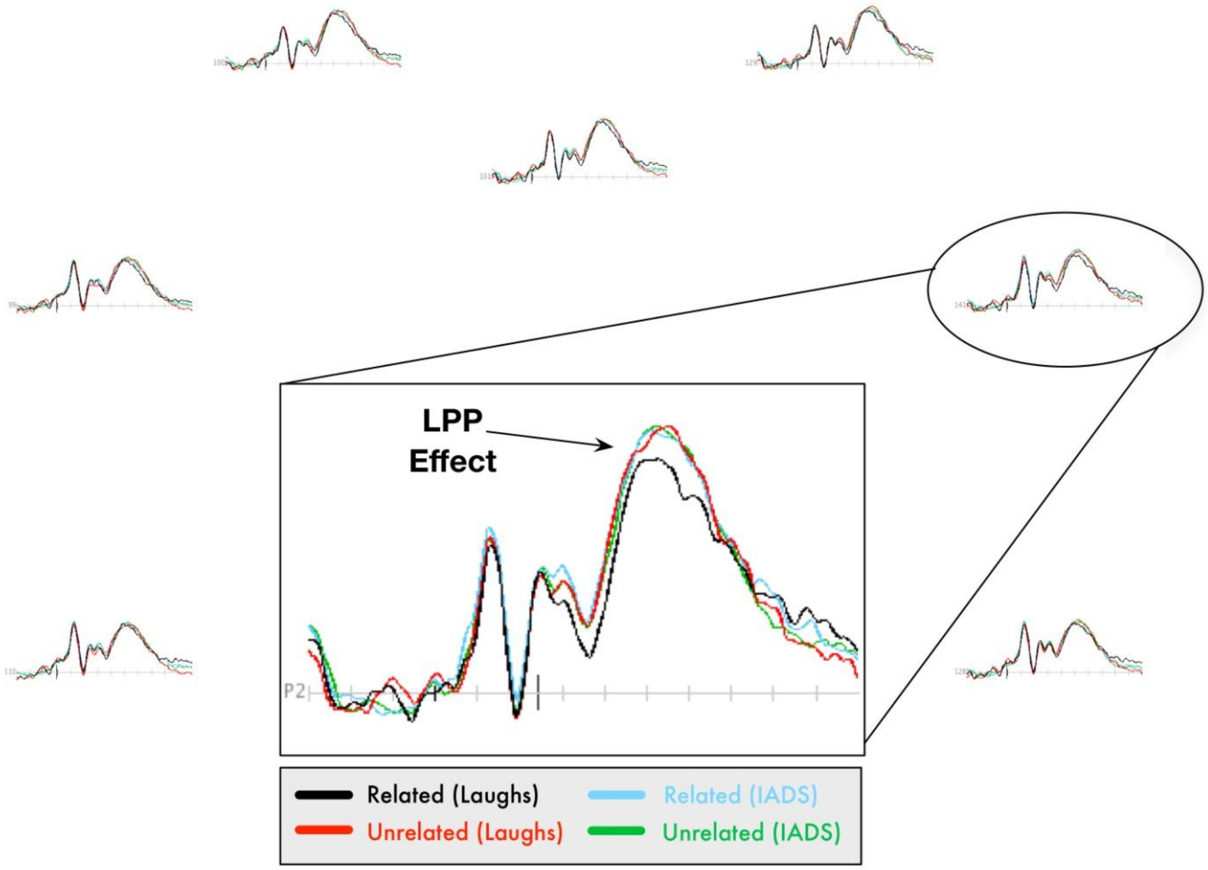

Figure 33. LPP relatedness effect in Part 1 for laughs versus IADS

The LPP window in Part 2 of the ERP experiment also showed a distinct pattern associated with laugh primes compared to IADS primes. Figure 34 shows the same centroparietal electrode sites as for Part 1 examined in the analysis. The laugh-unrelated condition evoked more positivity than the laugh-related condition at electrode site P1, *t*(24) = 2.72, *p* = .012, and at site P2, *t*(24) = 2.17, *p* = .04. As in Part 1, the IADS-unrelated and IADS-related conditions did not differ from each other in the LPP window.

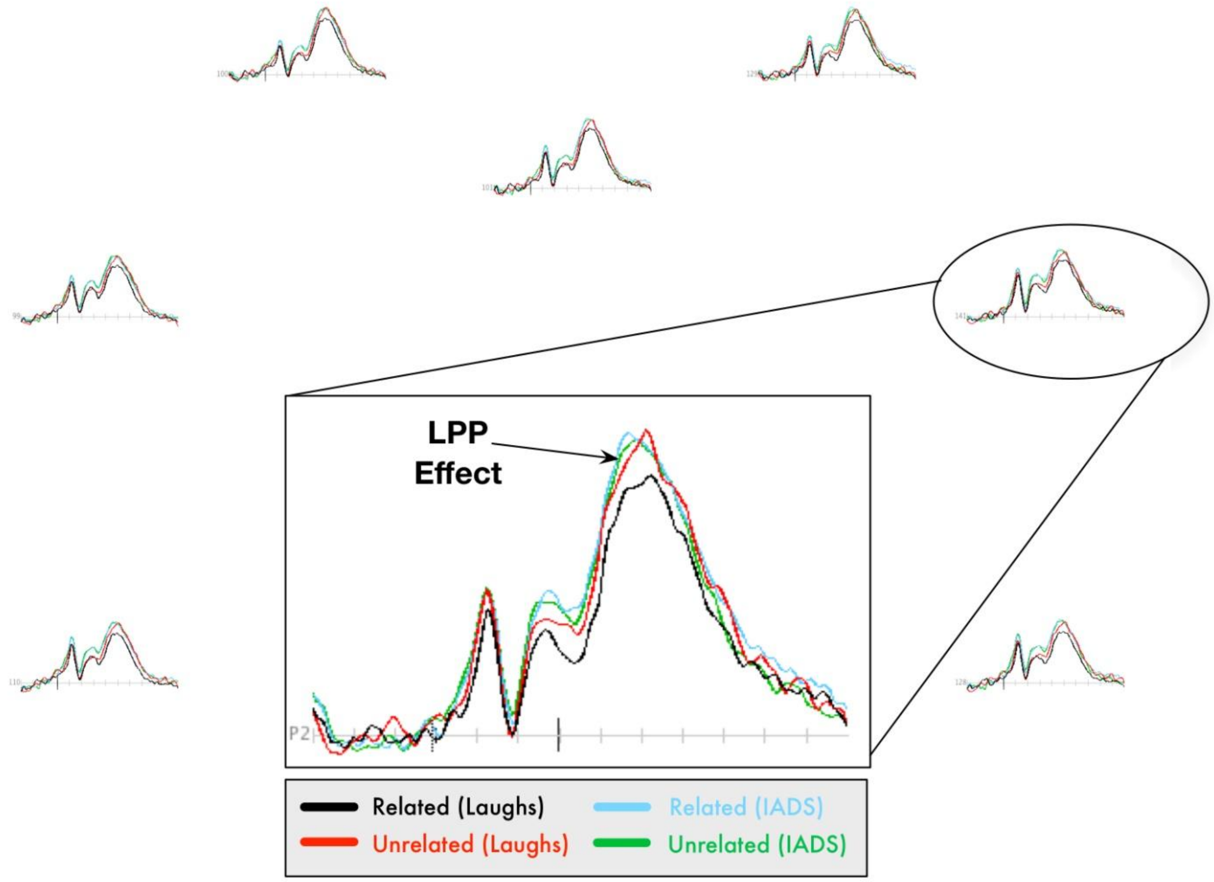

Figure 34. LPP relatedness effect in Part 2 for laughs versus IADS

## 5.3 Summary

### *5.3.1 Research Question 1: Emotion priming*

The behavioral effects showed that responses were faster and more accurate to congruent versus incongruent prime-target pairs. The ERP effects showed that an orbitofrontal effect was present. Words that were not emotionally primed elicited greater negativity compared to primed words. This effect was strongest over orbitofrontal electrodes at approximately 400-600 ms. There was an absence of an N400 effect in response to emotion priming. A late positive potential (LPP) priming effect was present and is discussed below under research question #4.

### *5.3.2 Research Question 2: Target valence effects*

The behavioral effects showed that, in general, response times were faster for positive versus negative words. The ERP effects showed that the EPN was stronger (more negative) in response to negative versus positive words, which is consistent with previous work. Also consistent with previous work, an LPP effect was present and was stronger (more positive) in response to negative versus positive words.

### *5.3.3 Research Question 3: Laughter-specific effects*

The behavioral effects showed that, in general, laughs elicited behavioral results that were more similar to positive versus negative sounds. The ERP showed an effect in which laughs elicited a sustained increase in positivity over orbitofrontal electrodes beginning approximately 200 ms after onset of the target word.

### *5.3.4 Research Question 4: Laughter-specific priming before and after mood manipulation*

Behavioral effects showed that overall, responses were faster in the second half of the experiment (after the mood manipulation). Otherwise, the patterns of behavioral responses were qualitatively similar in the Part 1 and Part 2 of the experiment. The ERP effects showed the orbitofrontal pattern described under research question #1. The pattern showed that there was laughter-specific priming in the second half of the experiment. Target words elicited greater negativity in the unrelated versus related condition. This effect was absent in the first half of the experiment. The LPP showed laughter-specific priming in both halves of the experiment Target words elicited greater positivity in the unrelated versus related condition. There was no LPP priming effect for environmental sounds.

## 6 SUMMARY AND CONCLUDING DISCUSSION

The behavioral data from behavioral experiments indicated that the new affective priming paradigm produced emotional priming effects. The results of the ERP experiment provided answers to the four primary research questions posed. The behavioral findings of Part 1 and Part 2 of the ERP experiment are qualitatively similar, although RT was faster in Part 2. The RT difference was likely due to both the use of a response pad during the ERP experiment rather than a computer keyboard, and because experimenters were observing the performance of each participant and communicating with them as the task progressed. Nevertheless, the consistency in performance in Experiment 1 and Part 1 of the ERP experiment provided support for the reliability of the effects found in the new affective priming task. The N400 pattern, which was expected to emerge as evidence of a priming effect, was not present. The absence of an N400 suggested that previous findings of N400 effects in emotion priming paradigms resulted from influences other than affective priming per se. However, exploratory examination of the ERP patterns during a similar time window showed a right lateralized orbitofrontal priming effect was present. Additionally, the EPN and LPP showed evidence of valence-specific processing. Laughter-specific effects were also found that differed from both positive and negative IADS responses in the orbitofrontal region. Finally, evidence of laughter-specific priming was found to differ in Parts 1 and 2 of the ERP experiment procedure.

### 6.1 Question 1: Emotion Priming (Orbitofrontal Effect)

The first question was whether emotionally charged (positive or negative) sounds prime affectively congruent emotions and emotion representations. Collapsing the behavioral data from Experiments 1 and 2 showed small, but significant priming effects for both RT and accuracy. Responses were faster and more accurate when the prime and target were affectively congruent than when incongruent. This finding was replicated in the behavioral data for the ERP experiment collapsing over data from Part 1 and Part 2. Therefore, while priming effects were hard to detect, they did provide evidence that the cross-modal priming paradigm utilizing short excerpts of environmental sounds did produce affective priming.

The ERP results told a more nuanced story. A small orbitofrontal priming effect distinguished between related and unrelated IADS prime-target combinations. The emotionally unrelated condition evoked a more negative pattern 400-600 ms than the emotionally related condition. The effect provided neurophysiological evidence linked to prime-target relatedness to accompany findings of affective priming in behavioral measures. The location and timing of the orbitofrontal effect was similar that found by Stenson (2012). This orbitofrontal priming effect has yet to be classified in the literature but may be related waveforms evoked by salience representation (Potts & Tucker, 2001), expectation (Potts, Martin, Burton, & Montague, 2006), emotion processing (Diedrich, Naumann, Maier, & Becker, 1997), and familiarity (Finnigan, Humphreys, Dennis & Geffen, 2002). An additional priming effect was present in the LPP window. It is discussed under research question 4 below concerning the effects of laughter primes.

Contrary to expectations, the contrast between affectively related and unrelated stimuli elicited no N400 effect. The absence of this effect leaves calls into question the robust N400 effects found in the results of other affective priming paradigms. If previous research findings affective priming paradigms are correct that emotion priming can evoke N400 effects, a difference should occur in the present paradigm. This brought up the possibility that the stimuli or task parameters may not be capable of evoking an N400 effect. In order to delve deeper into this question and encourage a new line of research, a follow-up experiment was initiated to determine if the prime sounds and target words selected for use in this investigation could evoke the classic semantic N400 effect. If no N400 emerged, it would suggest a problem with the stimuli, task parameters, or extraneous variables such as fatigue or habituation to the task may have obscured the N400 effect.

In the follow-up experiment stimulus pairs were rearranged such that the relationship between the symbolic meaning of sound primes and word targets was related or unrelated. Related prime sounds and words target were paired together in order to be easy to relate to one another. Unrelated primes and targets did not have an obvious semantic relationship. For example, the sound of a cat meow was paired with the word kitten in a related condition, and the sound of angry voices was paired with the word joy in an unrelated condition. The task parameters remained the same as those used in the behavioral and ERP experiments, except that participants were to make a judgment about whether the sound prime was semantically related or unrelated to the word target as quickly and accurately as possible. The results of the first four participants indicated that the expected N400 semantic priming effect was evoked. Figure 35 shows that semantically unrelated prime-target combinations evoked a negativity that peaked at 400 ms compared to the semantically related prime-target combinations. This effect can be contrasted with the emotion priming effect shown in Figure 20.

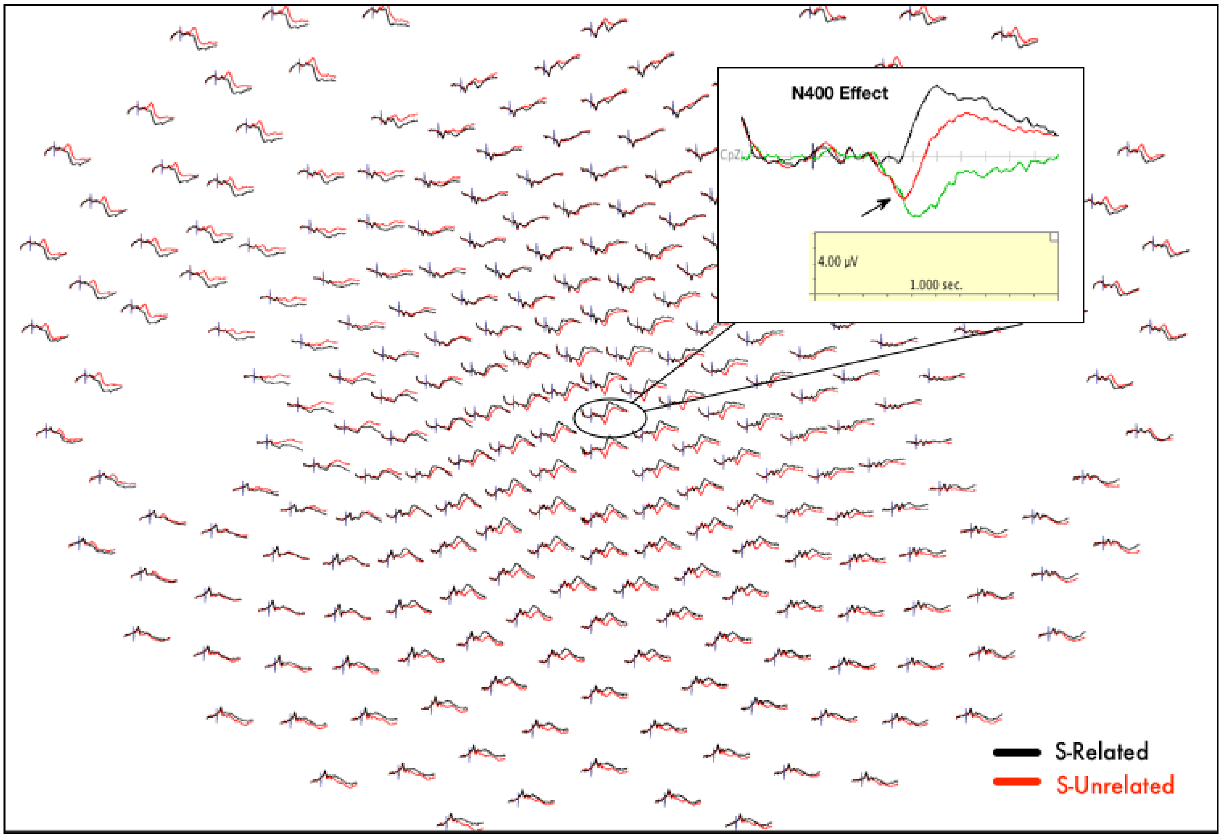

Figure 35. N400 effect evoked in Experiment 5

The semantic N400 effect was evoked using the rearranged stimuli employed in the affective paradigm. This shoed evidence that the parameters of the task, such as the 500 ms duration of the primes, the 900 ms target evaluation window, and the 500 ms SOA were capable of evoking an N400 priming effect similar to those reported in previous studies. This finding validates the effectiveness of the sound stimuli used in the present investigation and the new cross-modal paradigm. It also suggests that the N400 effect reported in previous affective priming paradigm studies may not be a function of affective expectations generated by primes that are congruent or incongruent with targets. The N400 ERP pattern effect found in these studies may instead be a function of underlying semantic relationships that accompany the stimuli used in the study.

### 6.2 Question 2: Valence-Specific Effects (EPN and LPP)

The second research question sought evidence of valence-specific effects within the priming paradigm. Some researchers claim that negative stimuli are preferentially processed (Bernat et al., 2001; Carretie et al., 2004; Scott et al., 2009). Others claim that positive stimuli receive preferential processing (Briggs & Martin, 2009; Kissler & Hauswald, 2008; Schacht & Sommer, 2009) or question whether there are any — quantitative or qualitative — differences in processing positive and negative stimuli.

In the behavioral data of three of the four experiments (Experiments 1, 3, and ERP), there was evidence that RT was faster to positive valence targets. This is consistent with findings in Zhang et al. (2012) and could be evidence of a positivity bias in response time (Kissler & Hauswald, 2008). Response time would typically be expected faster to negative stimuli because they garner more attention (Smith, Cacioppo, Larsen, & Chartrand, 2003; Dijksterhuis & Aarts, 2003). Interestingly, in Experiment 3, evaluations of targets when primed by negative sounds resulted in lower accuracy and slower RT than targets primed by positive sounds and laughs. All conditions in Experiment 3 had decrements in performance compared to the other experiments that could be attributed increased difficulty of the affective congruency evaluative response (judge affective congruency of prime and target). However, the especially low accuracy and increased RT for negatively primed targets suggested that when negative primes were explicitly attended in order to evaluate the target, the availability of processing resources was limited. For laughs and positive IADS primes the additional resources dedicated to the congruency evaluation made in Experiment 3 appeared to increase the priming effect evidenced through RT compared to the same prime conditions in the other experiments. Congruent conditions for positive primes were evaluated faster than incongruent conditions for positive primes. When primes were passively experienced in the other experiments, processing resources could be directed solely to the evaluation of the target. This simpler evaluation may explain why the affective priming effects were small in these experiments. Nevertheless, the primes did influence the target as indicated by the combined data used in meta-analyses to compare congruent and incongruent conditions. Taken together, affective priming demonstrated in the cross-modal paradigm was sensitive to task demands.

Regarding valence-specific effects in the ERP components, two patterns provided evidence that negative stimuli may receive preferential processing. The EPN pattern showed greater negativity for negative target words than for positive target words. This provides support for the negativity bias position regarding stimulus valence processing and argues against the possibility that such bias is due only to arousal level (Olofsson, 2008). This finding provides further evidence that the EPN is may be an early marker of affective processing (Schupp et al., 2004; Scott et al., 2009). Additionally, the LPP component showed greater positivity for negative targets compared to positive targets. It is important to recall that care was taken to ensure the sample of positive and negative ANEW stimuli selected as targets were balanced on arousal level and other psycholinguistic variables, while maximizing valence differences. It was hypothesized that ERP components during the EPN and LPP windows would not show valence-specific effects when positive and negative stimuli were matched on arousal. Because the EPN occurs relatively early in the processing stream, it may represent processing specificity that is evoked in a somewhat automatic fashion by arousal rather than valence. The contribution of arousal level to LPP differences was proposed to be the result of engaging more cognitive resources or possibly a higher level of activation during processing. Contrary to the hypothesis, the present findings provided support for valence-specific processing. In particular, it provided support for preferential processing of negative target stimuli, which was also reported in the LPP by Ito, Larsen, Smith, and Cacioppo (1998).

### 6.3 Question 3: Laughter-specific Response (Sustained Orbitofrontal Effect)

The third research question addressed the presence of laughter-specific effects in the priming paradigm. Schupp et al. (2003) reported that stimuli of evolutionary significance evoked larger ERP patterns than less important stimuli. This brings up the possibility that category specific emotion processing is evidenced in ERPs. Of interest along this vein is whether evolutionarily significant emotional meaning of stimuli such as pictures (e.g., erotica, mutilations) and sounds (e.g., threatening, happy) is preferentially processed compared to symbolic or learned emotional significance. This investigation is the first to use laughter, posited to have evolved as an important social signal. Although, laughs produced priming effects that were similar to other positive environmental sound, the ERP component differences suggest that there is some specificity with regard laughter processing that is only apparent at the neurocognitive level.

The behavioral results showed that, in general, laughs elicited effects in a similar manner as other positive prime sounds. In both accuracy and RT measures across all of the experiments laughs showed similar qualitative effects as positive sounds. In Experiment 3, laughs showed greater accuracy (but equal RT) of the prime-target congruency evaluation than positive sounds. This is likely due to the ease of recognition afforded to laughs compared to the other positive IADS sounds. Laughs were expected to signal positive emotion in a manner that is efficient and uses fewer attentional and processing resources than positive and negative sounds. This may explain why laughs showed similar accuracy and RT in Experiment 3 as obtained in the other experiments, whereas other sounds showed decreased performance.

One ERP pattern window showed a clear distinction between laughs and positive and negative IADS. Within the MFN window over orbitofrontal sites, laughs evoked a less negative pattern than either positive or negative IADS. The pattern differences between positive and negative IADS were not statistically different. An orbitofrontal effect showed that laughs have a unique effect related to priming that begins approximately 200 ms after target onset and was sustained over the course of the ERP duration.

If laughs are a special category, they should be examined further with regard to other categories of stimuli. While there was variation within the sample of laughs used in the investigation, they represent a single stimulus category. The environmental sound categories compared to laughs contained a variety of sound types including mechanical, weather, musical, violence, cheers, environmental soundscapes, and human as well as animal vocalizations. If laughs do garner category-specific processing it is possible that the differences in behavioral and ERP measures might arise from their vocal nature. For instance, social characteristics associated with vocalizations may be processed differently than nonvocal sounds even when both are non-linguistic. In order to investigate this possibility, it may be necessary to first make comparisons of laughter to other positive and negative categories of human non-liguistic vocalizations, such as erotic sounds, pleasant surprise, screams, unpleasant moans, and crying. These comparisons could demonstrate how laughs differ from other affective nonlinguistic sounds produced by humans. Additionally, studies that vary prosody may be informative. For example, a simple acoustic sound “ahh” could be vocalized in manners that express happy, sad, and fearful prosodies that are compared to laugh burst prosody. This would maintain the frequency content while varying the affective meaning. Further studies might investigate differences amongst mechanical, animal, and music that convey affective meaning. There is evidence for differential activations in the superior temporal that occur between human versus animal vocalizations (Fectau, Armony, Joanette, & Belin, 2004) human speech and non-liguistic vocalizations and a variety of environmental sounds (Belin, Zatorre, & Ahad, 2002).

A major challenge for future research is how to deal with individual differences in appraisal of different sound stimuli used in investigations. Since not everyone perceives the same stimulus as equally positive or negative, it may be necessary to create stimulus sets that are individualized. For example, study participants might rate a variety of stimuli prior to their experiment session, and the stimulus conditions are generated for each participant. Individualized stimuli would maximize affective differences amongst affective stimulus categories for participants, which increases the ability to detect behavioral and ERP differences. The downside to this method is that homogeneity of stimuli used across participants would be lost. A large corpus of auditory sounds is necessary to select enough stimuli of different types for use in paradigms such as ERPs, which require a large number of trials.

The understanding of the laughter network connectivity is not well understood (Meyer et al., 2007). Observations from clinical conditions, such as hypothalamic tumors (Striano et al. 2005) that result in pathological laughter, and stimulation of supplementary motor area cortex (Fried et al, 1998) and subthalamic nucleus (Krack et al. 2001) present a number of possible laugh network components involved in laughter production. A review by Wild et al. (2003) suggests that emotion related subcortical regions, such as the amygdala, thalamus, hypothalamus, and pons, as well as voluntary regions, such as frontal premotor and motor regions that are involved in the production of laughter. The findings of studies on laughter production point to a division between involuntary and voluntary networks involved in laughter production (Owren & Amoss, In press). The perception of laughter, on the other hand, is associated with activations of bilateral amygdala and temporal auditory cortex regions (Sander & Scheich, 2001). Meyer et al. (2005) found that laughter, speech, and nonvocal sounds bilaterally activated the peri-sylvian cortex and were functionally separable using fMRI. Laughter in particular activated right hemisphere auditory and somatosensory regions, whereas nonvocal sounds activated medial Heschl's gyrus, planum temporale and parietal operculum. Findings of Osaka et al (2003) suggest that the extrastriate, primary motor cortex, and the supplementary motor area may be components of a network involved in the representation of laughter. Such evidence suggests that laughter may receive preferential processing by brain regions distinct from those that process nonvocal sounds and regions that process speech. More research investigations are necessary to uncover neurocognitive specialization of processing during laughter perception. The corpus of laughter stimuli developed for the present investigation provides means for pursuing an answer to this question.

### 6.4 Question 4: Socioemotional Context Effects (Orbitofrontal and LPP)

The fourth research question of this investigation addressed laughter-specific priming changes due to a social anxiety mood manipulation. Behavioral responses in Part 2 of the ERP experiment, following the mood manipulation, were faster than during Part 1, the neutral context. The increased familiarity with the target stimuli, which they evaluated in the first half, accounts for the increase in performance and also suggests that fatigue was not an important factor in the behavioral response. Otherwise, the patterns of accuracy and RT were qualitatively similar in Part 1 and Part 2. In other words, a reversal of laughs from positive primes in Part 1 to negative primes in Part 2 was not apparent in the behavioral results. However, there were changes in the

ERP pattern evoked during the MFN window in the orbitofrontal patterns from Part 1 to Part 2 of the ERP experiment. The orbitofrontal pattern showed laughter-specific priming in Part 2. Laughs paired with negative targets (laugh-unrelated condition) evoked greater negativity than laughs paired with positive targets (laugh-related condition). This effect was not present in Part 1. There was also evidence of emotional priming in the LPP window. In both Part 1 and Part 2, the LPP of the laugh-unrelated condition evoked greater positivity than the laugh-unrelated condition. The LPPs of related- and unrelated-IADS conditions did not differ from each other in either the orbitofrontal MFN window or the LPP.

A multitude of findings in the literature regarding late ERP component patterns have reported differences in the LPP window associated with task conditions. The LPP has been associated with stimulus deviance and novelty (Goldstein, Spencer, & Donchin, 2002; Polich, 2007), emotional stimulus processing (Liu, Huang, McGinnis-Deweese, Keil, & Ding, 2012; Hajcak, Dunning, & Foti, 2009; Schupp et al., 2003), and priming (Herring et al. 2011). Here, the LPP to the laugh-related condition showed less positivity than the laugh-unrelated condition, and both related-IADS and unrelated-IADS conditions. The LPP pattern responded to evaluative categorization of target stimuli in previous studies, where it was more positive in amplitude to incongruent conditions than congruent conditions (Cacioppo, Crites, Berntson, & Coles, 1993; Cacioppo, Crites, Gardner, & Berntson, 1994; Ito & Cacioppo, 2000), particularly when negative stimuli are preceded by positive stimuli (Crites, Cacioppo, Gardner, & Bertson, 1995). As noted, the LPP for IADS-related and IADS-unrelated conditions did not differ. This is likely due to the IADS-related condition containing congruent associations for both negative and positive primes and targets. Similarly, the IADS-unrelated condition contained incongruent associations between both positive and negative primes and targets. The laugh-related and laugh-unrelated conditions consistently have laughs as primes. Thus, it is possible that IADS LPP differences were washed out when the comparison conditions were formed. It is tempting to suggest that the laugh prime produces a special effect on the allocation of cognitive resources necessary for processing the targets which is then evidenced in the LPP for that condition. This would represent functional evidence of laughter-specific influences on neurocognitive processing. However, closer comparison to IADS congruency conditions and other human vocalization categories is required.

The mood manipulation procedure used in the present investigation did not appear to significantly alter the mood state of participants. The results of the three assessments of PA and NA of over the course of the ERP experiment showed that there was not an increase in NA over the three assessment times. This lack of change in NA suggested the mood manipulation was not successful in activating an anxious state. Instead the participants declined in their PA rating from the beginning of Part 1 to the end of Part 1, and did not decrease further in PA following the mood manipulation. Although laughter has flexible meaning depending on the context in which it is experienced, the sensitivity to laughter in general may be preset by prior experience. A manipulation of context in an experimental setting may be too weak to change perceptual predispositions toward laughter.

Both accuracy and RT improved from the Part 1 to Part 2. Additionally, there was a latency shift in the peak of the LPP that showed that the LPP in Part 2 was approximately 50 ms sooner than in Part 1. This matches the approximate change in RT and ties the behavioral response to the LPP. This change is likely due to practice effects and not the mood manipulation. Unlike behavioral measures alone, ERP patterns point out multiple brain processes activated over the course of the experiment. And, in cases such as the LPP latency shift, may be correlated with behavioral measures. Differences in ERP patterns found between Part 1 and 2 with regard to the orbitofrontal pattern and the LPP suggested that ERP patterns can point out subtleties in processing that may inform hypotheses for future investigations.

### 6.5 Limitations and Future Work

Some limitations of the present experiment include the use of a longer SOA than is typical for other priming paradigms. It is possible that stronger effects of affective priming may be found using a shorter SOA (250-300 ms). However, priming studies with SOAs of 1000 ms have also found effects (Wu et al., 2012; Steinbeis et al., 2008). A future study using an SOA of 300 ms, in which the 500 ms prime sound overlaps with the target word by 200 ms, could determine whether the typical 250-200ms SOA is optimal for this type of design. If a shorter SOA is necessary to for a prime stimulus to influence the target, the overlap of the affective prime sounds with the target word should result in stronger priming effects. However, it is also possible that shortening the SOA may not strengthen the priming effect. As mentioned previously, a sound must unfold over a period of time in order to convey information. If the sound prime overlaps with the target stimulus to which participants must respond, the processing of the prime sound may not be sufficiently complete to influence the target fully. Furthermore, because the response to the target stimulus must occur within 900 ms of target onset, the overlap of prime sound processing may result in a higher error rate. Therefore, future experiments should a range of SOA periods in order find the optimal priming effect elicited with this stimulus set.

The social anxiety mood manipulation did not appear to be powerful enough to activate socially anxious feelings as evidenced by the lack of change in NA. Activating social anxiety in a volunteer participant population could be counterproductive because they may decline to participate further in the experiment. However, recruiting groups of high and low socially anxious participants could be a more effective way to investigate differences. Participants who are low and high in social anxiety may show differences in processing that are not apparent in the present sample. The high anxiety group may show different responses to laughter and negative stimuli than the low anxiety group, given that high anxiety is often associated with a more sensitivity to negative stimuli. A possible outcome might be that the LPP pattern in high anxious groups may show an increased positivity in the LPP to more negative stimuli compared to low anxious groups (Li et al., 2007).

The order in which the mood manipulation was performed could not be counterbalanced. It was necessary to conduct the manipulation before Part 2 to avoid carryover of negative feelings to the neutral context in Part 1. In future studies, a between-subjects design could compares high and low socially anxious groups that were given a pleasant or socially anxious mood manipulation. Alternatively, the computer game Cyberball (Williams & Jarvis, 2006), which is used in research to influence feelings of social acceptance, would allow the mood manipulation to change over the course of the task. The game involves the participant tossing a virtual ball between players, who actually do not exist. The game can be programmed to toss the ball frequently to the actual participant or to ignore them. The number of times the participant receives a toss or is excluded alters their feeling of ostrcizism, even if they believe they are only playing against the computer. This manipulation could be employed to activate feelings of social inclusion or exclusion prior to performing the ERP task or at different times throughout the session.

Perhaps the most intriguing finding of the ERP experiment was the absence of an N400 effect. Absence of the effect suggested a problem with the theoretical mechanism associated with emotion priming. Outlined in the background section on emotion priming literature there were a number of studies that reported N400 effects in which emotionally incongruent conditions evoked more negative patterns than emotionally congruent conditions. These echoed findings of semantic priming N400 effects (Kutas and Federmeier, 2000) and suggested similarly acting processing mechanisms in emotion priming. The most pertinent of these studies was Steinbeis and Koelsch (2010), which served as a modal for the development of the cross-modal priming paradigm. In their study, N400 priming effects (300-500 ms) were reported. Significant effects were not found in earlier (100-300 ms) or later (500-700 ms; 700-900 ms) pattern windows. Other affective priming studies have found priming effects that were evidenced in the LPP along with N400 effects (Aguado et al., 2013; Zhang et al., 2010). Still other studies have found priming effects in the LPP without accompanying N400 effects (Herring et al., 2011; Werheid, Alpay, Jentzsch, & Sommer, 2005). These studies suggest that dissociable processing mechanisms may exist for semantic versus emotional priming. Herring et al. (2011) points out that differences between the tasks may have obscured LPP effects, inadvertently elicited N400 effects, or led to engagement of processes that evoked both effects. Low trial numbers may have reduced statistical power that led to failure to find LPP effects. Inadvertent semantic relationships between primes and targets may have evoked N400 effects. Additionally, the level of difficulty in “integrating” the meaning of the prime and target combination may have elicited semantic-like influences that evoked an N400. At present, there are too few studies available to make reliable inferences about how specific task differences affect the N400 and the LPP in emotional priming.

The presence of an LPP priming effect and absence of an N400 effect found in this investigation suggests that this paradigm has avoided semantic priming between meaningful sounds and words. What remains in question is why Steinbeis and Koelsch (2010) evoked an N400 without an LPP using musical chords as primes. Inspection of the ERP waveforms in

Steinbeis and Koelsch (2010) showed that their incongruent condition did appear to contain an LPP that was more positive for the incongruent condition than the congruent condition. It seems plausible that the task parameters which Herring suggested might affect N400 and LPP priming may be explanatory. First, Steinbeis and Koelsch used a comparatively small number of prime and target stimuli in their study (48 primes, 48 targets). In the present study, many more primes and targets were utilized (234 primes, 156 targets), which allowed for more combinations primes and targets. Therefore, statistical power may have hidden a significant LPP effect in their study. Second, the relatively few stimuli used may have resulted in inadvertent semantic relationships that evoked N400 patterns. Some of their positive target words, such as harmony, peace, pleasure, grace, calm, and beauty are easy to associate (integrate) semantically with "pleasant sounding" consonant chords, and difficult to associate with "unpleasant sounding" dissonant chords. Likewise, some of their negative target words, such as aversion, violence, atrocity, anguish, suffering, and pain are easy to associate with dissonant chords, and difficult to associate with consonant chords. In the present investigation the greater number of prime sounds and word targets made it possible to avoid these spurious associations. Taken together, these influences could explain the absence of the N400 in this study compared to Steinbeis and Koelsch. The goal of future investigations into emotion priming should now focus on how to control and test semantic relationships formed between emotional laden stimuli and the role of integrative complexity in evoking N400 and LPP priming effects.

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# APPENDIX A: AUDITORY STIMULI (PRIMES)

| ExptStimID | IADSstimID | ArousalRating | ValenceRating | ValenceCategory |
|---|---|---|---|---|
| 1 | 105C | 5.68 | 3.72 | negative |
| 2 | 105E | 5.72 | 4.08 | negative |
| 3 | 113B | 4.04 | 4.04 | negative |
| 4 | 113C | 5.88 | 3.92 | negative |
| 5 | 115A | 4.25 | 4.04 | negative |
| 6 | 115B | 4.72 | 3.76 | negative |
| 7 | 115C | 4.20 | 3.76 | negative |
| 8 | 115E | 4.36 | 4.08 | negative |
| 9 | 130A | 4.72 | 3.68 | negative |
| 10 | 132A | 6.00 | 4.08 | negative |
| 11 | 170B | 6.04 | 3.72 | negative |
| 12 | 241A | 4.68 | 3.72 | negative |
| 13 | 241B | 4.04 | 3.79 | negative |
| 14 | 241C | 4.24 | 3.88 | negative |
| 15 | 241D | 3.80 | 2.92 | negative |
| 16 | 242A | 4.12 | 3.56 | negative |
| 17 | 242B | 4.64 | 3.16 | negative |
| 18 | 242C | 4.76 | 3.64 | negative |
| 19 | 242D | 5.23 | 3.35 | negative |
| 20 | 244B | 4.28 | 3.76 | negative |
| 21 | 244C | 5.24 | 3.48 | negative |
| 22 | 244F | 4.36 | 3.88 | negative |
| 23 | 245B | 4.00 | 4.08 | negative |
| 24 | 251A | 4.12 | 3.88 | negative |
| 25 | 252A | 5.85 | 3.38 | negative |
| 26 | 252C | 4.32 | 4.00 | negative |
| 27 | 255A | 5.71 | 2.44 | negative |
| 28 | 255C | 5.28 | 2.08 | negative |
| 29 | 255D | 4.48 | 4.08 | negative |
| 30 | 260B | 5.00 | 4.04 | negative |
| 31 | 261B | 5.52 | 3.64 | negative |
| 32 | 261C | 5.72 | 3.44 | negative |
| 33 | 261E | 5.88 | 3.92 | negative |
| 34 | 270A | 5.08 | 3.72 | negative |
| 35 | 278A | 4.88 | 3.80 | negative |
| 36 | 279B | 6.08 | 3.20 | negative |
| 37 | 279C | 6.08 | 3.17 | negative |
| 38 | 279E | 5.84 | 3.40 | negative |
| 39 | 281A | 5.72 | 4.04 | negative |
| 40 | 282B | 5.80 | 4.04 | negative |
| 41 | 285A | 5.36 | 3.36 | negative |
| 42 | 285D | 5.88 | 3.24 | negative |
| 43 | 285E | 6.00 | 3.23 | negative |

| ExptStimID | IADSstimID | ArousalRating | ValenceRating | ValenceCategory |
|---|---|---|---|---|
| 44 | 286C | 5.64 | 3.80 | negative |
| 45 | 286D | 5.68 | 2.96 | negative |
| 46 | 290C | 5.72 | 2.64 | negative |
| 47 | 290D | 6.00 | 4.00 | negative |
| 48 | 290E | 5.16 | 3.84 | negative |
| 49 | 290F | 5.92 | 3.76 | negative |
| 50 | 291A | 5.96 | 3.04 | negative |
| 51 | 292A | 6.04 | 2.56 | negative |
| 52 | 292B | 5.80 | 3.96 | negative |
| 53 | 292C | 6.00 | 2.72 | negative |
| 54 | 296A | 5.20 | 3.72 | negative |
| 55 | 296D | 5.76 | 3.38 | negative |
| 56 | 373C | 5.31 | 4.04 | negative |
| 57 | 376C | 4.80 | 4.08 | negative |
| 58 | 420A | 5.16 | 3.96 | negative |
| 59 | 422A | 4.84 | 4.00 | negative |
| 60 | 423A | 5.80 | 3.56 | negative |
| 61 | 424C | 5.60 | 3.88 | negative |
| 62 | 424E | 6.00 | 3.80 | negative |
| 63 | 501B | 5.84 | 3.76 | negative |
| 64 | 600B | 5.44 | 3.68 | negative |
| 65 | 602A | 5.24 | 3.88 | negative |
| 66 | 626A | 6.04 | 3.64 | negative |
| 67 | 627A | 4.48 | 4.08 | negative |
| 68 | 698A | 5.92 | 3.36 | negative |
| 69 | 702A | 4.32 | 3.24 | negative |
| 70 | 702B | 4.88 | 2.64 | negative |
| 71 | 702C | 4.52 | 3.16 | negative |
| 72 | 702D | 4.56 | 3.04 | negative |
| 73 | 702E | 4.60 | 3.12 | negative |
| 74 | 703A | 5.28 | 3.71 | negative |
| 75 | 706A | 5.16 | 4.08 | negative |
| 76 | 706B | 5.28 | 4.00 | negative |
| 77 | 715A | 5.77 | 4.08 | negative |
| 78 | 719A | 5.20 | 3.57 | negative |
| 79 | 730A | 4.96 | 4.08 | negative |
| 80 | 910A | 5.84 | 3.88 | negative |
| 81 | 107A | 5.08 | 4.81 | positive |
| 82 | 110A | 5.28 | 6.20 | positive |
| 83 | 110B | 4.88 | 6.76 | positive |
| 84 | 110C | 4.84 | 6.60 | positive |
| 85 | 110F | 5.00 | 5.48 | positive |
| 86 | 110H | 4.96 | 6.00 | positive |
| 87 | 111A | 5.44 | 5.00 | positive |
| 88 | 112B | 5.16 | 4.92 | positive |
| 89 | 120C | 4.80 | 5.48 | positive |

| ExptStimID | IADSstimID | ArousalRating | ValenceRating | ValenceCategory |
|---|---|---|---|---|
| 90 | 150B | 4.80 | 5.12 | positive |
| 91 | 150C | 5.28 | 4.96 | positive |
| 92 | 204A | 5.80 | 4.92 | positive |
| 93 | 205A | 5.52 | 5.36 | positive |
| 94 | 215A | 6.12 | 4.92 | positive |
| 95 | 220A | 5.12 | 5.72 | positive |
| 96 | 224A | 4.80 | 5.36 | positive |
| 97 | 224B | 5.00 | 5.16 | positive |
| 98 | 224C | 4.88 | 5.16 | positive |
| 99 | 224D | 4.80 | 5.12 | positive |
| 100 | 224E | 4.84 | 5.12 | positive |
| 101 | 230B | 5.12 | 5.08 | positive |
| 102 | 230C | 5.24 | 5.25 | positive |
| 103 | 246C | 5.12 | 4.83 | positive |
| 104 | 254B | 4.72 | 6.08 | positive |
| 105 | 254C | 5.32 | 5.00 | positive |
| 106 | 260A | 5.16 | 5.36 | positive |
| 107 | 260C | 5.12 | 5.20 | positive |
| 108 | 278B | 5.52 | 5.80 | positive |
| 109 | 278C | 5.16 | 5.00 | positive |
| 110 | 311A | 5.28 | 5.40 | positive |
| 111 | 311B | 5.88 | 6.48 | positive |
| 112 | 311C | 4.84 | 6.00 | positive |
| 113 | 319A | 5.04 | 5.00 | positive |
| 114 | 352A | 5.12 | 4.88 | positive |
| 115 | 352D | 4.80 | 5.80 | positive |
| 116 | 353A | 5.76 | 5.68 | positive |
| 117 | 353B | 5.36 | 6.04 | positive |
| 118 | 353C | 5.76 | 5.92 | positive |
| 119 | 353D | 5.04 | 6.12 | positive |
| 120 | 355B | 5.28 | 4.92 | positive |
| 121 | 355C | 5.16 | 6.08 | positive |
| 122 | 355F | 5.24 | 5.24 | positive |
| 123 | 358D | 4.80 | 5.04 | positive |
| 124 | 360B | 5.28 | 5.33 | positive |
| 125 | 360C | 5.16 | 5.44 | positive |
| 126 | 363A | 4.96 | 5.80 | positive |
| 127 | 367A | 5.44 | 5.52 | positive |
| 128 | 367B | 4.80 | 5.44 | positive |
| 129 | 367D | 5.36 | 5.92 | positive |
| 130 | 367F | 4.88 | 5.40 | positive |
| 131 | 415B | 5.92 | 4.84 | positive |
| 132 | 601B | 5.60 | 5.36 | positive |
| 133 | 601D | 5.00 | 6.00 | positive |
| 134 | 610A | 4.76 | 5.12 | positive |
| 135 | 611A | 5.36 | 4.88 | positive |

| ExptStimID | IADSstimID | ArousalRating | ValenceRating | ValenceCategory |
|---|---|---|---|---|
| 136 | 714B | 5.36 | 5.38 | positive |
| 137 | 716A | 5.60 | 5.24 | positive |
| 138 | 716B | 5.44 | 6.52 | positive |
| 139 | 717A | 4.76 | 5.44 | positive |
| 140 | 717B | 5.20 | 5.40 | positive |
| 141 | 726A | 4.80 | 5.44 | positive |
| 142 | 802A | 4.96 | 5.32 | positive |
| 143 | 802B | 5.00 | 5.00 | positive |
| 144 | 802C | 5.00 | 5.52 | positive |
| 145 | 802D | 5.28 | 4.84 | positive |
| 146 | 808A | 5.04 | 5.52 | positive |
| 147 | 808B | 5.60 | 5.68 | positive |
| 148 | 808C | 5.08 | 5.75 | positive |
| 149 | 808D | 4.84 | 5.60 | positive |
| 150 | 811A | 4.72 | 6.16 | positive |
| 151 | 811F | 4.84 | 6.24 | positive |
| 152 | 812A | 4.96 | 6.24 | positive |
| 153 | 813A | 4.80 | 5.96 | positive |
| 154 | 815A | 6.28 | 6.12 | positive |
| 155 | 815B | 6.12 | 5.68 | positive |
| 156 | 815C | 5.80 | 5.63 | positive |
| 157 | 817A | 5.88 | 6.56 | positive |
| 158 | 817B | 5.88 | 6.56 | positive |
| 159 | 820B | 5.28 | 5.44 | positive |
| 160 | 820D | 5.12 | 6.16 | positive |

| ExptStimID | LEAPstimID | Arousal Rating | Valence Rating | Gender Voice | Valence |
|---|---|---|---|---|---|
| 161 | F089 | 4.24 | 6.32 | female | positive |
| 162 | F144 | 4.24 | 5.96 | female | positive |
| 163 | F100 | 4.28 | 5.76 | female | positive |
| 164 | F014 | 4.31 | 6.19 | female | positive |
| 165 | F061 | 4.31 | 5.00 | female | positive |
| 166 | F035 | 4.32 | 5.71 | female | positive |
| 167 | F061 | 4.32 | 5.80 | female | positive |
| 168 | F082 | 4.32 | 6.24 | female | positive |
| 169 | F142 | 4.32 | 5.24 | female | positive |
| 170 | F011 | 4.36 | 5.58 | female | positive |
| 171 | F017 | 4.36 | 5.68 | female | positive |
| 172 | F071 | 4.36 | 6.24 | female | positive |
| 173 | F100 | 4.36 | 6.32 | female | positive |
| 174 | F129 | 4.36 | 5.88 | female | positive |
| 175 | F140 | 4.36 | 6.13 | female | positive |
| 176 | F031 | 4.40 | 5.48 | female | positive |
| 177 | F035 | 4.40 | 5.52 | female | positive |
| 178 | F039 | 4.40 | 5.84 | female | positive |
| 179 | F014 | 4.42 | 5.73 | female | positive |
| 180 | F067 | 4.44 | 5.76 | female | positive |
| 181 | F129 | 4.44 | 5.28 | female | positive |
| 182 | F089 | 4.48 | 5.40 | female | positive |
| 183 | F047 | 4.52 | 6.00 | female | positive |
| 184 | F011 | 4.56 | 5.84 | female | positive |
| 185 | F016 | 4.60 | 5.08 | female | positive |
| 186 | F066 | 4.60 | 5.64 | female | positive |
| 187 | F146 | 4.60 | 6.12 | female | positive |
| 188 | F087 | 4.63 | 5.36 | female | positive |
| 189 | F030 | 4.64 | 5.56 | female | positive |
| 190 | F144 | 4.64 | 6.32 | female | positive |
| 191 | F016 | 4.72 | 6.12 | female | positive |
| 192 | F062 | 4.72 | 5.20 | female | positive |
| 193 | F051 | 4.84 | 5.60 | female | positive |
| 194 | F139 | 4.84 | 6.20 | female | positive |
| 195 | F140 | 4.84 | 5.76 | female | positive |
| 196 | F066 | 4.88 | 6.36 | female | positive |
| 197 | F017 | 4.96 | 4.96 | female | positive |
| 198 | F082 | 5.00 | 5.96 | female | positive |
| 199 | F087 | 5.00 | 5.84 | female | positive |
| 200 | F067 | 5.36 | 5.64 | female | positive |
| 201 | M112 | 4.20 | 5.32 | male | positive |
| 202 | M116 | 4.20 | 6.00 | male | positive |
| 203 | M120 | 4.20 | 6.13 | male | positive |
| 204 | M136 | 4.20 | 5.92 | male | positive |
| 205 | M020 | 4.24 | 5.72 | male | positive |
| 206 | M027 | 4.24 | 5.56 | male | positive |

| | | | | | |
|---|---|---|---|---|---|
| 207 | M034 | 4.24 | 6.20 | male | positive |
| 208 | M074 | 4.24 | 5.24 | male | positive |
| 209 | M083 | 4.24 | 6.20 | male | positive |
| 210 | M111 | 4.24 | 6.28 | male | positive |
| 211 | M135 | 4.24 | 6.32 | male | positive |
| 212 | M024 | 4.28 | 5.67 | male | positive |
| 213 | M069 | 4.28 | 5.84 | male | positive |
| 214 | M103 | 4.28 | 6.04 | male | positive |
| 215 | M111 | 4.28 | 5.76 | male | positive |
| 216 | M131 | 4.28 | 5.36 | male | positive |
| 217 | M055 | 4.32 | 4.28 | male | positive |
| 218 | M117 | 4.32 | 5.36 | male | positive |
| 219 | M118 | 4.32 | 6.52 | male | positive |
| 220 | M121 | 4.32 | 5.52 | male | positive |
| 221 | M022 | 4.36 | 5.20 | male | positive |
| 222 | M104 | 4.36 | 5.88 | male | positive |
| 223 | M134 | 4.36 | 6.16 | male | positive |
| 224 | M136 | 4.36 | 5.16 | male | positive |
| 225 | M027 | 4.44 | 5.80 | male | positive |
| 226 | M069 | 4.44 | 6.20 | male | positive |
| 227 | M094 | 4.44 | 5.20 | male | positive |
| 228 | M055 | 4.48 | 6.00 | male | positive |
| 229 | M112 | 4.48 | 6.48 | male | positive |
| 230 | M134 | 4.48 | 6.04 | male | positive |
| 231 | M136 | 4.48 | 5.48 | male | positive |
| 232 | M092 | 4.56 | 5.52 | male | positive |
| 233 | M114 | 4.56 | 5.60 | male | positive |
| 234 | M112 | 4.60 | 6.60 | male | positive |
| 235 | M134 | 4.60 | 5.75 | male | positive |
| 236 | M119 | 4.68 | 6.16 | male | positive |
| 237 | M135 | 4.68 | 6.04 | male | positive |
| 238 | M122 | 4.88 | 5.24 | male | positive |
| 239 | M024 | 5.36 | 6.20 | male | positive |
| 240 | M111 | 4.20 | 4.84 | male | positive |

## APPENDIX B: VISUAL WORD STIMULI (TARGETS)

| ANEW ID | Word | Valence | Length | Freq. | Conc. | Arousal Rating | Valence Rating |
|---|---|---|---|---|---|---|---|
| 1892 | fair | positive | 4 | 77 | 413 | 5.67 | 7.2 |
| 1702 | cookie | positive | 6 | 1 | 634 | 5.93 | 8 |
| 2665 | sweet | positive | 5 | 70 | 463 | 6.92 | 8.23 |
| 248 | kiss | positive | 4 | 17 | 564 | 7.55 | 8.24 |
| 157 | fame | positive | 4 | 18 | - | 7.14 | 7.93 |
| 69 | cheer | positive | 5 | 8 | - | 6.3 | 8.5 |
| 2486 | safety | positive | 6 | 47 | 323 | 5.25 | 7.33 |
| 268 | luxury | positive | 6 | 21 | 346 | 5.04 | 8.03 |
| 1745 | cure | positive | 4 | 28 | 352 | 7.77 | 8.77 |
| 530 | sexy | positive | 4 | - | - | 7.24 | 7.88 |
| 457 | trust | positive | 5 | 52 | 300 | 5.31 | 7.21 |
| 844 | leader | positive | 6 | 74 | 487 | 6.35 | 7.9 |
| 239 | jewel | positive | 5 | 1 | 594 | 5.31 | 7.24 |
| 2131 | laugh | positive | 5 | 28 | 433 | 8.33 | 9 |
| 184 | gift | positive | 4 | 33 | 533 | 6.59 | 8.38 |
| 1663 | climax | positive | 6 | 14 | - | 7.75 | 7.83 |
| 1559 | bonus | positive | 5 | 2 | - | 6.93 | 8.2 |
| 1658 | clean | positive | 5 | 70 | 392 | 5.67 | 8.27 |
| 2821 | wisdom | positive | 6 | 44 | 275 | 6.92 | 7.77 |
| 2166 | luck | positive | 4 | 47 | 275 | 6.93 | 7.56 |
| 2573 | smart | positive | 5 | 21 | 304 | 6.27 | 7.73 |
| 241 | joyful | positive | 6 | 1 | - | 5.81 | 8.52 |
| 2052 | hobby | positive | 5 | 4 | 449 | 6 | 7.5 |
| 336 | puppy | positive | 5 | 2 | 623 | 5.76 | 7.66 |
| 517 | kitten | positive | 6 | 5 | 612 | 5.15 | 7 |
| 427 | talent | positive | 6 | 40 | 290 | 6.08 | 7.65 |
| 1002 | sugar | positive | 5 | 34 | 620 | 5.14 | 7.05 |
| 2538 | shower | positive | 6 | 15 | 588 | 6.17 | 7.67 |
| 265 | loyal | positive | 5 | 18 | - | 5.24 | 7.93 |
| 2801 | wealth | positive | 6 | 22 | 370 | 5.07 | 7.57 |
| 72 | circus | positive | 6 | 7 | 535 | 6.45 | 7.75 |
| 1639 | chef | positive | 4 | 9 | - | 6.5 | 7.67 |
| 2196 | meal | positive | 4 | 30 | 602 | 6.07 | 8.13 |
| 827 | jolly | positive | 5 | 4 | - | 5.45 | 7.45 |
| 1980 | giggle | positive | 6 | 1 | - | 6.35 | 8.18 |
| 2576 | smile | positive | 5 | 58 | 514 | 6.69 | 8.06 |
| 2263 | oasis | positive | 5 | - | - | 5.38 | 8.15 |
| 506 | couple | positive | 6 | 122 | - | 7.38 | 7.96 |
| 2488 | sale | positive | 4 | 44 | 364 | 7.25 | 7.5 |
| 2455 | rich | positive | 4 | 74 | 377 | 6.13 | 7.87 |

| ANEW ID | Word | Valence | Length | Freq. | Conc. | Arousal Rating | Valence Rating |
|---|---|---|---|---|---|---|---|
| 1034 | wish | positive | 4 | 110 | 270 | 5.32 | 7.32 |
| 302 | palace | positive | 6 | 38 | 579 | 5.29 | 7.65 |
| 2552 | sister | positive | 6 | 38 | 575 | 6.85 | 8.46 |
| 358 | reward | positive | 6 | 15 | 396 | 5.23 | 7.78 |
| 1019 | treat | positive | 5 | 26 | 399 | 5.71 | 7.5 |
| 514 | food | positive | 4 | 147 | 597 | 6.42 | 7.42 |
| 503 | cash | positive | 4 | 36 | 547 | 7.65 | 8.46 |
| 200 | happy | positive | 5 | 98 | 355 | 6.19 | 8.19 |
| 1541 | birth | positive | 5 | 66 | 471 | 7.75 | 8.25 |
| 16 | angel | positive | 5 | 18 | 399 | 4.65 | 7.81 |
| 2043 | hero | positive | 4 | 52 | 428 | 6.69 | 8.08 |
| 211 | honor | positive | 5 | 66 | - | 5.77 | 7.69 |
| 438 | thrill | positive | 6 | 5 | 320 | 7.81 | 7.85 |
| 1618 | castle | positive | 6 | 7 | - | 6.69 | 7.94 |
| 77 | comedy | positive | 6 | 39 | 365 | 5.61 | 8.57 |
| 174 | friend | positive | 6 | 133 | 450 | 5.35 | 8.12 |
| 266 | lucky | positive | 5 | 21 | - | 6.15 | 8.35 |
| 682 | champ | positive | 5 | 1 | - | 5.85 | 7.15 |
| 2818 | winner | positive | 6 | 8 | - | 6.94 | 8.25 |
| 326 | pretty | positive | 6 | 107 | 341 | 5.37 | 7.85 |
| 1487 | award | positive | 5 | 46 | - | 7.69 | 9 |
| 872 | merry | positive | 5 | 8 | 370 | 5.5 | 8.09 |
| 64 | caress | positive | 6 | 1 | - | 5.39 | 7.94 |
| 138 | elated | positive | 6 | - | - | 6.22 | 7.43 |
| 2368 | praise | positive | 6 | 17 | 354 | 6.33 | 8.13 |
| 359 | riches | positive | 6 | 2 | - | 5.96 | 7.85 |
| 1410 | actor | positive | 5 | 24 | - | 6.31 | 7.06 |
| 668 | brave | positive | 5 | 24 | 283 | 6.35 | 7.55 |
| 987 | song | positive | 4 | 70 | 514 | 6.8 | 7.85 |
| 1825 | eager | positive | 5 | 27 | 302 | 6.79 | 7.93 |
| 1992 | goal | positive | 4 | 60 | 482 | 6.45 | 7.36 |
| 264 | loved | positive | 5 | - | - | 6.69 | 8.83 |
| 2378 | prince | positive | 6 | 33 | 542 | 6.93 | 7.67 |
| 826 | joke | positive | 4 | 22 | 388 | 6.82 | 8 |
| 1977 | genius | positive | 6 | 23 | 342 | 6.17 | 7.92 |
| 507 | dancer | positive | 6 | 31 | 558 | 6.65 | 7.46 |
| 1983 | glad | positive | 4 | 38 | 318 | 5.93 | 7.93 |
| 1959 | funny | positive | 5 | 41 | - | 7.5 | 8.75 |
| 2830 | wrath | negative | 5 | 9 | 304 | 5.94 | 2.19 |
| 269 | maggot | negative | 6 | - | - | 5.54 | 1.92 |
| 751 | fight | negative | 5 | 98 | 455 | 7.4 | 2.65 |
| 165 | filth | negative | 5 | 2 | 467 | 5.85 | 2.04 |
| 1623 | cavity | negative | 6 | 12 | - | 5.8 | 2.2 |

| ANEW ID | Word | Valence | Length | Freq. | Conc. | Arousal Rating | Valence Rating |
|---|---|---|---|---|---|---|---|
| 788 | hell | negative | 4 | 95 | 355 | 6.05 | 1.67 |
| 595 | injury | negative | 6 | 27 | 497 | 5.81 | 1.85 |
| 2798 | wart | negative | 4 | 11 | - | 4.81 | 2.62 |
| 481 | vomit | negative | 5 | - | - | 5.62 | 1.96 |
| 92 | cruel | negative | 5 | 15 | 367 | 5.96 | 1.57 |
| 1972 | gang | negative | 4 | 22 | 492 | 6.67 | 2.25 |
| 2600 | sorrow | negative | 6 | 9 | 282 | 5.55 | 1.42 |
| 1432 | alarm | negative | 5 | 16 | - | 7.54 | 2.62 |
| 106 | demon | negative | 5 | 9 | 302 | 7.32 | 1.39 |
| 213 | horror | negative | 6 | 17 | 341 | 7.69 | 2.48 |
| 817 | insult | negative | 6 | 7 | 375 | 6.55 | 1.68 |
| 2783 | virus | negative | 5 | 13 | - | 5.57 | 2.86 |
| 46 | bomb | negative | 4 | 36 | 595 | 7.31 | 1.9 |
| 101 | debt | negative | 4 | 13 | 416 | 6.46 | 2.12 |
| 1802 | doubt | negative | 5 | 114 | - | 5.08 | 2.17 |
| 329 | prison | negative | 6 | 42 | 570 | 5.61 | 1.97 |
| 755 | flood | negative | 5 | 19 | 553 | 6.09 | 2.68 |
| 713 | danger | negative | 6 | 70 | 338 | 7.42 | 1.85 |
| 592 | fear | negative | 4 | 127 | 326 | 7.19 | 1.85 |
| 344 | rape | negative | 4 | 5 | 472 | 7.38 | 1.08 |
| 2144 | liar | negative | 4 | 3 | 409 | 7.13 | 2.27 |
| 964 | robber | negative | 6 | 2 | 545 | 5.81 | 2.18 |
| 100 | death | negative | 5 | 277 | 365 | 4.75 | 1.55 |
| 53 | brutal | negative | 6 | 7 | 402 | 7.36 | 2.46 |
| 815 | insane | negative | 6 | 13 | - | 5.95 | 2.23 |
| 618 | victim | negative | 6 | 27 | 467 | 6.12 | 1.92 |
| 2284 | orphan | negative | 6 | 1 | - | 5.6 | 1.87 |
| 2693 | terror | negative | 6 | 25 | 326 | 7.5 | 1.5 |
| 493 | wicked | negative | 6 | 9 | - | 6.37 | 2.97 |
| 461 | ulcer | negative | 5 | 5 | 558 | 6.04 | 1.72 |
| 2408 | rash | negative | 4 | 1 | 523 | 5.85 | 1.69 |
| 363 | roach | negative | 5 | 2 | - | 7.5 | 1.95 |
| 2064 | hunger | negative | 6 | 17 | 410 | 5.07 | 2.36 |
| 313 | pest | negative | 4 | 4 | 479 | 5.77 | 2.76 |
| 361 | riot | negative | 4 | 7 | 414 | 6.58 | 2.5 |
| 319 | poison | negative | 6 | 10 | 527 | 6.62 | 1.81 |
| 256 | lice | negative | 4 | 2 | 543 | 4.92 | 2.12 |
| 2160 | loss | negative | 4 | 86 | 313 | 5.85 | 1.46 |
| 712 | damage | negative | 6 | 33 | 406 | 6.05 | 2.45 |
| 8 | afraid | negative | 6 | 57 | 336 | 6.68 | 1.83 |
| 1963 | fury | negative | 4 | 19 | 305 | 7.54 | 2.14 |
| 60 | cancer | negative | 6 | 25 | 615 | 6.26 | 1.41 |
| 202 | hatred | negative | 6 | 20 | 239 | 6.76 | 1.69 |

| ANEW ID | Word | Valence | Length | Freq. | Conc. | Arousal Rating | Valence Rating |
|---|---|---|---|---|---|---|---|
| 1870 | exam | negative | 4 | - | - | 7.5 | 2.07 |
| 2758 | tyrant | negative | 6 | 2 | 467 | 5.93 | 2.87 |
| 2628 | sting | negative | 5 | 5 | 509 | 6.85 | 1.62 |
| 446 | toxic | negative | 5 | 3 | - | 6.61 | 2.14 |
| 435 | thief | negative | 5 | 8 | 519 | 7.19 | 1.5 |
| 115 | devil | negative | 5 | 25 | 274 | 6.76 | 1.96 |
| 1489 | awful | negative | 5 | 17 | - | 5.73 | 2.93 |
| 2527 | shame | negative | 5 | 21 | 287 | 6.47 | 1.8 |
| 2762 | uneasy | negative | 6 | 22 | - | 6.13 | 2.53 |
| 413 | stress | negative | 6 | 107 | - | 7.47 | 2 |
| 588 | dead | negative | 4 | 174 | 429 | 6.04 | 1.42 |
| 275 | menace | negative | 6 | 9 | 377 | 5.72 | 2.68 |
| 706 | crisis | negative | 6 | 82 | 319 | 6.08 | 1.72 |
| 750 | fever | negative | 5 | 19 | 492 | 4.73 | 2.48 |
| 1714 | court | negative | 5 | 230 | 509 | 6.17 | 2.5 |
| 2015 | guilt | negative | 5 | 33 | 299 | 5.93 | 1.67 |
| 10 | agony | negative | 5 | 9 | 348 | 6.34 | 2.41 |
| 704 | crime | negative | 5 | 34 | 387 | 5.75 | 2.33 |
| 236 | jail | negative | 4 | 21 | 590 | 5.73 | 1.91 |
| 474 | venom | negative | 5 | 2 | 476 | 6.55 | 1.8 |
| 769 | greed | negative | 5 | 3 | 262 | 4 | 2.85 |
| 2696 | theft | negative | 5 | 10 | 361 | 6.91 | 1.91 |
| 1740 | cult | negative | 4 | 11 | 349 | 6.69 | 1.92 |
| 366 | rude | negative | 4 | 6 | - | 6.26 | 2.35 |
| 2705 | threat | negative | 6 | 42 | 335 | 7 | 1.82 |
| 1 | abuse | negative | 5 | 18 | - | 6.88 | 1.46 |
| 400 | slime | negative | 5 | - | 545 | 5.53 | 2.25 |
| 741 | evil | negative | 4 | 72 | - | 6.27 | 2.46 |
| 171 | fraud | negative | 5 | 8 | 304 | 5.92 | 2.65 |
| 301 | pain | negative | 4 | 88 | 426 | 7.12 | 1.54 |

# APPENDIX C: PHOPHIKAT-45

**Age:**___________

**Gender:** O male O female

**Are you?** O single O cohabiting O married O separated O widowed

**Instructions:**

The following statements refer to your feelings, actions, and perceptions **in general**. Please try as much as possible to describe your **habitual** behavior patterns and attitudes by marking an X through one of the four alternatives. Please use the following scale:

(1) strongly disagree
(2) moderately disagree
(3) moderately agree
(4) strongly agree

**For example:**

I am a cheerful person ................................................... (1) (2) (3) (4)

If you strongly agree with this statement, that is, if you are **in general** a cheerful person, **mark an X through (4)**.

If you strongly disagree, that is, if you are **habitually *not*** cheerful ***at all***, **mark an X through (1).**

If you have difficulty answering a question, pick the response that **most closely** represents you.

**Please answer <u>every</u> question, do not omit any.**

| | | |
|---|---|---|
| 1 | When someone laughs in my presence I get suspicious. | (1) (2) (3) (4) |
| 2 | When I am with other people, I enjoy making jokes at my own expense to make the others laugh. | (1) (2) (3) (4) |
| 3 | I enjoy exposing others and I am happy when they get laughed at. | (1) (2) (3) (4) |
| 4 | I avoid drawing attention to myself in public places because I fear that people could become aware of my insecurities and could make fun of me. | (1) (2) (3) (4) |
| 5 | I do not hesitate to tell friends or acquaintances something embarrassing or misfortunate that happened to me, even at the risk of being laughed at. | (1) (2) (3) (4) |
| 6 | Often, disputes emerge because of funny remarks or jokes that I make about other people. | (1) (2) (3) (4) |
| 7 | When strangers laugh in my presence I often think they are laughing at me. | (1) (2) (3) (4) |
| 8 | It makes no difference to me whether people laugh at me or laugh with me. | (1) (2) (3) (4) |
| 9 | When making jokes or funny remarks about other people I'd rather follow the motto "An eye for an eye, and a tooth for a tooth" than "If someone strikes you on the right cheek, offer him the other also." | (1) (2) (3) (4) |
| 10 | When others make joking remarks about me I feel paralyzed. | (1) (2) (3) (4) |
| 11 | I enjoy it when other people laugh at me. | (1) (2) (3) (4) |
| 12 | Humorless people have broken off their friendships with me, or at least threatened to, because I excessively ridiculed them about something | (1) (2) (3) (4) |

| | | |
|---|---|---|
| | embarrassing or unfortunate that happened to them. | |
| 13 | I believe that I make funny or ridiculous impression on others, though I wish I didn't. | (1) (2) (3) (4) |
| 14 | I am the joker in my circle of friends, who entertains others (often with jokes at my own expense). | (1) (2) (3) (4) |
| 15 | If other people poke fun at me then I pay them back in the same way—but even more so. | (1) (2) (3) (4) |
| 16 | I try hard to control myself in order to not attract negative attention and make a ridiculous impression. | (1) (2) (3) (4) |
| 17 | I enjoy it if other people poke fun at me since this might also be a sign of recognition. | (1) (2) (3) (4) |
| 18 | If it is entertaining to other people it is justifiable to make jokes or funny remarks that might be painful or mean to someone. | (1) (2) (3) (4) |
| 19 | When I have made an embarrassing impression somewhere, I avoid that place from then on. | (1) (2) (3) (4) |
| 20 | If someone caught me on a camera while something embarrassing or misfortunate happened to me, I would not mind if s/he sent the video to a television show that broadcasts them. | (1) (2) (3) (4) |
| 21 | Some people set themselves up for someone to make fun of them. | (1) (2) (3) (4) |
| 22 | If someone has teased me in the past I feel uncomfortable around them ever after. | (1) (2) (3) (4) |
| 23 | I have a talent for being a comedian or clown. | (1) (2) (3) (4) |
| 24 | Since it is only for fun, I do not see any problem with exposing others in a funny way. | (1) (2) (3) (4) |
| 25 | It takes me a very long time to recover from having been laughed at. | (1) (2) (3) (4) |
| 26 | In order to make people laugh I make the most out of embarrassments or misfortunes that happen to me which other people would be ashamed of. | (1) (2) (3) (4) |
| 27 | Laughing at others is part of life. People who do not like to be laughed at should just fight back. | (1) (2) (3) (4) |
| 28 | When I am not paying close attention, the risk is high for me to attract negative attention and appear peculiar to others. | (1) (2) (3) (4) |
| 29 | I enjoy making people laugh by telling them embarrassing things or misfortunes that happened to me. | (1) (2) (3) (4) |
| 30 | If I am with a group of people and I am the only one that notices someone has done something embarrassing or that something embarrassing has happened to him/her, I do not hesitate to tell the others about it. | (1) (2) (3) (4) |
| 31 | It is difficult for me to hold eye contact because I fear being assessed in a disparaging way. | (1) (2) (3) (4) |
| 32 | If I am with other people and something embarrassing happens to me (e.g., a slip of the tongue or a misfortune) I am more pleased than angry and laugh along with them. | (1) (2) (3) (4) |

| | | |
|---|---|---|
| 33 | I do not have a guilty conscience when I laugh at the misfortunes (e.g., slips of the tongue) of others. | (1) (2) (3) (4) |
| 34 | Although I frequently feel lonely, I tend to not take part in social activities in order to protect myself from derision. | (1) (2) (3) (4) |
| 35 | If I make a blunder, I enjoy it a little because I can hardly wait to tell my friends about this misfortune. | (1) (2) (3) (4) |
| 36 | Nothing is better than stealing a poser's thunder with a funny remark. | (1) (2) (3) (4) |
| 37 | When I have made a fool of myself in front of others I freeze and lose my ability to behave appropriately. | (1) (2) (3) (4) |
| 38 | I do not mind sharing something embarrassing that happened to me to a group if I know the others will find it funny. | (1) (2) (3) (4) |
| 39 | It is easier for me to laugh at others than to make fun of myself. | (1) (2) (3) (4) |
| 40 | I feel uneasy when dancing because I am convinced that everyone watching me thinks I am ridiculous. | (1) (2) (3) (4) |
| 41 | Nothing much could happen to me that I would be so ashamed of as to not tell others about it. | (1) (2) (3) (4) |
| 42 | In my circle of friends I am known for my "sharp tongue" (e.g., making cynical remarks and jokes about others). | (1) (2) (3) (4) |
| 43 | If I did not fear making a fool of myself I would speak more often in public. | (1) (2) (3) (4) |
| 44 | My friends know me to not be ashamed of telling them about embarrassing situations that happened to me. | (1) (2) (3) (4) |
| 45 | I notice that I sometimes cross the line and jokes that were meant to be harmless are painful instead (at least from the viewpoint of shy or reserved people). | (1) (2) (3) (4) |

**Please check to see that you have answered every statement.**

**Scoring key PhoPhiKat**

PhoPhiKat-30: Pho = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28
PhoPhiKat-45: Pho = 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, 37, 40, 43
PhoPhiKat-30: Phi = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29
PhoPhiKat-45: Phi = 2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 32, 35, 38, 41, 44
PhoPhiKat-30: Kat = 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
PhoPhiKat-45: Kat = 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45

# APPENDIX D: SOCIALLY ANXIOUS EVENT NARRATIVE

Please recall a specific autobiographical social or performance situation from any period in your life (e.g., childhood, teenage, adulthood) during which you felt social anxiety, a situation that you can see clearly in your mind's eye, a vivid memory characterized by strong social humiliation, embarrassment and/or shame. Please write a single paragraph describing what happened, who was with you, what you thought and felt during the event.

*[Open space for participants to fill in.]*

What was your age at the time of the event?

With respect to the specific situation you described above, you may notice self-focused negative self-beliefs, for example, "I was so stupid," "Others must think I am so insecure," etc.

Please compose 3–4 distinct negative self-beliefs about yourself in the situation above. These should be self-critical beliefs.

Negative self-beliefs:

*[Open space for participants to fill in.]*

Now rank order from 1 to 4 the statements in terms of how negative the statement is for you by placing the number 1 (strongest), 2 (next strongest) and so on.

Please go to the next page and answer 4 questions regarding this social situation.

1. How vividly can you re-imagine or re-experience that situation **NOW**?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Not at all | | Slightly | | Moderately | | A lot | | Very much |

2. How much humiliation, embarrassment or shame did you feel when you experienced this situation **when it happened**?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Not at all | | Slightly | | Moderately | | A lot | | Very much |

3. How much humiliation, embarrassment or shame do you feel **NOW** when you recall this situation?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Not at all | | Slightly | | Moderately | | A lot | | Very much |

4. How much do you **actively avoid** situations similar to this event?

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Not at all | | Slightly | | Moderately | | A lot | | Very much |

# APPENDIX E: SOCIAL ANXIETY ASSESSMENTS

## Liebowitz Social Anxiety Scale

This measure assesses the way that social phobia plays a role in your life across a variety of situations. Read each situation carefully and answer two questions about that situation. The first question asks how anxious or fearful you feel in the situation. The second question asks how often you avoid the situation. If you come across a situation that you ordinarily do not experience, imagine "what if you were faced with that situation," and then, rate the degree to which you would fear this hypothetical situation and how often you would tend to avoid it. Please base your ratings on the way that the situations have affected you in the last week.
Fill out the following scale by circling the most suitable answer provided below.

| **Situation** | **Fear** | **Avoidance** |
|---|---|---|
| Instructions: Circle the number that corresponds to your level of fear and avoidance of the situations below. | 0 - None<br>1 - Mild<br>2 - Moderate<br>3 - Severe | 0 - Never<br>1 - Occasionally<br>2 - Often<br>3 - Usually |
| 1. Telephoning in public. | 0 1 2 3 | 0 1 2 3 |
| 2. Participating in small groups. | 0 1 2 3 | 0 1 2 3 |
| 3. Eating in public places. | 0 1 2 3 | 0 1 2 3 |
| 4. Drinking with others in public places. | 0 1 2 3 | 0 1 2 3 |
| 5. Talking to people in authority. | 0 1 2 3 | 0 1 2 3 |
| 6. Acting, performing or giving a talk in front of an audience. | 0 1 2 3 | 0 1 2 3 |
| 7. Going to a party. | 0 1 2 3 | 0 1 2 3 |
| 8. Working while being observed. | 0 1 2 3 | 0 1 2 3 |
| 9. Writing while being observed. | 0 1 2 3 | 0 1 2 3 |
| 10. Calling someone you don't know very well. | 0 1 2 3 | 0 1 2 3 |
| 11. Talking with people you don't know very well. | 0 1 2 3 | 0 1 2 3 |
| 12. Meeting strangers. | 0 1 2 3 | 0 1 2 3 |
| 13. Urinating in a public bathroom. | 0 1 2 3 | 0 1 2 3 |
| 14. Entering a room when others are already seated. | 0 1 2 3 | 0 1 2 3 |
| 15. Being the center of attention. | 0 1 2 3 | 0 1 2 3 |
| 16. Speaking up at a meeting. | 0 1 2 3 | 0 1 2 3 |
| 17. Taking a test. | 0 1 2 3 | 0 1 2 3 |
| 18. Expressing a disagreement or disapproval to people you don't know very well. | 0 1 2 3 | 0 1 2 3 |
| 19. Looking at people you don't know very well in the eyes. | 0 1 2 3 | 0 1 2 3 |
| 20. Giving a report to a group. | 0 1 2 3 | 0 1 2 3 |
| 21. Trying to pick up someone. | 0 1 2 3 | 0 1 2 3 |
| 22. Returning goods to a store. | 0 1 2 3 | 0 1 2 3 |
| 23. Giving a party. | 0 1 2 3 | 0 1 2 3 |
| 24. Resisting a high pressure salesperson. | 0 1 2 3 | 0 1 2 3 |

## Social Phobia Scale (SPS)

Please indicate the degree to which you feel the statement is characteristic or true of you.
Circle your response using the following scale: 0 – Not at all
1 – Slightly
2 – Moderately
3 – Very
4 – Extremely

| | | |
|---|---|---|
| 1. | I become anxious if I have to write in front of other people. | 0 1 2 3 4 |
| 2. | I become self-conscious when using public toilets. | 0 1 2 3 4 |
| 3. | I can suddenly become aware of my own voice and of others listening to me. | 0 1 2 3 4 |
| 4. | I get nervous that people are staring at me as I walk down the street. | 0 1 2 3 4 |
| 5. | I fear I may blush when I am with others. | 0 1 2 3 4 |
| 6. | I feel self-conscious if I have to enter a room where others are already seated. | 0 1 2 3 4 |
| 7. | I worry about shaking or trembling when I'm watched by other people. | 0 1 2 3 4 |
| 8. | I would get tense if I had to sit facing other people on a bus or a train. | 0 1 2 3 4 |
| 9. | I get panicky that others might see me to be faint, sick or ill. | 0 1 2 3 4 |
| 10. | I would find it difficult to drink something if in a group of people. | 0 1 2 3 4 |
| 11. | It would make me feel self-conscious to eat in front of a stranger at a restaurant. | 0 1 2 3 4 |
| 12. | I am worried people will think my behaviour odd. | 0 1 2 3 4 |
| 13. | I would get tense if I had to carry a tray across a crowded cafeteria. | 0 1 2 3 4 |
| 14. | I worry I'll lose control of myself in front of other people. | 0 1 2 3 4 |
| 15. | I worry I might do something to attract the attention of others. | 0 1 2 3 4 |
| 16. | When in an elevator I am tense if people look at me. | 0 1 2 3 4 |
| 17. | I can feel conspicuous standing in a queue (in a waiting line). | 0 1 2 3 4 |
| 18. | I get tense when I speak in front of other people. | 0 1 2 3 4 |
| 19. | I worry my head will shake or nod in front of others. | 0 1 2 3 4 |
| 20. | I feel awkward and tense if I know people are watching me. | 0 1 2 3 4 |

## Social Interaction Anxiety Scale (SIAS)

Please indicate the degree to which you feel the statement is characteristic or true of you.
Circle your response using the following scale: 0 – Not at all
1 – Slightly
2 – Moderately
3 – Very
4 – Extremely

| | | |
|---|---|---|
| 1. | I get nervous if I have to speak with someone in authority (teacher, boss, etc.). | 0 1 2 3 4 |
| 2. | I have difficulty making eye-contact with others. | 0 1 2 3 4 |
| 3. | I become tense if I have to talk about myself or my feelings. | 0 1 2 3 4 |
| 4. | I find difficulty mixing comfortably with the people I work with. | 0 1 2 3 4 |
| 5. | I tense-up if I meet an acquaintance in the street. | 0 1 2 3 4 |
| 6. | When mixing socially I am uncomfortable. | 0 1 2 3 4 |
| 7. | I feel tense if I am alone with just one other person. | 0 1 2 3 4 |
| 8. | I am at ease meeting people at parties, etc. | 0 1 2 3 4 |
| 9. | I have difficulty talking with other people. | 0 1 2 3 4 |
| 10. | I find it easy to think of things to talk about. | 0 1 2 3 4 |
| 11. | I worry about expressing myself in case I appear awkward. | 0 1 2 3 4 |
| 12. | I find it difficult to disagree with another's point of view. | 0 1 2 3 4 |
| 13. | I have difficulty talking to attractive persons of the opposite sex. | 0 1 2 3 4 |
| 14. | I find myself worrying that I won't know what to say in social. | 0 1 2 3 4 |
| 15. | I am nervous mixing with people I don't know well. | 0 1 2 3 4 |
| 16. | I feel I'll say something embarrassing when talking. | 0 1 2 3 4 |
| 17. | When mixing in a group I find myself worrying I will be ignored. | 0 1 2 3 4 |
| 18. | I am tense mixing in a group. | 0 1 2 3 4 |
| 19. | I am unsure whether to greet someone I know only slightly. | 0 1 2 3 4 |