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THE N400 ERP: SEMANTIC VS. EVALUATIVE INCONGRUITIES

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2008

Dedication

To my family for never giving up on me.

THE N400 ERP: SEMANTIC VS. EVALUATIVE INCONGRUITIES

by

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THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF ARTS

Department of Psychology

THE UNIVERSITY OF TEXAS AT EL PASO

December 2008

Acknowledgements

I would like to thank Dr. Stephen L. Crites for taking a chance on me and for providing me with the guidance needed to complete this project. I would also like to thank Guadalupe Corral, Katherine White, Andrew Mojica and all the undergraduates in the laboratory! Without the friendship, love and support of these very important people, I would not have survived.

Abstract

The objective of this research was to utilize both behavioral (response times) and psychophysiological measures (ERPs – N400 & Pre-response Positivity) to uncover the cognitive mechanism responsible for the evaluative priming effect (spreading activation vs. response competition) by controlling for semantic influences. This research project examined the evaluative incongruity effect by controlling for semantic influences in two separate studies. The first study kept semantic associations among word pairs completely random, while the second study controlled for semantic associations by either pairing words from the same semantic category (e.g., animal-animal) or from different semantic categories (e.g., animal-person). Participants completed an evaluative task by indicating if the second word in the word pair was good or bad. Although the results from study 1 did not show a significant behavioral evaluative effect, the response competition mechanism was supported by findings that showed a marginally significant response-monitoring ERP component (PRP). Response competition was further supported with both behavioral and psychophysiological findings in study 2. The results showed a behavioral evaluative effect, where participants responded faster to evaluatively congruent word pairs than to incongruent word pairs and also found a significant PRP. The N400 was not found in either of the two studies and therefore did not lend support for spreading activation. The findings from both of these studies support response competition as the mechanism underlying the evaluative priming effect and question the possible role of spreading activation. Future studies should further explore the comparative approach by varying word pairs on both a semantic and evaluative dimension.

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Chapter 1: Introduction

The cognitive mechanisms underlying evaluative processes, such as attitudes and emotions, have yet to be fully understood. The cognitive processes that are activated when a person encounters an attitude object are of great importance because attitudes help guide behavior and act as a "ready aid" when making decisions (Fazio, Ledbetter, & Towles-Schwen, 2000). To investigate evaluative processes, researchers have utilized variations of existing semantic paradigms to determine the cognitive mechanism underlying the evaluative priming effect. The aim of this research was to utilize both behavioral and psychophysiological measures to uncover the cognitive mechanism responsible for the evaluative priming effect as well as to examine the role of semantic associations. In order to discuss relevant literature examining evaluative effects, it is necessary to first discuss the cognitive mechanism responsible for the semantic priming effect established in foundational research studies.

1.1 Behavioral Semantic Priming

For decades semantic priming has been investigated and established as a procedure that involves the presentation of a word prime that either semantically matches or mismatches the target word. The semantic priming effect has commonly been examined by using the lexical decision task, in which participants are instructed to indicate whether a target letter string is or is not a word. The effect is said to be present when a participant responds faster and more accurately to a target word (e.g., table) when it is preceded by a semantically related word prime (e.g., chair) compared to a semantically unrelated word prime (e.g., cat) (Neely, 1977; for a review see Hutchison, 2003). The cognitive mechanism that has been proposed to underlie the semantic priming effect is automatic spreading activation (Neely, 1977). The theory of spreading activation was first introduced by Collins and Loftus (1975) who stated that semantic memory is organized in a network of nodes that represent concepts. Concepts that are associatively related to each other will be closer to each other in the network and therefore, when one node is activated through priming, this will automatically activate other closely related concepts. This theory extends to semantic priming because participants respond more quickly to target words that are semantically related to the prime (Neely, 1977).

1.2 ADAPTING PSYCHOPHYSIOLOGICAL MEASURES

For many years cognitive psychologists have relied upon behavioral measures, such as reaction times and response accuracy, to explore the time course of mental processes that are involved with the evaluation of a stimulus and the organization/execution of a response (Coles, 1989). Behavioral studies that implement response times as their dependent variable have been informative in terms of proposing underlying mechanisms responsible for cognitive processes; however, response times may represent several components or cognitive processes and not solely the one of experimental interest, which limits the conclusions that can be made by researchers (Bargh & Chartrand, 2000). Coles (1989) proposed the integration of cognitive psychology with the psychophysiological approach (specifically event-related brain potentials) in order to fully examine psychological processing. By integrating these two measures, problems that exist with only using reaction times as a dependent variable can be avoided. Researchers are now implementing event-related potentials (ERPs), alongside response times to investigate the mechanisms responsible for different cognitive processes (Coles, 1989). The information gathered from such experimental designs allows researchers to discern the properties behind the behavioral effects they have found.

The ERP is a time-locked measure of electrical brain activity in response to, or in preparation for, specific events (Fabiani, Gratton, & Coles, 2007). When a person first encounters a stimulus, a sequence of neural processing is activated in order to identify and asses the stimulus and then prepare a response. The electrical activity associated with this sequence of processing is referred to as the ERP. The ERP is comprised of components, which are positive or negative deflections in the electrical signal that are defined by their sensitivity to experimental manipulations, timing, and scalp distribution (Donchin, 1981; Fabiani, Gratton, & Coles, 2007; Kotchoubey, 2006). These components can be named for their polarity, either positive (P) or negative (N) (e.g., N1, P2) or for their latency after stimulus onset (e.g., P300, N400) (Kounios, 1996). ERP components have been described as having an association with the neural mechanisms underlying cognitive processes that occur in response to the presentation of a stimulus (Kotchoubey, 2006, Kounios, 1996). Various factors that affect ERP components have been examined and have provided important information on attention, categorization, memory, language processes, error monitoring, and expectancy (Fabiani, Gratton, & Coles, 2007). Thus, the integration of ERPs with behavioral response times would shed light on questions concerning the cognitive mechanisms underlying priming effects.

1.3 THE N400 ERP – SEMANTICS

The N400 ERP component is a central-posterior negativity peaking around 400ms and is elicited by semantic incongruities. It is thought to reflect the ease of integrating a stimulus into a given context based upon the cognitive effort needed to access information from long-term memory (Kutas & Federmeier, 2000). Kutas and Hillyard (1980) were the first to study the N400 and used a sentence verification paradigm to examine semantic incongruities. The results from this foundational study demonstrated that semantically incongruent sentences (e.g., “He spread the warm bread with *socks*”) elicited a significantly larger N400 compared to semantically congruent sentences (e.g., “It was his first day at *work*.”). This study opened the door for researchers to explore other relevant factors that could possibly affect the N400, such as the level of meaning associated within a word pair priming paradigm (Bentin, McCarthy & Wood, 1985). Bentin and colleagues (1985) examined word pairs that either were semantically congruent (e.g., bread-butter) or incongruent (e.g., brick-butter) and the results showed that semantically incongruent word pairs elicited a significantly larger N400 peak amplitude than congruent word pairs. The N400 effect has also been extensively studied by using masked paradigms that consist of presenting a prime word for 50 ms or less and masking it by presenting a random letter string either after the prime, before the prime or at both time points. Masked paradigms have been utilized to examine the N400 effect to ensure that participants are unable to consciously perceive the prime word, thus demonstrating automatic processing and lending support to the spreading activation mechanism underlying the N400 effect (Kiefer, Weisbrod, Kern, Maier, & Spitzer, 1998) Indirect semantic priming has also provided strong evidence that spreading activation is responsible for the N400 semantic priming effect (Kreher, Holcomb, & Kuperberg, 2006). Indirect semantic priming involves using a prime that is associated with another word that is in turn associated with the target (e.g., lion-stripes are associated through the word tiger); therefore, through spreading activation the prime will activate the associated or mediator word that will then activate the target.

1.4 BEHAVIORAL – EVALUATIVE PRIMING

The theory of spreading activation has also been examined as a possible mechanism for the automatic activation of attitudes from memory (Fazio, Sanbonmatsu, Powell & Kardes, 1986). Fazio and colleagues (1986) employed a variant of the semantic priming procedure to examine the automaticity of attitudes. The participants viewed adjective word pairs that were either evaluatively congruent (e.g., appealing-delightful) or evaluatively incongruent (e.g., repulsive-delightful) and the task was to indicate if the target word was good or bad. The results showed that participant responses were facilitated when the word pairs were evaluatively congruent (e.g., positive-positive, negative-negative). The presentation time of the prime and the inter-stimulus blank screen, together called stimulus onset asynchrony (SOA), was also manipulated to 300ms and 1000ms by Fazio et al. (1986). The argument for this manipulation was that if the facilitation where to be due to a response strategy (e.g., response conflict), than longer SOAs would allow participants more time to enhance this effect; however, if the facilitation where to be due to automatic processes (spreading activation) than no enhanced effects would be found with longer SOAs. The results did not show facilitation effects with the longer SOA of 1000ms but the effect was found to occur with the SOA of 300ms, thus lending support to spreading activation. These findings are parallel to the study conducted by Neely (1977), which also only found semantic facilitation of semantically congruent word pairs to short SOAs. The conclusion gathered from these studies indicated that affect, much like semantic knowledge, can be activated automatically due to the spreading activation of affective associations (Fazio, Sanbonmatsu, Powell & Kardes, 1986).

Other researchers have also shown evidence for the automaticity of attitude activation but question whether spreading activation is the mechanism responsible for the evaluative priming effect (Klauer, Robnagel & Musch, 1997). Klauer, Robnagel and Musch (1997) investigated the mechanism underlying the evaluative priming effect by manipulating the percent of evaluatively congruent and incongruent prime-target pairs (75 congruent / 50 incongruent) and the SOA. The results from this study found evaluative priming to occur at the short SOAs of 0ms and 100ms, which showed evidence for the automaticity of attitude activation and raised the possibility that a "response-bias mechanism" may be underlying the evaluative priming effect.

Researchers now debate the link that was initially made by Fazio and colleagues (1986) with semantic priming (Bargh, Chaiken, Raymond & Hymes, 1996; Klauer, Robnagel & Musch, 1997; Klauer & Musch, 2003, De Houwer, Hermans, Rothermund, & Wentura, 2002; Wentura, 1999). Spreading activation, as previously described, involves the activation of concepts that are more closely associated, which is based on the number of features that are held in common between the two concepts (Bargh, Chaiken, Raymond & Hymes, 1996). The problem with spreading activation lies in the fact that many concepts contain a positive or negative feature in common. Therefore, a prime word can activate a large portion of the network and essentially flood it (Bargh, Chaiken, Raymond & Hymes, 1996; Wittenbrink, 2007).

The alternative mechanism that has been proposed to underlie evaluative priming effects is called response conflict/competition, which was derived from the well established Stroop task (Klauer & Musch, 2003). During a Stroop task a stimulus or stimulus set is presented that activates two different responses (MacLeod, 1991; Klauer & Teige-Mocigemba, 2007): a central one that must be executed based on the task instructions (e.g., respond to the color of ink) and an irrelevant one that must be inhibited (the name of the color), such as the word yellow presented in blue font. Participants' responses are slowed as a result of the conflict between the two stimulus inputs. In most research in which response conflict theory is applied to an evaluative task, the effects are stated to occur as a result of the prime automatically activating or inducing an evaluative response to the congruent or incongruent target (Klauer & Musch, 2003). For example, if the prime was positive (e.g., sunshine) it would activate a "good" response but if the prime was negative (e.g., headache) it would activate a "bad" response (Storbeck & Robinson, 2004). Response times are facilitated when the valence of the target matches the valence of the prime but not when the prime and target are incongruent. Response times are slowed during incongruent trials because time is needed to resolve the conflict (Storbeck & Robinson, 2004; Wittenbrink, 2007). The main difference between this proposed mechanism and the spreading activation theory is that primes are thought to play a role in the selection of a correct response rather than the direct semantic encoding of targets (De Houwer, Hermans, Rothermund & Wentura, 2002).

These findings have been supported by several research studies, such as those conducted by De Houwer, Hermans, Rothermund & Wentura (2002) who specifically compared the spreading activation mechanism with the response conflict mechanism as possible determinants of the evaluative priming effect. De Houwer and colleagues (2002) state that if the true mechanism underlying the evaluative effect is indeed spreading activation, then evaluative priming should also occur during non-evaluative tasks, such as semantic categorization. These studies varied the valence of animal (e.g., butterfly-cockroach) and person categories (e.g., friend-snob) as well as the task participants were asked to complete. Results demonstrated that when participants were asked to semantically categorize targets, the evaluative priming effect was not found. However, when participants were completing an evaluative task (good vs. bad), the evaluative priming effect was found to be significant. These studies further support response competition as the mechanism underlying the evaluative priming effect as evidenced by the finding that during the evaluative task, primes automatically activated a response to the target but not during the semantic categorization task. Therefore, it can be summarized that the valence of the prime could not influence the response to the target because of the unrelated task, lending support to the response competition mechanism (De Houwer, Hermans, Rothermund & Wentura, 2002; Klauer and Musch, 2002).

The behavioral studies that have examined response conflict as the mechanism underlying the evaluative effect have shown evidence that the prime prepares the participant to respond in a certain way. For example, if the target is evaluatively congruent to the prime then the response would be facilitated but if the target is incongruent then a conflict occurs that requires time to resolve. Researchers have also shown that the response conflict effect is reconciled when the participant is categorizing the target stimuli along another dimension, because only information from the prime that is relevant to the response is integrated (Klauer and Musch, 2002). Although the aforementioned studies argue that spreading activation is not the mechanism underlying the behavioral evaluative priming effect as initially proposed by Fazio et al. (1986), Fazio (2001) now raises the possibility that both mechanisms (spreading activation and response competition) play a role in the observed evaluative priming effects and questions the support that has been given to the response competition mechanism because of the nature the words employed in these studies. Fazio (2001) argues that his initial evaluative study (1986) examined word pairs that were synonyms of the words “good” (e.g., appealing, pleasant, delightful) and “bad” (e.g., repulsive, disgusting, horrible) and could be applied to any attitude object and thus a prime word would activate the encoding of an evaluatively congruent target word through spreading activation. Fazio also clearly states that studies that have supported the response competition mechanism have used words that are more diverse in their meaning (e.g., gold, sun, candy vs. virus, dirt bomb) (Fazio, 2001; Wittenbrink, 2007). Fazio argues that before any final conclusions can be made as to which mechanism is responsible for the evaluative priming effect, future studies should examine the nature of the target word in relation to the prime word. Given this debate, ERPs would be of great help with identifying the mechanism underlying the behavioral evaluative effects discussed thus far.

1.5 N400 ERP – Evaluative

Given the debate concerning the cognitive mechanism underlying the evaluative effect (spreading activation vs. response competition), the N400 might provide a means of examining these processes. Few researchers have investigated the N400 and spreading activation in relation to evaluative incongruities and those that have, examined the prosody of vocalization and word meanings (Bostanov & Kotchoubey, 2004; Schirmer, Zysset, Kotz, & Yves von Cramon, 2004; Schirmer & Kotz, 2003; Schirmer, Kotz, & Friederici, 2002 & 2005). Studies conducted by Schirmer, Kotz and Friederici (2002 & 2005) examined an evaluatively neutral sentence that either was spoken with a happy or sad intonation, followed by a target word valence that either was congruent with the prosody of the sentence (e.g., 'success' following a happy intonation) or incongruent (e.g., 'failure' following a happy intonation). The results from these studies showed that participants responded faster and exhibited a smaller N400 peak amplitude when the valence of the target word matched the preceding prosody context compared to incongruent words, which elicited a larger N400 peak amplitude. Shirmer and colleagues suggested that these results indicate that emotional prosody is similar to semantics in regard to the contextual integration of a word. The sensitivity of the N400 to evaluative incongruities has also been found by other researchers who utilized the prosody of vocalization paradigm, lending support to role of spreading activation (Schirmer and Kotz, 2003; Bostanov & Kotchoubey, 2004). Although, these studies reported that the N400 effect was elicited by evaluative incongruities (when the emotional prosody of the word differed from its emotional meaning), the possibility that the results could have been influenced by semantic incongruities is also possible.

In addition to the four prosody experiments, two other experiments explored whether the N400 could be used to examine evaluative incongruities by using a priming paradigm with visual stimuli (Morris, Squires, Taber & Lodge, 2003; Zhang, Lawson, Guo & Jiang, 2006). The objective of the study conducted by Morris and colleagues (2003) was to determine if attitudes towards political leaders, ideas and issues are spontaneously activated when preceded by a political stimulus (e.g., Clinton-honest). The N400 was found to be largest for incongruent word pairs, which provides evidence that the N400 is also sensitive to incongruent evaluative visual stimuli. The limitations of this study, as mentioned throughout the prosody experiments, is that semantic congruity was not considered as a possible confound. This study only used 5 positive and 5 negative political primes and only 15 positive and 15 negative adjectives as targets. This small number of stimuli could have resulted in word pairs that were both evaluatively and semantically incongruent. Zhang et al. (2006) also researched the evaluative priming paradigm and effects on the amplitude of the N400, however, unlike Morris and colleagues (2003), many more stimuli were utilized. A total of 720 prime-target word pairs were presented and 720 prime-target pairs that used pictures as the prime were shown to participants who completed an evaluative task. Zhang et al. (2006) stated that using a very large stimuli set would rule out any semantic and associative relationships other than affect and although this study did report a significant N400 effect to evaluatively incongruent word pairs, the results are not definitive because the study used a reference site for the scalp electrodes that would effectively eliminate the N400.

1.6 Response – Locked ERP Components

To further investigate the cognitive mechanism underlying the evaluative incongruity effect, researchers should not only examine the presence or absence of the stimulus-locked N400 component but should also examine response-locked ERP components. Response-locked ERP components occur prior and immediately after the execution of a response and indicate control processes thought to reflect the conflict involved with selecting the correct response (Fabiani, Gratton & Federmeier, 2007; Johnson, Barnhardt & Zhu, 2004). For example, Johnson and colleagues (2004) have demonstrated the increase of a medial frontal negativity (MFN) component, occurring approximately 100 ms after the execution of the response, as well as an increase in reaction times with incompatible responses to stimuli. Johnson and colleagues (2004) stated that the MFN provides insight to the executive processing involved in monitoring functions and it was further stated that these brain mechanisms reflect response conflict. If a response-locked ERP component were found to be sensitive to evaluative incongruities, this would provide strong evidence for the presence of a response competition mechanism and not for spreading activation. The evaluative N400 studies, as previously discussed, did not examine the presence or absence of a response-locked ERP component and thus cannot definitively support spreading activation as the mechanism responsible for the evaluative effects that were found.

1.7 Controlling for Semantic Influence

The impact of semantic relations on evaluative priming was investigated in a behavioral study by Storbeck and Robinson (2004). Several experiments were conducted using stimuli that varied on two dimensions: category and valence (e.g., animal: puppy-leech, texture: fluffy-sharp). The first experiment varied semantic congruency (e.g., animal-animal, religion-religion; animal-religion, religion-animal) and evaluative congruency (e.g., good-good, bad-bad, good-bad, bad-good), which was a 2 (semantic congruency) x 2 (evaluative congruency) design, and the task required participants to indicate if the target word was good or bad. The response times were only found to be significant for semantic congruency and not for evaluative congruency, even though the task made the evaluative variation more salient. The second experiment asked participants to complete an evaluative task but the stimuli only varied evaluatively and not semantically. Therefore, participants made evaluative judgments on stimuli taken from only one of the possible three semantic categories (animal, religion, or texture). The results for response latencies did show evidence for evaluative priming, where congruent word pairs were responded to more quickly than incongruent word pairs. These findings clearly demonstrate that if a word pair varies both semantically and evaluatively, even though the task is evaluative in nature, the semantic variation of the word pair prevents an evaluative effect from being elicited. However, when the word pair is from the same semantic category and only varied on an evaluative dimension, the evaluative priming effect can be found.

If semantic and evaluative incongruities are not controlled for, researchers are unable to define the mechanism responsible for these effects and thus the mechanism responsible for the evaluative effect has yet to be firmly established. Storbeck and Robinson (2004) demonstrated that in order to find an evaluative effect, word pairs must be semantically controlled for. The N400 evaluative studies that were previously mentioned failed to control for the influence of semantic variation and therefore, further research is needed to examine semantic and evaluative incongruities by continuing to investigate the comparative approach, as advanced by Storbeck and Robinson (2004).

The goal of this research project was to examine the evaluative incongruity effect by controlling for semantic influences in two separate studies. The first study controlled the influence of semantic associations among word pairs by following Zhang and colleagues' (2006) approach. This approach consisted of using a large number of stimuli and randomly selecting word pairs, thus making it unlikely that the two words would have a strong semantic association. An advantage to using a large number of stimuli is that it prevents any alterations in the ERPs due to repeated viewing effects. The second study controlled the influence of semantic associations among word pairs by following Storbeck and Robinson's (2004) paradigm that either paired words from the same semantic category (e.g., animal) or from different semantic categories (e.g., animal-person). Systematically controlling for semantic associations among word pairs allows for closer examination of the semantic influence on evaluatively incongruent word pairs; however, following this paradigm also limits the number of stimuli, which may lead to alterations in the ERP due to repetition effects. These two separate studies replicate and extend the two different manners of controlling semantic influences as initially examined by Zhang et al. (2006) and Storbeck and Robinson (2004).

1.8 STUDY 1

These present studies collectively demonstrate the need to further examine semantic and evaluative incongruities by including ERPs as a psychophysiological measure. Therefore, the objective of the first study was to expand on the existing literature by using a word pair priming paradigm to investigate the cognitive mechanism responsible for the evaluative incongruity effect. This was accomplished by examining response times, the stimuli-locked N400 ERP component, and the response-locked behavioral monitoring component. The first study followed a similar design as Zhang et al. (2006) where evaluative incongruities were examined using visual stimuli that were not semantically controlled for and were kept random. It was hypothesized that only a behavioral evaluative priming effect would be found where response times to evaluatively congruent word pairs would be faster than to incongruent word pairs, as previously shown by Fazio et al. (1986). It was further hypothesized that stimulus-locked analyses would not find a significant N400 effect because the underlying mechanism responsible for the evaluative effect would be response competition and not spreading activation. It was also hypothesized that a response-monitoring ERP component would be found to be sensitive to the evaluative incongruity effect, indicating the presence of response competition.

Chapter 2: Method – Study 1

2.1 PARTICIPANTS

A total of 22 ERP sessions were completed at the same time as the behavioral study, however, the final sample only included data from 19 participants after data from 2 participants was discarded due to excessive electrical artifacts and 1 that was previously removed due to poor accuracy rates (10 females; 9 males). The age of the participants ranged from 18 to 29 with an average age of 20.

2.2 STIMULI

These word pairs were generated by selecting 120 of the most negative and 120 of the most positive words from the Affective Norms for English Words (ANEW) (Bradley & Lang, 1999). The valence of the words was determined by using a scale from 1 to 9, with 1 being the most negative and 9 being the most positive. The mean for the 120 positive words selected was 7.96 and 2.06 for negative words. See Appendix C.

2.3 PROCEDURE

Before the experiment began, the experimenter (1) explained the risks and benefits of the experiment, (2) thoroughly described the procedure, (3) asked participants to read and sign an informed consent form, and (4) completed a demographic questionnaire. During the ERP session the experimenters prepared the participant for EEG recording by placing an elastic cap containing the EEG electrodes on the participant and attaching mastoid, VEOG, and HEOG electrodes. Once these preparations were complete, the participant was taken to an isolated room and seated in a comfortable reclining chair approximately 0.5 m in front of a monitor on which the experimental stimuli were displayed. Before the participants started the evaluative task the experimenter made sure participants clearly understood the instructions, turned on a white noise machine to help mask external noise, and left the experimental chamber. Participants then initiated the experiment by pressing a button on the keypad.

The experimenter informed participants that the experiment consisted of 3 blocks of word pairs with a 2 minute break between each block. Participants were informed that the word pairs would be flashed centrally upon the computer monitor and were asked to complete an evaluative task. The goal of this evaluative task was for participants to push one of two buttons on a keypad to indicate if the second word was good or bad. Prime words were preceded by a 200 ms focus "+" and a 100 ms blank screen. Prime words were presented for 150 ms, with an inter-stimulus interval of 100 ms and the target words were presented for 1500 ms followed by an inter-trial interval (blank screen) of 1500ms. In the event that a participant failed to respond within 1500 ms, the program automatically continued to the next word pair. Words were randomly selected from the positive and negative word lists that were generated from the Affective Norms for English Words (ANEW) (Bradley & Lang, 1999) to create a total of 360 word pairs. These word pairs were divided into 3 blocks of 120 word pairs, where the first 8 pairs of each block were practice trials. There was a total (not including the practice trials) of 84 word pairs for each of the following conditions: 1) positive-positive 2) negative-negative 3) negative-positive 4) positive-negative.

2.4 Data Acquisition and Reduction

Bioelectrical activity was recorded using Ag/AgCl electrodes. Electroencephalographic (EEG) activity was recorded from 29 scalp locations and referenced to the right mastoid. Electrical activity was also recorded from the left mastoid so a digital linked reference could be computed following data collection. Vertical electrooculographic (VEOG) activity was recorded from the left eye by supraorbital and infraorbital electrodes. Electrodes located outside the outer canthi of the right and left eyes recorded horizontal electooculographic (HEOG) activity. The electrodes were filled with a high conductivity gel, and electrical impedance at each recording location was reduced to less than 15 Kohms. Neuroscan amplifiers were used to amplify, filter (bandpass of 0.05-30 Hz), and digitize (500 Hz) the bioelectrical signals that were recorded continuously during the experiment.

Stimulus-Locked ERPs. A number of steps were taken to reduce and quantify the bioelectrical data. First, EEG data were re-referenced to a digitally linked-mastoids reference. Second, a digital zero-phase shift, band pass filter (0.15 and 10 Hz, 24 dB/octave) was applied to the continuous data. Third, epochs associated with each target stimulus (0.2 s prestimulus, 0.7 s stimulus, & 0.6 s poststimulus periods) were extracted from the continuous data and each epoch and electrode site was baseline corrected to the mean of its pre-stimulus period. Fourth, epochs containing extreme activity at VEOG were excluded from further analyses. Fifth, a regression procedure for removing VEOG artifacts from the EEG recordings was applied. Sixth, the sweeps associated with each stimulus were re-epoched (0.1 s prestimulus, 0.7 s stimulus, & 0.5 s poststimulus periods) and baseline corrected to the mean of the 0.1 s prestimulus period. Seventh, data were manually reviewed, and electrodes were deleted from further analyses if there was a problem (e.g., if an electrode came loose). Eight, epochs containing extreme activity at any scalp site were excluded from further analyses. Ninth, the EEG recordings over each recording site for each participant were averaged separately within each of the experimental conditions. Tenth, the ERPs, peak amplitude, latency and area of the N400 component were recorded from each ERP waveform using a latency window of 300 to 500 ms from target onset.

Response-Locked ERPs. The response monitoring data acquisition followed the same steps as the N400 data acquisition with the exception that a 1800ms epoch (1300ms prior to the response to 500ms after the response) was examined. The response locked ERP was calculated for a pre-response positive component (PRP) from -100 to 0ms.

Chapter 3: Results – Study 1

3.1 Behavioral Accuracy

The data analysis was conducted by examining 19 participants in a 2 (evaluative congruency) x 2 (target valence) ANOVA using an arcsine transformation. The results showed no significant differences among accuracy rates for evaluatively congruent (M = 93.891, SD= 4.98) and incongruent (M = 93.170, SD = 4.99) word pairs, $F(1, 18) = 1.355$, $p < .260$. No significant differences among accuracy rates where found for word pairs ending with a positive target (M = 94.424, SD = 4.37) or a negative target (M = 92.638, SD = 6.47), $F(1, 18) = .946$, $p < .344$. The overall percent correct averaged across participants was 93.53%.

3.2 Behavioral Response Latencies

Log transformations were performed on the response latencies prior to analysis; however, response times are reported in milliseconds for ease of interpretation. Reaction times were examined by following the same data analysis used for the behavioral accuracy, which consisted of a 2 (evaluative congruency) x 2 (target valence) ANOVA. The results indicated a significant main effect for target valence, where participants responded significantly faster to positive targets (M = 752.981 ms, SD = 116.32) than to negative targets (M = 786.275 ms, SD = 105.72), $F(1, 18) = 10.4$, $p<.005$. This finding is in line with the argument put forth by Unkelbach, Fiedler, Bayer, Stegmuller and Danner (2008) that positive objects are in general rated faster compared to negative objects. The results did not find a significant difference in response times to evaluatively congruent (M = 770.389 ms, SD = 107.37) and incongruent word pairs (M = 768.866 ms, SD = 111.11), $F(1, 18) = .083$, $p<.776$. The significant interaction between evaluative congruency and target word valence was found, $F(1, 18) = 4.44$, $p<.049$. The simple comparisons examined the following: good-good (M = 750.181 ms, SD = 119.46) vs. bad-good (M = 755.781 ms, SD = 114.28), which was not found to be significantly different, F (1, 18) = 1.40, $p<.252$ and bad-bad (M = 790.598 ms, SD = 101.44) vs. good-bad (M = 781.951 ms, SD = 112.90), which was also not found to be significantly different F (1, 18) = 1.559, $p<.228$. However, the trend for this interaction did show that participants responded faster to good-good word pairs compared to bad-good word pairs, which is consistent with existing literature (Fazio, Sanbonmatsu, Powell, Kardes, 1986).

3.3 N400 Stimulus – Locked

In order to examine the role of spreading activation as the possible mechanism underlying the behavioral evaluative effect, data from 19 participants were included in the ERP analysis. The average peak amplitude for this deflection was examined using an analysis similar to that performed with the behavioral study, 2 (evaluative congruency) x 2 (target valence) x 5 (Site: FZ, FCZ, CZ, CPZ, PZ) ANOVA. The evaluative congruency effect was not found to be significant, F (1, 18) = .160, $p<.694$. Evaluatively congruent word pairs elicited a mean peak amplitude of -.141 μV (SD = 2.29) and incongruent word pairs elicited a mean peak amplitude of -.042 μV (SD = 2.61). The valence of the target was also not found to elicit a significant N400, F (1, 18) = .469, $p<.502$ where the mean peak amplitude for positive target words was .011 μV (SD = 2.42) and -.194 for negative words (SD = 2.54). These findings support the behavioral studies previously discussed (De Houwer, Hermans, Rothermund & Wentura, 2002; Klauer and Musch, 2002) by demonstrating that spreading activation could not explain the behavioral evaluative effect found.

3.4 PRP Response – Locked

A response locked analysis was conducted to further determine the role of response competition as the cognitive mechanism responsible for the evaluative behavioral effect and to examine the PRP component that possibly indicative of response monitoring. The average peak amplitude for this deflection examined 9 frontal electrode sites (F3, FC3, C3, FZ, FCZ, CZ, F4, FC4, C4) using an analysis similar to that performed on the stimulus-locked ERP analysis, which consisted of a 2 (evaluative congruency) x 2 (target valence) x 9 (frontal electrode sites) ANOVA. The results showed a marginally significant main effect for evaluative congruency, $F(1, 18) = 4.265$, $p = .054$. Evaluatively incongruent word pairs elicited a more positive peak amplitude (M = 2.727 μV, SD = 4.28) than evaluatively congruent word pairs (M = 2.316 μV, SD = 4.04). Although, the findings did not reach significance, the results do raise the possibility of response monitoring prior to executing the response. The valence of positive target words (M = 2.679 μV, SD = 4.41) and negative target words (M = 2.364 μV, SD = 3.99) were not found to have a significant effect on the peak amplitude of the pre-response positive component, $F(1, 18) = .923$, $p<.350$.

Extended data analyses examined behavioral and psychophysiological differences between congruent word pairs and incongruent word pairs to investigate the evaluative priming effect. Previous researchers have examined the evaluative effect by analyzing congruent vs. incongruent word pairs, thus to make comparisons with these studies we carried out similar analyses (De Houwer, Hermans, Rothermund & Wentura, 2002; Morris, Storbeck & Robinson, 2004; Squires, Taber & Lodge, 2003; Zhang, Lawson, Guo & Jiang, 2006). See Appendix A.

3.5 DISCUSSION – STUDY 1

The first study examined an evaluative priming paradigm that kept semantic associations among word pairs random. The behavioral data does not support our hypothesis which stated that a behavioral evaluative priming effect would be found where response times to evaluatively congruent word pairs would be faster than to incongruent word pairs. However, a significant interaction was found between evaluative congruency and target valence. The simple comparisons, although not significant, did show a trend where participants responded faster to good-good word pairs compared to bad-good word pairs, which is in line with previous evaluative priming research (Fazio et al., 1986). It was further hypothesized that the N400 would not be sensitive to evaluative incongruities and as the data showed, the N400 effect was not found. On the other hand, analysis of the PRP component found a marginally significant effect where a more positive peak was elicited by evaluatively incongruent word pairs. The findings from the response-locked analysis support our initial hypothesis and indicate the possible role of response monitoring. These findings demonstrate the inability to elicit an N400 effect but show the presence of the PRP component (although marginal). Our findings question spreading activation as the cognitive mechanism responsible for the evaluative priming effect.

Chapter 4: Methods – Study 2

The objective of the second study was to examine the N400 component to word pairs that were systematically varied on both semantic and evaluative dimensions, which closely mirrored the evaluative priming paradigm examined by Storbeck and Robinson (2004). It was hypothesized that only a significant behavioral evaluative effect, and not a semantic effect, would be found where evaluatively congruent word pairs would be responded to significantly faster than incongruent word pairs via a response competition mechanism. It was also hypothesized that a significant N400 effect would only be elicited by semantic incongruities, where semantically incongruent word pairs would elicit a significantly larger N400 effect compared to semantically congruent word pairs. The N400 was hypothesized not be sensitive to evaluative incongruities, providing further support to the response competition mechanism. It was also hypothesized that a response-monitoring component would be sensitive to the evaluative incongruity effect, indicating the presence of response competition.

4.1 PARTICIPANTS

A total of 26 ERP sessions were completed at the same time as the behavioral study, however, the final sample only included data from 21 participants after data from 5 participants was discarded due to excessive electrical artifacts (14 females; 12 males). The age of the participants ranged from 18 to 49 with an average age of 20.

4.2 STIMULI

These word pairs were generated by selecting negative and positive animal/person (e.g. butterfly, thief) words from the ANEW list (Bradley & Lang, 1999), where 4 of the animal words were also selected after referring to the word stimuli list used in Storbeck and Robinson

(2004). Both the animal and person category consisted of 10 negative and 10 positive words. The mean valence of the negative animal words was 3.12 and the mean for negative person words was 2.43. The mean valence of the positive animal words was 7.12 and the mean for the positive person words was 7.6. See Appendix C.

4.3 PROCEDURE

The procedure and data acquisition was consistent with study 1 with the exception of the following: The experimenter informed participants that the experiment consisted of 4 blocks of word pairs with a 2 minute break between each block. Participants completed an evaluative task where participants were asked to indicate if the second word was good or bad by pushing one of two buttons on a keypad. The main difference between this study and that of study 1 was the use of different word pairs, where semantic category was controlled for. Words were randomly selected from the positive and negative animal/person word lists to create a total of 528 word pairs. There was a total (not including the practice trails) of 128 word pairs for each of the following conditions: 1) semantically matched-evaluatively matched (e.g. killer-pervert, kitten-dove) 2) semantically matched-evaluatively mismatched (e.g. champion-robber, puppy-snake) 3) semantically mismatched-evaluatively matched (e.g. addict-scorpion, shark-traitor) 4) semantically mismatched-evaluatively mismatched (e.g. friend-spider, butterfly-thief). These word pairs were divided into 4 blocks of 132 word pairs, where the first 4 pairs were practice trials and consisted of two words from each category that were not included in the experimental trails (e.g., rat, bees, koala, dove, thief, addict, saint, and spouse).

Chapter 5: Results – Study 2

5.1 Behavioral Accuracy

The data was analyzed by conducting a 2 (semantic congruency) x 2 (evaluative congruency) x 2 (target category) x 2 (target valence) ANOVA using arcsine transformations. The results found no significant differences among accuracy rates for semantically congruent (M = 91.481, SD= 7.87) and incongruent (M = 91.369, SD = 8.24) word pairs, $F(1, 20) = .058$, $p < .813$. No significant differences among accuracy rates where found for evaluatively congruent (M = 92.020, SD = 6.938) and incongruent (M = 90.830, SD = 9.21) word pairs, $F(1, 20) = 1.295$, $p < .269$. The overall percent correct averaged across participants was 91.42%.

5.2 Behavioral Response Latencies

Log transformations were performed on the response latencies, as in study 1, and response times are reported in milliseconds for ease of interpretation. Reaction times were examined by following the same data analysis used for the behavioral accuracy, which consisted of a 2 (semantic congruency) x 2 (evaluative congruency) x 2 (target category) x 2 (target valence) ANOVA. The results showed a significant main effect for both evaluative congruency and target category. The main effect for evaluative congruency indicated that evaluatively congruent word pairs were responded to faster (M = 677.22 ms, SD = 105.34) than evaluatively incongruent word pairs (M = 688.955 ms, SD = 101.05), $F(1, 20) = 5.376$, $p < .031$. The main effect for target category showed that word pairs with an animal target word were responded to faster (M = 676.319, SD = 111.21) than word pairs with a person target word (M = 689.86, SD = 94.94), $F(1, 20) = 8.033$, $p < .010$. This finding had previously been reported by De Houwer and colleagues (2002) who also found that responses were faster towards animal words than towards person words. A significant interaction between evaluative congruency and target word valence was also found, F (1, 20) = 10.839, *p*<.004. Simple comparisons showed a significant difference between good-good (M = 666.67ms, SD = 107.48) and bad-good word pairs (M = 689.96ms, SD = 99.99), F (1, 20) = 9.912, *p*<.005. However, no significant difference was found between bad-bad (M = 687.79ms, SD = 109.39) and good-bad (M = 687.95ms, SD = 105.41) word pairs, F (1, 20) = .024, *p*<.879. This finding replicates the trend that was found in study 1, although the simple comparisons did not reach significance in study 1. The results of this analysis further support our hypothesis, which stated that evaluatively congruent word pairs would be responded to faster than incongruent word pairs. A main effect for semantic congruency was not found, F (1, 20) = 1.122, *p*<.302. Semantically congruent words (M = 681.965ms, SD = 105.55) were responded to only slightly faster than incongruent words (M = 684.213 ms, SD = 99.98).

5.3 N400 Stimulus – Locked

The average peak amplitude for this deflection was examined using an analysis similar to that performed on behavioral response latencies, 2 (semantic congruency) x 2 (evaluative congruency) x 2 (target category) x 2 (target valence) x 5 (Site: FZ, FCZ, CZ, CPZ, PZ) ANOVA. The results indicated a significant main effect for target category, where a more negative peak amplitude was elicited by word pairs ending with animal target (M = -.928 μV, SD = 3.11) than to person target (M = .040 μV, SD = 3.23), F (1, 20) = 24.691, *p*<.000. Thus, the behavioral effect which reported that animal target words were responded to faster than person words, also elicited a larger N400 effect. In addition, a significant interaction between semantic congruency and target category was found, F (1, 20) = 5.194, *p*<.034. The simple comparisons showed a significant difference between animal-animal (M = -.555μV, SD = 2.92) and person-animal word pairs (M = -1.302μV, SD = 3.44), F (1, 20) = 5.481, *p*<.030. However, no significant difference was found between person-person (M = -.069μV, SD = 3.27) and animal-person (M = .150μV, SD = 3.27) word pairs, $F(1, 20) = .847$, $p<.369$. This analysis support our hypothesis, which stated that an N400 effect would be significantly more negative for semantically incongruent word pairs compared to congruent word pairs. We had also hypothesized that the N400 would not be sensitive to evaluative incongruities, which was supported by the data where evaluatively incongruent word pairs (M = -.516 μV, SD = 3.25) did not elicit a significant N400 effect compared to congruent word pairs (M = -.372 μV, SD = 3.1), $F(1, 20) = .562$, $p<.462$.

5.4 PRP Response – Locked

The average peak amplitude for this deflection examined 9 frontal electrode sites (F3, FC3, C3, FZ, FCZ, CZ, F4, FC4, C4) using an analysis similar to that performed on the stimulus locked ERP analysis, which consisted of a 2 (semantic congruency) x 2 (evaluative congruency) x 2 (target category) x 2 (target valence) x 9 (frontal electrode sites) ANOVA. The evaluative congruency main effect was found to be significant and showed that evaluatively incongruent word pairs elicited a more positive peak amplitude (M = 3.828 μV, SD = 4.61) than evaluatively congruent word pairs (M = 2.596 μV, SD = 3.95), $F(1, 19) = 18.648$, $p<.010$. A target category main effect was also found to be significant, which showed that person target words elicited a more positive peak amplitude (M = 3.589 μV, SD = 4.43) than animal target words (M = 2.835 μV, SD = 4.14), $F(1, 19) = 7.281$, $p<.014$.

Extended data analyses examined the evaluative priming effect in a similar manner as study 1. As previously mentioned, researchers have examined the evaluative effect by analyzing congruent vs. incongruent word pairs. To make comparisons with these studies we carried out similar analyses (De Houwer, Hermans, Rothermund & Wentura, 2002; Morris, Storbeck & Robinson, 2004; Squires, Taber & Lodge, 2003; Zhang, Lawson, Guo & Jiang, 2006). See Appendix B.

5.5 DISCUSSION – STUDY 2

The second study examined evaluative priming while systematically controlling for semantic associations of word pairs. The behavioral data support our hypothesis which stated that only a behavioral evaluative priming effect, and not a semantic priming effect, would be found. The behavioral evaluative priming effect showed that participants responded significantly faster to evaluatively congruent word pairs than to incongruent word pairs. We had also hypothesized that a significant N400 effect would only be elicited by semantic incongruities, where semantically incongruent word pairs would elicit a significantly larger N400 effect compared to semantically congruent word pairs and although a main effect for semantic congruency was not found, a significant interaction between semantic congruency and target category was found. The simple comparisons from this interaction showed support for our hypothesis by finding a significant difference between animal-animal and person-animal word pairs. It was further hypothesized that the N400 effect would not occur in response to evaluatively incongruent word pairs, which was supported by the data. Analysis of the PRP component further supported our hypothesis by demonstrating a significant effect where a more positive peak was elicited by evaluatively incongruent word pairs. These findings indicate the possible role of response monitoring and further question spreading activation as the cognitive mechanism responsible for the evaluative priming effect.

Chapter 6: General Discussion

The aim of this research was to utilize both behavioral and psychophysiological measures to uncover the cognitive mechanism responsible for the evaluative priming effect (spreading activation vs. response competition) by controlling for semantic influences in two separate studies. The first study controlled the influence of semantic associations among word pairs by following Zhang and colleagues' (2006) approach, which kept these associations random. The second study controlled the influence of semantic associations among word pairs by following Storbeck and Robinson's (2004) paradigm that either paired words from the same semantic category (e.g., animal-animal) or from different semantic categories (e.g., animal-person). The behavioral and psychophysiological findings from both of these studies support response competition as the mechanism underlying the evaluative priming effect. An evaluative behavioral effect was not found in study 1, where semantic associations were kept random, but was found in study 2, which controlled for the semantic category of the word pairs. The behavioral findings in study 2 revealed faster response times to evaluatively congruent word pairs than to incongruent word pairs, as previously shown by Fazio et al. (1986). We also hypothesized in study 2 that only a behavioral evaluative priming effect would be found and not a semantic priming effect, indicating that response competition is the mechanism responsible for this effect and not spreading activation. As the results showed, a semantic behavioral effect was not found, thus lending support to our hypothesis.

In order to fully investigate the underlying mechanism responsible for the evaluative priming effect, the N400 was also examined. Previous research has shown that the N400 effect supports the concept of activating semantic knowledge from memory through spreading activation in a word pair priming paradigm (Kiefer, Weisbrod, Kern, Maier, & Spitzer, 1998;

Kreher, Holcomb, & Kuperberg, 2006). Therefore, if the N400 was also sensitive to evaluative incongruities, it would indicate spreading activation as the mechanism responsible for this effect. Both studies 1 and 2 hypothesized that response competition would be the mechanism responsible for the evaluative effect and thus the N400 would not be sensitive to evaluative priming effects. As the data revealed, no N400 effect was found in response to evaluative incongruities. It was also hypothesized in study 2 that a significant N400 effect would only be elicited by semantic incongruities, where semantically incongruent word pairs would elicit a significantly larger N400 effect compared to semantically congruent word pairs and although a significant main effect for semantic congruency was not found, the results did reveal a significant interaction between semantic congruency and target category. Simple comparisons demonstrated that a significantly larger N400 peak amplitude was elicited by semantically incongruent word pairs (person-animal) than to congruent word pairs (animal-animal). This data support our hypothesis by demonstrating the sensitivity of the N400 to detect semantic effects and the limitation of the N400 to detect evaluative effects.

The possibility that the response competition mechanism is responsible for the behavioral evaluative effect found in study 2 was further examined by investigating the response-locked ERP analysis. It was hypothesized that a response-monitoring component would be sensitive to the evaluative incongruity effect, indicating the presence of response competition for both studies. Although results from study 1 were marginally significant, both studies demonstrated the same trend, which showed that evaluatively incongruent word pairs elicited a larger PRP compared to congruent word pairs. This ERP component has not been characterized within existing literature, yet the replication of the finding in both studies conducted indicates that this response locked component may reflect response monitoring/preparation. Behavioral and ERP evidence from both studies support the response competition mechanism as the underlying factor responsible for the evaluative priming effect found.

These two studies closely examined the cognitive mechanism responsible for the evaluative priming effect and the results shed light on the debate concerning spreading activation vs. response competition. The behavioral data, the N400, and the PRP taken together have provided evidence for response competition as the mechanism responsible for the evaluative priming effect. The findings have shown support for response competition by demonstrating both a behavioral evaluative effect as well as a PRP component. The semantic effect was not detected within the behavioral data; however, the N400 was found to be elicited by semantic incongruities. If spreading activation was the underlying mechanism, the data would have shown both a behavioral and an N400 effect for semantic incongruities as well as for evaluative incongruities, which was not the case. Thus, the findings from both studies provide evidence for response competition as the underlying mechanism behind the evaluative priming effect.

Existing literature has demonstrated the usefulness of the N400 in exploring semantic integration in given contexts (Kutas & Federmeier, 2000) and more recently researchers have begun to examine the sensitivity of the N400 to evaluative incongruities via prosody of vocalization and meaning of the word (Bostanov & Kotchoubey, 2004; Schirmer, Zysset, Kotz, & Yves von Cramon, 2004; Schirmer & Kotz, 2003; Schirmer, Kotz, & Friederici, 2002 & 2005) and by using word stimuli (Morris, Squires, Taber & Lodge, 2003; Zhang, Lawson, Guo & Jiang, 2006). The results from both of our studies raise questions regarding the findings from previously discussed research studies which demonstrated that the N400 was sensitive to evaluative incongruities. For example, a study conducted by Schirmer, Kotz and Friederici (2002 & 2005) examined prosody of vocalization and (e.g., congruent - ‘success’ following a happy intonation; incongruent - ‘failure’ following a happy intonation) the results showed that participants responded faster and elicited a smaller N400 peak amplitude when the valence of the target word matched the preceding prosody context compared to incongruent words. The researchers suggested that emotional prosody is similar to semantics in regard to the contextual integration of a word. Although, this conclusion was drawn by the researchers, the question still remains if the effect could have been due to the semantic incongruity between the non-evaluative meaning of happy and sad. The studies that employed verbal stimuli (Morris, Squires, Taber & Lodge, 2003; Zhang, Lawson, Guo & Jiang, 2006) also found the N400 effect in response to evaluative incongruities; however, semantic associations among word pairs were never systematically controlled for and thus could have confounded their conclusions as well. The two studies we conducted did not replicate the findings of previous researchers and in fact, the N400 effect was only found to be significant for semantically incongruent word pairs (e.g., animal-animal vs. person-animal). The findings from our studies question the conclusions made by previous research studies because the influence of semantic associations was not considered in the evaluative paradigms that were implemented and thus a more comparative approach (semantic and evaluative considerations) should be the focus of future research studies.

Study 2 replicated previous behavioral studies, by demonstrating that evaluatively congruent word pairs were responded to faster than evaluatively incongruent word pairs. Storbeck and Robinson (2004) did not find this behavioral effect when the word pairs varied on both semantic and evaluative dimensions. In fact, the evaluative effect was only found when the semantic category of word pairs was controlled for. The results of our second study showed a main effect for evaluative congruency that was found when word pairs varied along both dimensions. The possible explanation for this discrepancy could lie in the different number of trials employed, where Storbeck and Robinson (2004) presented much fewer trials than the studies we conducted.

The question now concerns under what conditions response competition is responsible for the evaluative behavioral effect. Fazio (2001) raised the question as to the nature of the words (adjectives or nouns) used in evaluative priming paradigms and the roles of spreading activation and response competition. Fazio (2001) suggests that when paradigms use adjectives instead of nouns, both mechanisms can be responsible for the effect. Our first study did not systematically control for the nature of the word and the words that were included in this study consisted of adjectives (e.g., loneliness), nouns (e.g., rabies) and verbs (e.g., suffocate). Therefore, the number of adjectives, nouns and verbs were random but this does not rule out the possibility that this variation could have played a factor in our results. Future research should control for the nature of the word (e.g., adjectives vs. nouns) and examine the possibility of finding both the N400 effect and an evaluative behavioral effect as a method to further explore Fazio's (2001) hypothesis.

The present findings support response competition as the mechanism underlying the evaluative priming effect and question the possible role of spreading activation. The overall findings demonstrated a behavioral effect in study 2 as well as a significant PRP effect to evaluative incongruities. The N400 was only found to be elicited by semantically incongruent word pairs in study 2. Future studies should further explore the comparative approach, by varying word pairs on both a semantic and evaluative dimension. Such studies should also examine both behavioral and psychophysiological measures in order to fully understand the activation and limitation of mechanisms underlying these cognitive processes.

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Appendix A

Behavioral Data

Behavioral Accuracy. The data analysis was conducted by examining 19 participants in a one factor ANOVA (evaluatively congruent vs. incongruent) using an arcsine transformation. The results showed no significant differences among accuracy rates for evaluatively congruent (M = 93.891, SD= 4.98) and incongruent (M = 93.170, SD = 4.99) word pairs, $F(1, 18) = 1.355$, $p < .260$. The overall percent correct averaged across participants was 93.53%.

Behavioral Response Latencies. Log transformations were performed on response latencies prior to analysis; however, response times are reported in milliseconds for ease of interpretation. Reaction times were examined by following the same data analysis used for the behavioral accuracy, which consisted of a one factor ANOVA (evaluatively congruent vs. incongruent). The results did not find a significant difference in response times to evaluatively congruent (M = 770.389 ms, SD = 107.37) and incongruent word pairs (M = 768.866 ms, SD = 111.11), $F(1, 18) = .083$, $p < .776$.

N400 Stimulus-Locked

In order to examine the role of spreading activation as the possible mechanism underlying the behavioral evaluative effect, data from 19 participants were included in the N400 ERP analysis. The average peak amplitude for this deflection was examined among the five center electrodes (FZ, FCZ, CZ, CPZ, PZ) using a one factor ANOVA (evaluatively congruent vs. incongruent). The evaluative congruency effect was not found to be significant, $F(1, 18) = .160$, $p < .694$. Evaluatively congruent word pairs elicited a mean peak amplitude of -.141 μV (SD = 2.29) and incongruent word pairs elicited a mean peak amplitude of -.042 μV (SD = 2.61).

Pre-response Positivity (PRP) Response-Locked

A response locked analysis was also conducted to determine whether response competition was the cognitive mechanism responsible for the evaluative behavioral effect found and to more closely examine ERP components that may be indicative of response monitoring. The average peak amplitude for the pre-response positive (PRP) component was examined in 9 frontal electrode sites (F3, FC3, C3, FZ, FCZ, CZ, F4, FC4, C4) using an analysis similar to that performed on the stimulus-locked ERP analysis, which consisted of a one factor ANOVA (evaluatively congruent vs. incongruent). The results showed a marginally significant main effect for evaluative congruency, $F(1, 18) = 4.265$, $p < .054$. Evaluatively incongruent word pairs elicited a more positive peak amplitude (M = 2.727 μV, SD = 4.28) than evaluatively congruent word pairs (M = 2.316 μV, SD = 4.04). Although, the findings did not reach significance ($p < .05$), the results do raise the possibility of response monitoring prior to executing the response.

Appendix B

Behavioral Data

Behavioral Accuracy. The data analysis was conducted by examining 21 participants in a 2 (semantic congruency) x 2 (evaluative congruency) ANOVA, using arcsine transformations. The results showed no significant differences among accuracy rates between these different word pairs. The overall percent correct averaged across participants was 91.42%.

Behavioral Response Latencies. As in Study 1, log transformations were performed on the response latencies and response times are reported in milliseconds for ease of interpretation. Response times were examined by following the same data analysis used for the behavioral accuracy, which consisted of a 2 (semantic congruency) x 2 (evaluative congruency) ANOVA. The main effect for evaluative congruency indicated that evaluatively congruent word pairs were responded to faster (M = 677.22 ms, SD = 105.34) than evaluatively incongruent word pairs (M = 688.955 ms, SD = 101.05), $F(1, 20) = 5.376$, $p < .031$, which replicates Fazio et al. (1986). Although Storbeck and Robinson (2004) did not find a main effect for evaluative congruency when semantic congruity was varied, the increase in the number of trials of this study could have increased the power and thus increased the evaluative effect. A main effect for semantic congruency was not found, $F(1, 20) = 1.122$, $p < .302$. Semantically congruent words (M = 681.965ms, SD = 105.55) were responded to only slightly faster than incongruent words (M = 684.213 ms, SD = 99.98).

N400 Stimulus-Locked

The average peak amplitude was examined among the five center electrodes (FZ, FCZ, CZ, CPZ, PZ) in a 2 (semantic congruency) x 2 (evaluative congruency) ANOVA. The results did not indicate any significant effects. Our initial hypothesis stated that a significant N400 would be elicited by semantically incongruent word pairs (M = -.576 μV, SD = 3.33) compared to congruent word pairs (M = -.312 μV, SD = 2.99), however this effect was not found, F (1, 20) = 2.039, p<.169. We had also hypothesized that the N400 would not be sensitive to evaluative incongruities, which was supported by the data where evaluatively incongruent word pairs (M = -.516 μV, SD = 3.25) did not elicit a significant N400 effect compared to congruent word pairs (M = -.372 μV, SD = 3.1), F (1, 20) = .562, p<.462.

PRP Response-Locked

A response locked analysis was conducted in order to examine response competition as the mechanism responsible for the evaluative behavioral effect found and to further examine the PRP component, which is possibly indicative of response monitoring. The average peak amplitude for this deflection examined 9 frontal electrode sites (F3, FC3, C3, FZ, FCZ, CZ, F4, FC4, C4) using an analysis similar to that performed on the stimulus-locked ERP analysis, which consisted of a 2 (semantic congruency) x 2 (evaluative congruency) ANOVA. The evaluative congruency main effect was found to be significant and showed that evaluatively incongruent word pairs elicited a more positive peak amplitude (M = 3.828 μV, SD = 4.61) than evaluatively congruent word pairs (M = 2.596 μV, SD = 3.95), F(1, 19) = 18.648, p<.010. These results replicate the findings from study 1 (although the findings were marginally significant) and further support response competition as the mechanism underlying the evaluative behavioral effect found.

Appendix C

Negative Word List: Affective Norms for English Words (ANEW)

rape	1.25	dead	1.94	divorce	2.22
suicide	1.25	jail	1.95	punishment	2.22
funeral	1.39	cruel	1.97	traitor	2.22
cancer	1.5	illness	2.48	crucify	2.23
rejected	1.5	paralysis	1.98	hell	2.24
murderer	1.53	poison	1.98	humiliate	2.24
suffocate	1.56	toothache	1.98	fearful	2.25
torture	1.56	afraid	2	loser	2.25
death	1.61	bankrupt	2	sickness	2.25
lonely	2.17	upset	2	dreadful	2.26
sad	1.61	headache	2.02	rotten	2.26
slaughter	1.64	assault	2.03	fat	2.28
infection	1.66	despise	2.03	gangrene	2.28
poverty	1.67	accident	2.05	massacre	2.28
betray	1.68	burial	2.05	regretful	2.28
syphilis	1.68	prison	2.05	insult	2.29
grief	1.69	seasick	2.05	violent	2.29
terrorist	1.69	maggot	2.06	whore	2.3
failure	1.7	vomit	2.06	crash	2.31
terrified	1.72	war	2.08	lice	2.31
disaster	1.73	leprosy	2.09	stupid	2.31
rabies	1.77	stress	2.09	anger	2.34
tragedy	1.78	bomb	2.1	defeated	2.34
ulcer	1.78	toxic	2.1	roach	2.35
abuse	1.8	trauma	2.1	insecure	2.36
mutilate	1.82	demon	2.11	tumor	2.36
depressed	1.83	anguished	2.12	execution	2.37
slave	1.84	hate	2.12	filth	2.47
addict	2.48	pain	2.13	disappoint	2.39
pollute	1.85	thief	2.13	injury	2.49
gloom	1.88	detest	2.17	starving	2.39
killer	1.89	lonely	2.17	malaria	2.4
hurt	1.9	troubled	2.17	alone	2.41
sick	1.9	corpse	2.18	deformed	2.41
nightmare	1.91	victim	2.18	rage	2.41
drown	1.92	stench	2.19	selfish	2.42
morgue	1.92	hostage	2.2	agony	2.43
disloyal	1.93	crushed	2.21	rude	2.5
misery	1.93	devil	2.21	scum	2.43
terrible	1.93	debt	2.22	ugly	2.43
				Average	**2.05725**

Positive Word List: Affective Norms for English Words (ANEW)

secure	7.57	enjoyment	7.8	god	8.15
freedom	7.58	truth	7.8	terrific	8.16
knowledge	7.58	adorable	7.81	vacation	8.16
spouse	7.58	beauty	7.82	lucky	8.17
kind	7.59	kindness	7.82	graduate	8.19
money	7.59	wedding	7.82	promotion	8.2
adventure	7.6	birthday	7.84	happy	8.21
beautiful	7.6	caress	7.84	baby	8.22
intimate	7.61	party	7.86	joyful	8.22
cute	7.62	sunrise	7.86	delight	8.26
leader	7.63	luxury	7.88	free	8.26
profit	7.63	waterfall	7.88	kiss	8.26
respect	7.64	achievement	7.89	treasure	8.27
family	7.65	merry	7.9	pleasure	8.28
food	7.65	home	7.91	success	8.29
improve	7.65	diamond	7.92	orgasm	8.32
nature	7.65	pillow	7.92	romantic	8.32
thoughtful	7.65	snuggle	7.92	victory	8.32
honor	7.66	fame	7.93	cash	8.37
sunset	7.68	handsome	7.93	comedy	8.37
desire	7.69	satisfied	7.94	fun	8.37
honest	7.7	aroused	7.97	excellence	8.38
rescue	7.7	acceptance	7.98	win	8.38
riches	7.7	confident	7.98	affection	8.39
wealthy	7.7	ecstasy	7.98	mother	8.39
cuddle	7.72	liberty	7.98	sweetheart	8.42
peace	7.72	diploma	8	friendly	8.43
car	7.73	hug	8	champion	8.44
progress	7.73	sexy	8.02	laughter	8.45
savior	7.73	beach	8.03	humor	8.56
admired	7.74	millionaire	8.03	joy	8.6
friend	7.74	passion	8.03	miracle	8.6
outstanding	7.75	proud	8.03	reward	7.53
pretty	7.75	sex	8.05	love	8.72
spring	7.76	thrill	8.05	paradise	8.72
sunlight	7.76	cheer	8.1	triumphant	8.82
gift	7.77	joke	8.1	glory	7.55
justice	7.78	valentine	8.11	holiday	7.55
trophy	7.78	music	8.13	loyal	7.55
wise	7.52	rainbow	8.14	talent	7.56
				Average	**7.96075**

Animals

Bad	Valence	Good	Valence
bees	3.2	butterfly	7.71
cockroach	2.81	dove	6.9
maggot	2.06	kitten	6.86
mosquito	2.8	puppy	7.56
rat	3.02	rabbit	6.57
scorpion	3.69	panda	Used in Storbeck & Robinson
shark	3.65	pony	
snake	3.31	swan	
spider	3.33	giraffe	
wasp	3.37	koala	Newly Created
Average	**3.124**	**Average**	**7.12**

People

Bad	Valence	Good	Valence
addict	2.48	champion	8.44
alcoholic	2.84	leader	7.63
coward	2.74	patriot	6.71
criminal	2.93	saint	6.49
killer	1.89	savior	7.73
pervert	2.79	scholar	7.26
robber	2.61	sweetheart	8.42
terrorist	1.69	friend	7.74
thief	2.13	spouse	7.58
traitor	2.22	millionaire	8.03
Average	**2.432**	**Average**	**7.603**

Tables

Table 1.1: Results – Study 1

Study 1

	Evaluatively		Target	
	Congruent	**Incongruent**	**Positive**	**Negative**
Accuracy	93.89%	93.17%	94.42%	92.64%
Response Times	770.39ms	768.87ms	**752.98ms***	**786.28ms***
N400	-.141μV	- .042μV	.011μV	- .194μV
PRP	**2.316μV***	**2.727μV***	2.679μV	2.364μV

Note: * = p<.05

Table 2.1: Results – Study 2

Study 2

	Semantically		Evaluatively		Target		Target	
	Congruent	**Incongruent**	**Congruent**	**Incongruent**	**Animal**	**Person**	**Positive**	**Negative**
Accuracy	91.48%	91.37%	92.02%	90.83%	90.40%	92.45%	91.22%	91.63%
Response Times	681.97ms	684.21ms	**677.22ms***	**688.96ms***	**676.32ms***	**689.86ms***	678.30ms	687.87ms
N400	-.312μV	-.576μV	-.372μV	-.516μV	**-.928μV***	**.040μV***	-.513μV	-.375μV
PRP	3.096μV	3.328μV	**2.596μV***	**3.828μV***	**2.835μV***	**3.589μV***	3.245μV	3.179μV

Note: * = p<.05

Figures

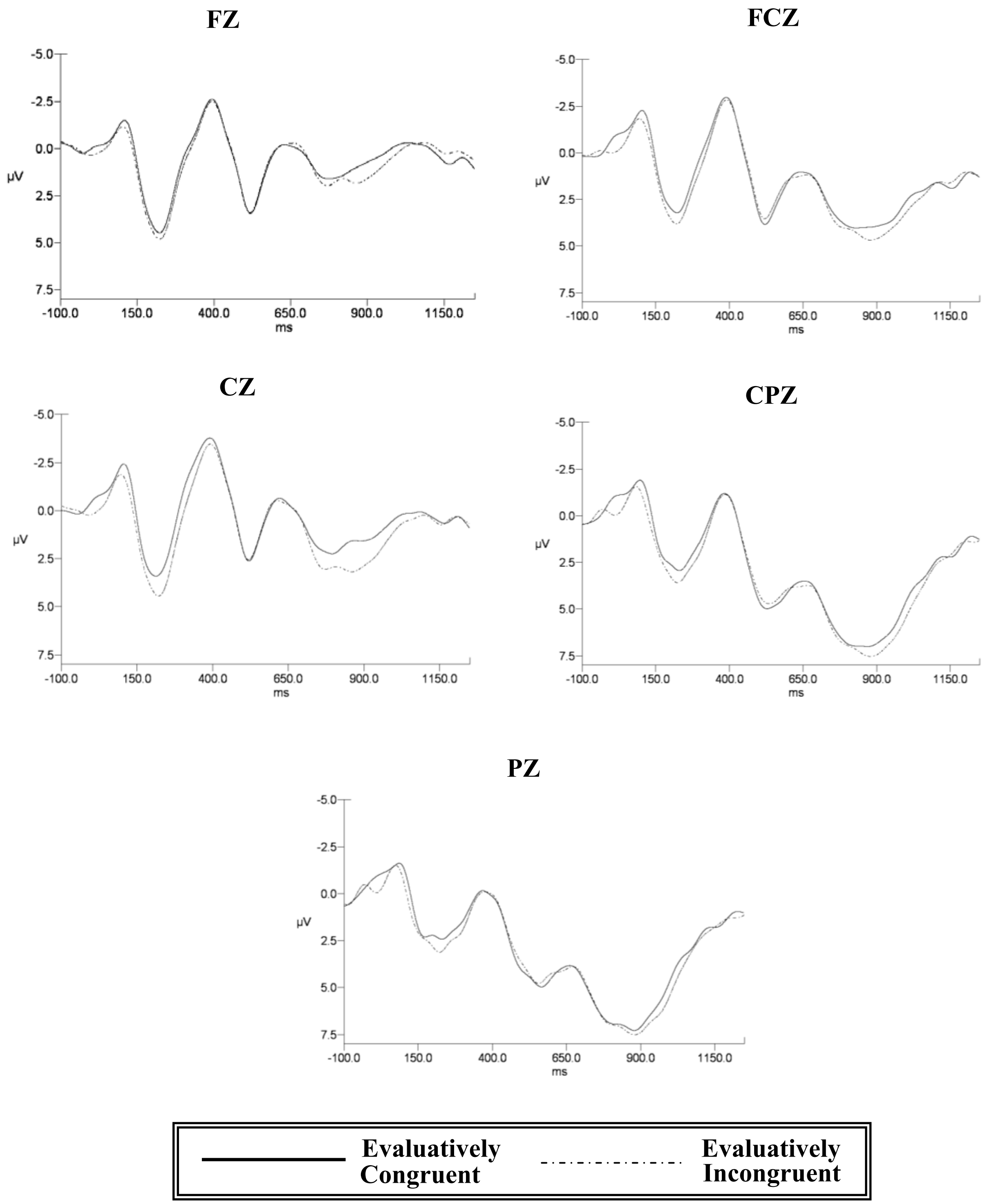

Figure 1.1: Study 1 – N400 Evaluative Effect

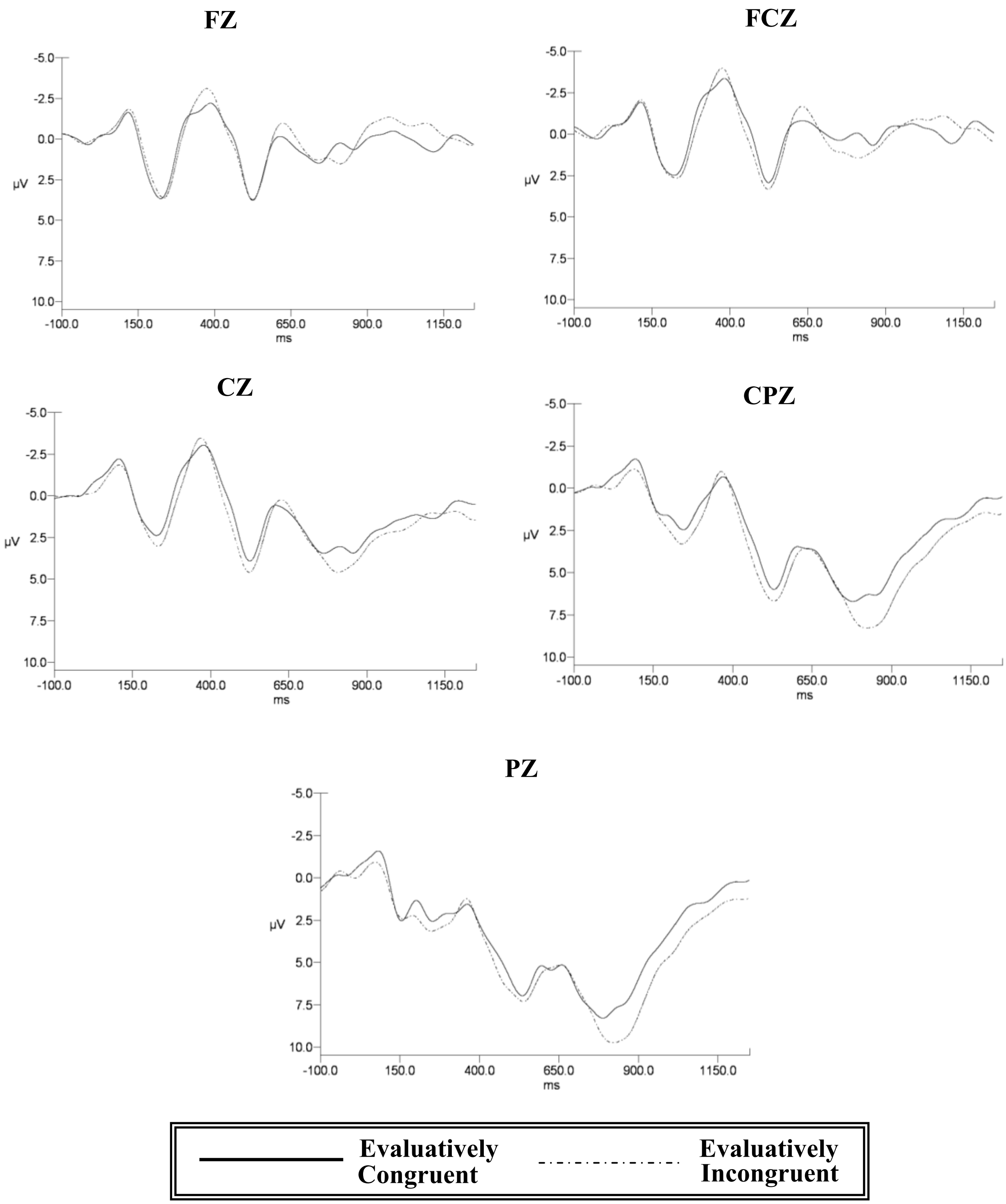

Figure 2.1: Study 2 – N400 Evaluative Effect

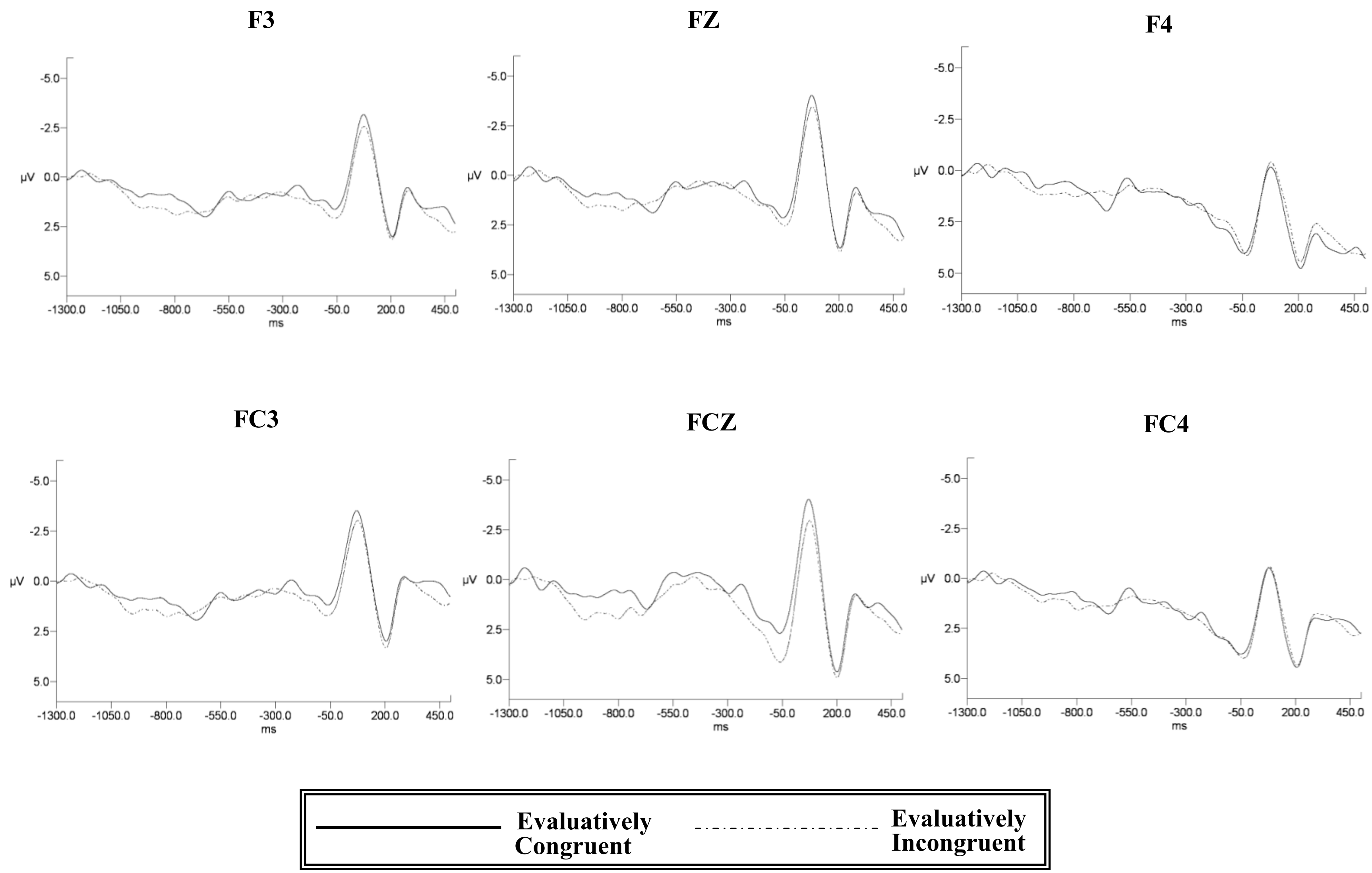

Figure 3.1: Study 1 – Pre-Response Positivity Evaluative Effect

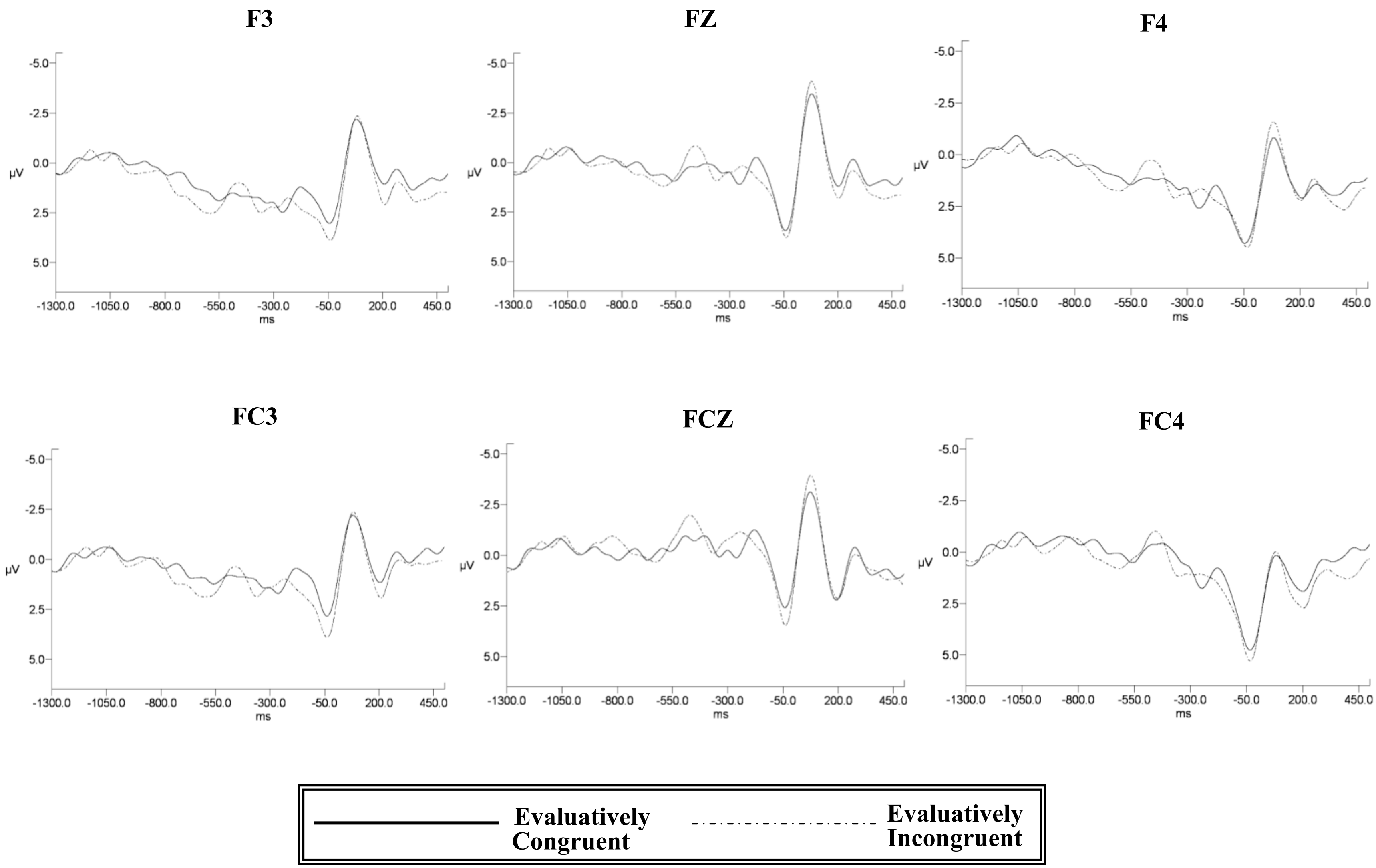

Figure 4.1: Study 2 – Pre-Response Positivity Evaluative Effect

Curriculum Vita

Jennifer Taylor was born in El Paso, Texas on November 18, 1982 to Robert and Hilda Taylor. She graduated from Loretto Academy in El Paso, Texas in May of 2000 and entered the University of Texas at El Paso (UTEP) in the fall of 2000. As a participant in the Research Experience for Undergraduate (REU) Program at UTEP, Jennifer was involved with research in neurobiology and psychobiology laboratories. Jennifer also participated in the (REU) program at Indiana University where she has researched molecular plant biology. She was actively involved in several honor societies such as Psi Chi, National Society of Collegiate Scholars, Alpha Chi Honor Society and the Golden Key Honor Society at UTEP. Jennifer was awarded with the most outstanding senior and Cum Laude honors from the Biology Department when she completed her Bachelors of Science degree at UTEP in May 2004. Jennifer was accepted to the Social Cognitive Neuroscience Doctoral Program in the Department of Psychology at UTEP in fall of 2005 and was a recipient of the Alliance for Graduate Education and the Professoriate (AGEP) Fellowship. Jennifer conducted evaluative cognitive processing research in Dr. Stephen L. Crites' laboratory and attended conferences to present her ongoing research. During this program she worked as a teaching assistant and as an instructor. Jennifer continues to work in Dr. Crites' laboratory on her dissertation research.

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