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Wait, what? Assessing stereotype incongruities using the N400 ERP component

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Numerous discoveries regarding stereotypes have been uncovered by utilizing techniques and methods developed by cognitive psychologists. The present study continues this tradition by borrowing psychophysiological techniques used for the study of memory and language, and applying them to the study of stereotypes. In this study, participants were primed with either the gender category 'Women' or 'Men', followed by a word which was either consistent with gender stereotypes (e.g. Women: Nurturing) or inconsistent (e.g. Women: Aggressive). Their task was to indicate whether the words matched or did not match, according to gender stereotypes. Both response times and event-related brain potentials (ERPs) were recorded during performance of the task. As predicted, stereotype incongruent word pairs were associated with larger N400 ERP amplitudes and slower response times, relative to congruent word pairs. The potential utility of this approach as an independent measure of stereotypes is discussed.

Keywords: ERPs; N400; stereotypes; social cognition; gender

The primary objective of social cognition is to increase our understanding of how people perceive, evaluate and act toward other people and social groups. Social cognition has borrowed heavily (and fruitfully) from approaches used and developed in cognitive research. For instance, by utilizing procedures developed for the study of memory, learning and language comprehension, social cognition researchers have uncovered numerous insights into the possible cognitive mechanisms underlying stereotypes and prejudice (Gaertner and McLaughlin, 1983; Dovidio *et al*., 1986; Banaji and Hardin, 1996; Blair and Banaji, 1996; Wittenbrink *et al*., 1997, 2001; Oakhill *et al*., 2005). Building upon this research, the present study implemented ideas and methods from cognitive neuroscience to explore stereotypes.

To identify cognitive mechanisms underlying stereotypes, it is important to maintain a conceptual distinction between stereotypes and prejudice. While stereotypes refer to beliefs associated with a social group (usually held at the cultural level), prejudice generally consists of negative affect held toward a social group (Amodio and Devine, 2006). For example, encountering an African American may activate stereotypes that African Americans are good at sports and expressive. On the other hand, encountering an African American might activate prejudice in an individual who grew up in a family that taught intolerance of other social groups. This distinction has not always been maintained in previous research because stereotypes and prejudice are often perceived as unavoidably connected (Judd *et al*., 2004) and because both can be examined using conventional priming procedures (Fazio *et al*., 1995; Wittenbrink *et al*., 1997; Kawakami *et al*., 1998). This has led to difficulties when interpreting whether results are due to stereotype or prejudice activation (Judd *et al*., 2004). Although prejudice and stereotypes often act in concert, recent research suggests that stereotypes and prejudice may depend upon partially separate neural pathways/processes and can lead to different forms of discriminatory behavior (Damasio, 1989; Mackie and Smith, 1998; Davis and Whalen, 2001; Amodio and Devine, 2006). Thus, to fully understand discrimination, it is vital to maintain a conceptual distinction between the two constructs.

One approach for separating stereotypes and prejudice, and exploring the cognitive processes that underlie each construct has been to use well-controlled experimental paradigms (Judd *et al*., 2004; Amodio and Devine, 2006). Although these paradigms have been very useful, they have relied primarily upon behavioral data in the form of response latencies, which have inherent limitations. Specifically, response latencies have limited sensitivity; a response is executed hundreds of milliseconds after stimulus perception, during which time multiple processes have taken place (Ito and Cacioppo, 2000). Although response times and accuracy rates can be used to make inferences regarding a sequence of cognitive processes (Gaertner and McLaughlin, 1983; Dovidio *et al*., 1986; Blair and Banaji, 1996), these inferences are limited and a more direct measure of intervening processes, such as event-related potentials (ERPs), would be advantageous.

When used in concert with behavioral measures, ERPs have provided researchers with a more complete approach to the study of cognitive processes (Coles, 1989). ERPs are considered electrical manifestations of brain activity in

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response to, or in preparation for, specific events (Fabiani *et al*., 2007). That is, when people encounter a stimulus, a sequence of neural units activates to process this stimulus and prepare a response. The electrical activity associated with the entire sequence is referred to as the ERP, and segments of the ERP, which are referred to as components (e.g. N100, N400, P300), reflect relatively discrete neural units or collections of neural units that are performing a more specific cognitive process. Because ERPs provide an instantaneous assessment of underlying neural activity, they allow for easier identification and isolation of individual cognitive processes (Rhodes and Donaldson, 2008). By examining the way various factors affect these ERP components, cognitive research has gleaned important information on attention, categorization, memory, language processes, error monitoring and expectancy (Fabiani *et al*., 2007). Amodio and colleagues (2006), for instance, have recently demonstrated how one ERP component, which is referred to as either the error related negativity (ERN) or medial-frontal negativity (MFN), can be used to explore processes involved with regulation and control of stereotypes and prejudice. This component is thought to reflect response monitoring and conflict detection (Johnson *et al*., 2004) and therefore is useful for studying stereotype control and inhibition, but not necessarily stereotype activation. Another component of the ERP, the N400, is specifically sensitive to modulations of meaning at the semantic/associative level (Kutas and Federmeier, 2000), and may therefore provide a means of exploring stereotype activation.

The N400 is a negative deflection manifesting ~400 ms following stimulus presentation, and is modulated by violations at the level of semantics or meaning. More specifically, the N400 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 (for review, see Kutas and Federmeier, 2000). Items that are incongruent with the context, compared to items that are congruent, elicit N400s with larger amplitudes. Although first observed in response to semantically incongruent sentence endings (Kutas and Hillyard, 1980, 1984), the N400 effect is also elicited by the second word in semantically incongruent word pairs (Bentin *et al*., 1985). Word pair studies have been primarily used to examine associations in lexical memory, with larger N400 amplitudes indicating more difficulty in accessing information (Kutas and Federmeier, 2000). For example, the word 'JELLY' is more difficult to access from lexical memory when primed with 'SHOE' than when primed with 'GRAPE'. Therefore, a larger N400 amplitude is associated with the word JELLY in the incongruent word pair SHOE: JELLY than with the congruent word pair GRAPE: JELLY. Because previous stereotype research has operated under the assumption that stereotypes are a specific class of semantic associations stored in memory (Gaertner and McLaughlin, 1983; Dovidio *et al*., 1986; Blair and Banaji, 1996), one might hypothesize that incongruities between stereotypically associated word pairs elicit the N400 effect. For example, within the context of 'MEN', the incongruent word 'SKIRT' would elicit a larger amplitude N400 than the congruent word 'BRIEFCASE'. However, research to date has not demonstrated that the N400 is reliably modulated by stereotype incongruities.

Only a few researchers have attempted to use the N400 to investigate stereotypes. Osterhout *et al*. (1997) presented participants with sentences containing stereotypically male or female occupations and pronouns that did or did not match the gender stereotypically implied by the occupation (e.g. *The* **beautician** *put* **herself** *through school vs The* **beautician** *put* **himself** *through school*). More recently, Bartholow and colleagues (2001, 2003) sought to examine the cognitive processing of social expectancy violations, which they likened to the violation of expectancies based upon stereotypes. Participants were presented with a series of sentences that first established the personality traits of a target person and then were presented with a sentence that described the target's behavior in a manner that violated the previously established personality traits. For the above studies, contextual violations modulated a late positive potential (LPP) of the ERP but did not affect the N400. However, the failure to find the N400 effect might be due to the task and the participants' processing strategies in these experiments, as research has shown the ERP to be dependent upon these factors (Mari-Beffa *et al*., 2005; Roehm *et al*., 2007). We therefore sought to implement a task and paradigm commonly used in both N400 and stereotype research.

The present research sought to determine whether incongruities within stereotypically associated word pairs elicit the N400 effect. We hypothesized that stereotypically incongruent word pairs would evoke larger N400 amplitudes, relative to those evoked by stereotypically congruent word pairs. A secondary objective was to replicate response latency effects observed in previous research on stereotypes (Banaji and Hardin, 1996; Blair and Banaji, 1996; Oakhill *et al*., 2005). We hypothesized that stereotypically incongruent word pairs would result in longer response latencies, relative to those associated with stereotypically congruent word pairs.

METHOD

Participants

The sample included data from 23 participants (13 female), all in good health. The age of the participants ranged from 18 to 27 with an average age of 20. For ethnicity, 16 participants self-identified as Hispanic/Latino, and the remaining as Not Hispanic/Latino. For race, 11 participants self-identified as White, two Native American, one Asian, one African American and seven as other. No specific exclusionary criteria were enforced.

Stimuli

Stimuli were word pairs that consisted of a gender category (Men or Women) followed by a target word. The target word was either a trait (e.g. nurturing, aggressive) or non-trait (e.g. makeup, mechanic) stereotypically associated with one of the gender categories. Target words included 14 female traits (e.g. caring, gossipy), 14 male traits (e.g. aggressive, powerful), 14 female non-traits (e.g. secretary, doll) and 14 male non-traits (e.g. engineer, cigars) chosen from previous gender stereotype research (Bem, 1974; Blair and Banaji, 1996; Oakhill *et al.*, 2005). Each target word was paired with both gender categories, making a total of 28 congruent word pairs (e.g. Women : Caring; Men : Engineer) and 28 incongruent word pairs (e.g. Women : Cigars; Men : Gossipy).

Procedure

Participants first read and signed an informed consent form and were prepared for EEG recording. Each participant was then taken to an isolated room and seated in a chair ~0.5 m in front of a computer monitor. The experimenter informed participants that they would see a series of word pairs and that their task was to indicate whether the second word matched or did not match the gender category that preceded it, according to social gender stereotypes.[1] Thus, participants made a binary decision. Each of the four experimental blocks contained 120 word pairs—the first eight word pairs were practice trials containing target words not used in the experimental trials and the remaining 112 were experimental trials. Word pairs were flashed centrally upon the computer monitor and participants indicated their response via a response pad. Prime words were preceded by a 200 ms focus '+' and a 100 ms blank screen. The prime word was then presented for 150 ms followed by a 100 ms ISI before the target word appeared for 150 ms. The target word was followed by a 100 ms blank screen and then a 1050 ms response window displaying a 'Match/Mismatch' instruction. The inter-trial interval was 1500 ms. If a participant failed to respond within the 1050 ms, the program automatically continued to the next word pair.

Data acquisition and reduction

Bioelectrical activity was recorded using Ag/AgCl electrodes from 29 scalp locations and referenced to the right mastoid. Vertical electrooculographic (VEOG) and horizontal electrooculographic (HEOG) activity were also recorded. Neuroscan amplifiers were used to amplify, filter (bandpass of 0.05–30 Hz) and digitize (1000 Hz) the bioelectrical signals that were recorded continuously during the experiment.

A number of steps were taken to reduce and quantify the bioelectrical data. The EEG data were re-referenced to a digital, linked-mastoids reference (Hagemann *et al.*, 2001). Epochs associated with each prime–target stimulus pair were extracted, and each epoch and electrode site was baseline corrected to the mean of its pre-stimulus period. A regression procedure for removing VEOG artifacts from the EEG recordings was applied (Semlitsch *et al.*, 1986) after epochs containing extreme activity at VEOG were excluded. Data were manually reviewed, and electrodes were deleted from further analyses if there was a problem (e.g. if an electrode came loose). Epochs containing extreme activity at any scalp site ($\pm 60\ \mu V$) were excluded from further analyses. The EEG recordings over each recording site for each participant were averaged separately within each of the experimental conditions.

RESULTS

Prior to conducting analyses, response accuracy and response latency were transformed (arcsine and log transformations, respectively) so that the assumptions of the ANOVA model were met. For ease of interpretation, however, accuracy is reported in percentages and response times in milliseconds. Participants were considered accurate if their match/mismatch judgments aligned with shared cultural gender stereotypes, as determined by prior research and pilot testing in the local population. For accuracy scores and response latencies, we conducted two 2 (Prime–Target Congruency) × 2 (Prime: Men/Women Category) × 2 (Target: Trait/non-trait Word) ANOVAs (only correct trials were included for response latencies). We examined the N400 amplitude using a 2 (Prime–Target Congruency) × 2 (Prime: Men/Women Category) × 2 (Target: Trait/non-trait Word) × 5 (Electrode site: Fz, FCz, Cz, CPz, Pz)[2] ANOVA (only correct trials were included in the analysis). Because physiological data frequently violate the sphericity assumption of the univariate ANOVA, we assessed significance using a multivariate (Wilks' Lambda) test and report the *F*-statistics and significance associated with the Wilks' Lambda.

Effect of congruency

Behavioral data replicated previous stereotype research. Participants demonstrated relatively high accuracy with regards to identifying when target words were a stereotypical match or mismatch with the preceding gender category ($M = 78.39\%$). As was the case in Oakhill *et al.* (2005), participants were more accurate for congruent word pairs ($M = 86.02\%$) than for incongruent word pairs ($M = 70.75\%$), $F(1,22) = 27.78$, $P < 0.001$, $\omega^2 = 0.538$. For response latencies, participants were faster to respond to congruent word pairs ($M = 711$ ms) than incongruent word pairs ($M = 793$ ms), $F(1,22) = 67.88$, $P < 0.001$, $\omega^2 = 0.744$. This also replicates prior research (Banaji and Hardin, 1996, Experiment 2; Blair and Banaji, 1996; Oakhill *et al.*, 2005), in which priming effects were

1 An explicit matching task was utilized because previous research has indicated that using an explicit task has the effect of enlarging N400 amplitudes (Chwilla *et al.*, 2000; Kreher *et al.*, 2006).

2 An analysis was also run to explore hemisphere effects. N400 amplitudes were larger over the left hemisphere, $F(1,10) = 5.616$, $P = 0.039$. No other hemisphere effects were significant.

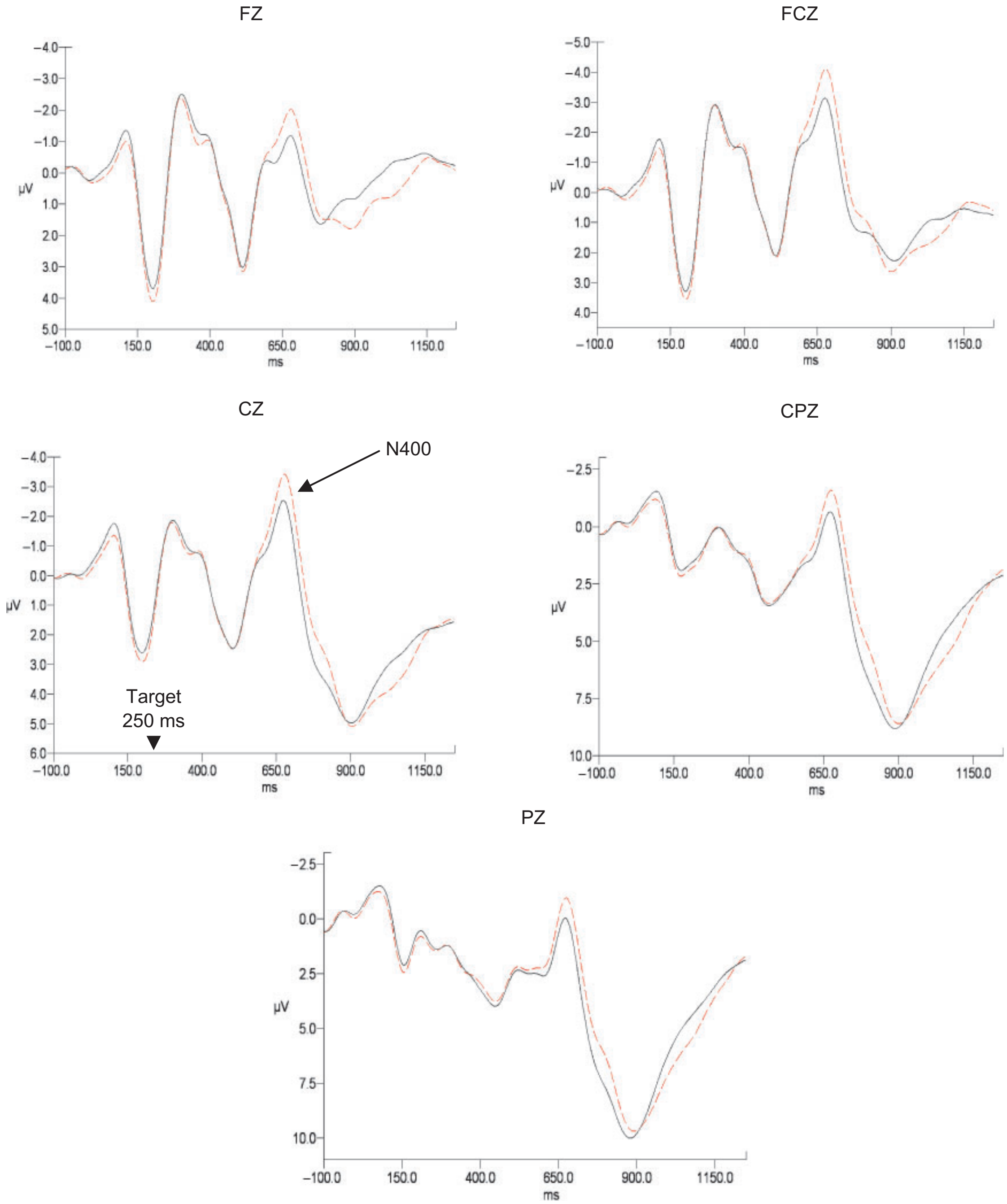

Fig. 1 Effect of congruency upon N400 amplitude. The five graphs depict ERP waveforms over the frontal (Fz) to posterior (Pz) midline scalp sites. The solid line reflects stereotypically congruent word pairs (e.g. Women : Secretary) and the dashed line reflects stereotypically incongruent pairs (e.g. Women : Mechanic). The PRIME was presented at 0 ms and the TARGET at 250 ms. Thus, the N400 which is a negative-going potential (negative is plotted up in the graphs) in response to TARGET words is observed at 650 ms.

interpreted to reflect spreading activation in associative memory (Collins and Loftus, 1975; Neely, 1977; Gawronski and Bodenhausen, 2005).

The expected ERP effect for congruency was also found. We hypothesized that negative amplitude in the 300–500 ms time window would be larger following incongruent word pairs than following congruent word pairs. As can be seen in Figure 1, N400 peak amplitude was more negative for incongruent word pairs ($M = -3.69$ μV) relative to congruent word pairs ($M = -2.77$ μV), $F(1,17) = 11.58$, $P = 0.003$, $\omega^2 = 0.315$.[3] Note that the N400 is ~650 ms after the onset of the prime in the figure, which equates to 400 ms after target onset (250 SOA between prime and target words). Due to its

3 This effect was also significant when the analysis was conducted upon all trials (correct and incorrect), $F(1,17) = 7.157$, $P = 0.016$.

latency (within the window of 300–500 ms) and modulation by word pair congruency, we believe that the effect observed belongs to the N400 family.[4]

Effect of trait *vs* non-trait target words

Accuracy, response latency and ERP amplitude all revealed effects for the type (trait/non-trait) of target word. Accuracy scores were higher for non-trait target words ($M = 83.72$) than for trait target words ($M = 73.06$), $F(1,22) = 90.51$, $P < 0.001$, $\omega^2 = 0.796$. Faster reaction times occurred for non-trait target words ($M = 481$ ms) than trait target words ($M = 522$ ms), $F(1,22) = 50.64$, $P < 0.001$, $\omega^2 = 0.683$, conceptually replicating previous findings (Blair and Banaji, 1996). Finally, the N400 amplitudes associated with word pairs using non-trait target words ($M = -4.23\,\mu V$) were significantly more negative than those associated with word pairs using trait target words ($M = -2.23\,\mu V$), $F(1,17) = 50.472$, $P < 0.001$, $\omega^2 = 0.683$.

Exploratory analyses

Because previous stereotype manipulations demonstrated modulation of a late positive potential (Bartholow *et al.*, 2001; Osterhout *et al.*, 1997), the LPP amplitude (quantified as the most positive peak 700–1200 ms following prime presentation; 450–950 ms following target presentation) was examined using the same analysis performed for the N400. In contrast with previous research (Bartholow *et al.*, 2001; Osterhout *et al.*, 1997), the late positive potential was not modulated by congruency ($F < 1$). All other effects were non-significant.

Similar analyses were also conducted on response latencies, the N400 and the LPP with participant gender as an additional factor. While the addition of participant gender had no effect upon the N400 results, several interesting interactions arose for response latencies and the LPP. There was a significant interaction for response latency between prime gender category and participant gender, $F(1,21) = 17.587$, $P < 0.001$, and also a significant three-way interaction between participant gender, gender category and congruency for response times [$F(1,21) = 14.363$, $P = 0.001$] and the LPP [$F(1,15) = 7.428$, $P = 0.016$] (Table 1). For congruent word pairs, all participants were quicker to make judgments when the prime gender category matched their own. For incongruent word pairs, this pattern held for male participants, but not for female participants. For the LPP, when word pairs were incongruent participants exhibited larger amplitudes to word pairs with a prime gender category that matched their own gender. For congruent word pairs, this pattern held for female participants but not for male participants.[5]

Table 1 Simple comparison means for response times and LPP amplitude (Participant Gender $\times$ Prime Gender Category $\times$ Congruency)

Prime	Target	Mean response times	Mean RT difference	Mean LPP amplitude	Mean LPP difference
Female participants					
Men	Congruent	490 ms	−83 ms**	9.00 μV	0.36 μV
Women	Congruent	407 ms		9.36 μV	
Men	Incongruent	526 ms	−7 ms	8.65 μV	0.71 μV
Women	Incongruent	519 ms		9.36 μV	
Male participants					
Men	Congruent	431 ms	−50 ms*	5.19 μV	−0.90 μV
Women	Congruency	481 ms		6.09 μV	
Men	Incongruent	542 ms	−24 ms*	6.16 μV	0.57 μV
Women	Incongruent	566 ms		5.59 μV	

Mean RT difference reflects decreases in response times associated with a match between prime category and participant gender. Mean LPP difference reflects increases in LPP amplitude associated with a match between prime category and participant gender.
*$P < .04$; **$P < .01$.

DISCUSSION

Findings from the present study replicate previous behavioral research and suggest that the N400 component is sensitive to violations of gender stereotypes in an associative priming paradigm. Participants made quicker judgments for stereotypically congruent prime–target word pairs (Women : Nurturing), relative to incongruent word pairs (Men : Nurturing). This congruency effect was also present in the ERP data—congruent prime–target word pairs elicited smaller N400 amplitudes relative to incongruent word pairs. Together, these findings suggest that target words were easier to access from associative memory due to facilitation from the preceding context of 'Men' or 'Women' when they matched gender stereotypes (Kutas and Federmeier, 2000; Gawronski and Bodenhausen, 2005). For example, target words such as 'Nurturing, Gossipy, Flowers, and Secretary' were easier to access and integrate when the preceding prime context was 'Women' than 'Men'. This led to a decrease in both the N400 amplitude and response latency.

We have interpreted the observed effect as the N400, based on behavioral and ERP similarities with N400 research on semantic priming, and believe that the effect reflects differential memory activation due to priming (Bentin *et al.*, 1985; Brown and Hagoort, 1993; Koivisto and Revonsuo, 2001; Franklin *et al.*, 2007; Rhodes and Donaldson, 2008). However, given that this is the first demonstration of

4 There was also a main effect for site, $F(4,14) = 15.787$, $P < 0.001$, and an interaction with congruency, $F(4,14) = 4.519$, $P = 0.015$, indicating that the congruency effect was largest over central–frontal sites (FCz and Cz). This pattern of distribution is somewhat unexpected and will require future investigation.

5 There was also a significant interaction between target word type and congruency, $F(1,21) = 4.452$, $P = 0.047$, which was qualified by an interaction with prime gender category, $F(1,21) = 5.353$, $P = 0.031$. Across congruency, prime gender category had a differential impact for traits, but not for non-traits. For congruent traits, participants were quicker to respond when the prime was Women than Men. For incongruent traits, participants were quicker to respond when the prime was Men than Women. This would imply that female stereotypical traits are more closely tied to their gender category than are male stereotypical traits.

N400 modulation due to stereotypes, it is important to consider other possible explanations. One issue is the extent to which the observed effect reflects neural activity associated solely with the prime. That is, because target onset was 250 ms after prime onset, a portion of the ERP after target onset likely reflects neural processes associated with the prime and not with the target. Because there were only two primes (the words 'Men' and 'Women') that each appeared in half of the trials, we systematically examined the entire ERP associated with these primes (i.e. collapsing across target congruency). The only effect was a larger P2 (peak latency = 198 ms) associated with the prime 'Women' compared to 'Men'. There was no evidence of any ERP differences associated with the primes after the onset of the target. These analyses, in conjunction with the large extant literature that has observed comparable N400 effects regardless of long or short SOAs (Boddy, 1986; Holcomb and Anderson, 1993; Anderson and Holcomb, 1995; Babad, 1997; Chwilla *et al.*, 1998; Hill *et al.*, 2002), suggest that the observed effects reflect the incongruity between prime and target rather than neural processes associated with the prime (Rugg, 1985; Kiefer *et al.*, 1998; Deacon *et al.*, 2000; Franklin *et al.*, 2007).

Another potential explanation for the observed ERP effect is that it reflects match/mismatch processes and not spreading memory activation. Previous literature indicates that other negative-going ERP components which peak between 200 and 300 ms (N2 and N250) are modulated by stimulus mismatches of a perceptual, physical or orthographic nature (Holcomb and Grainger, 2007; Folstein and Van Petten, 2008). That is, stimuli that are physically discrepant from preceding stimuli evoke a large amplitude potential ~200 ms following stimulus onset. It is possible that the N400 observed here is a result of this type of mismatch effect, and occurs later than has been previously observed because it reflects a more complicated semantic/associative mismatch rather than a mismatch in the physical nature of stimuli. Additional research will be needed to determine whether the effects observed here reflect spreading memory activation (less negative potential when the prime is associated with the target) or a semantic mismatch (more negative potential when the prime and target are incongruent). At this time, we are more inclined to think of the effect as spreading activation because the stimuli are more similar to those used in N400 research, and the conceptualization of stereotypes as semantic/associative memory structures fits with existing N400 research and theory. One way to disentangle these two possibilities is to explore whether the effect remains when the task does not require matching the prime and target. If the effect observed here is due to spreading activation, it should remain even when there is not an explicit matching requirement. If it is due to matching, however, the effect should disappear or be significantly diminished (Folstein and Van Petten, 2008).

It is also possible that the observed ERP effect reflects response conflict processes and not spreading memory activation. Research using ERPs to explore response conflict has examined either stimulus-locked ERPs (EEG is synchronized according to stimulus onset), as was done in this study, or response-locked ERPs (EEG is synchronized according to response onset). In stimulus-locked ERPs, response conflict can be seen in more negative-going potentials that peak between 200 and 500 ms after stimulus onset, depending on the complexity of the stimulus (Folstein and Van Petten, 2008). For example, when the Stroop task is used, incongruent stimuli are associated with a negative deflection peaking around 450 ms (Folstein and Van Petten, 2008). Because the stimulus-locked ERP negativity evoked by response conflict is often accompanied by an anterior LPP (Folstein and Van Petten, 2008), analyses were conducted on the LPP to investigate whether the observed effect might be due to response conflict. Findings revealed no significant LPP effects. In addition, we derived and examined response-locked ERPs to explore whether there was evidence that response conflict occurred during execution of the participants' task (Coles *et al.*, 1985; Johnson *et al.*, 2004). There was no difference between the ERPs evoked by congruent and incongruent word pairs and thus no evidence for response conflict. Finally, the nature of the task argues against response conflict as an explanation. That is, in most response conflict research, a stimulus or stimulus set is presented that activates two different responses (Klauer and Teige-Mocigemba, 2007)—a central one that must be executed based on the task instructions (e.g. respond to the color of ink in the Stroop task) and an irrelevant one that must be inhibited (the name of the color word in the Stoop task). In the present study, there was no 'irrelevant' stimulus because the task required participants to compare the two stimuli. Thus it is unlikely that two competing responses were activated. The lack of any ERP effects associated with response conflict in conjunction with the nature of the task suggests that the observed effects were probably not driven by response conflict.

The findings of this study suggest that the N400 is modulated by stereotype violations, however, two previous studies found no such effect (Bartholow *et al.*, 2001; Osterhout *et al.*, 1997). The N400 is thought to reflect the difficulty of accessing information from semantic/associative memory (Kutas and Federmeier, 2000). This form of memory is accumulated slowly over a long period of time, and a larger N400 is elicited when the context does not facilitate access to associative memory (Kiefer, 2007). The present study required participants to use this form of memory and demonstrated an N400 effect when the target was incongruent with stereotypes stored in associative memory. In Bartholow and colleagues' (2001) study, violations were manipulated differently. In their study, participants were presented with a series of sentences which first established the personality traits of a target person and then violated behavioral expectations of the same target person. Social expectancies were therefore created within the context of the experimental design, and violations constituted a mismatch between the local context and the target stimulus rather than a lack of facilitation in associative memory. Bartholow and colleagues found no evidence of an N400, which is consistent with the idea that the N400 effect reflects facilitated access to associative memory. They also found that the LPP was greater when there was a mismatch with the local context, which is consistent with research on the LPP (Nieuwenhuis *et al.*, 2005).

The effects observed by Osterhout and colleagues (1997) may also be due to a mismatch between local context and stimuli. In their study, participants were presented with sentences which contained stereotypically male or female occupations and pronouns that did or did not match the gender stereotypically implied by the occupation (e.g. *The* **beautician** *put* **herself** *through school vs The* **beautician** *put* **himself** *through school*). Incongruent sentences elicited an LPP, which the authors interpret as an indication that stereotype incongruent pronouns were perceived as grammatically incorrect. In other words, the stereotypical occupations served as the local grammatical context for the pronouns rather than facilitating access to associative memory. Moreover, because the LPP is very large, it can obscure the N400 when present (Chwilla *et al.*, 1998; Franklin *et al.*, 2007) so it is possible that any N400 effect in Osterhout and colleagues' findings (1997) was hidden by the large LPP. Together, these studies indicate that to observe the effect of stereotypes on the N400 a paradigm that forces participants to directly access associative memory may be important.

The primary purpose of this research was to introduce a potential tool that may be used in addition to behavioral measures for the study of stereotypes. In light of this purpose, we wish to avoid over-speculation with regards to the theoretical implications of the findings. A couple possible theoretical applications do, however, bear mentioning. The first is that the N400 ERP component in concert with behavioral data may provide an alternative means for independently investigating stereotypes. Because both stereotype and prejudice priming lead to response latency effects (Wittenbrink *et al.*, 1997), it becomes difficult to separately identify the mechanisms that underlie these constructs without placing increasingly restrictive controls upon the paradigm (Judd *et al.*, 2004; Amodio and Devine, 2006). The present study has demonstrated that the N400 is sensitive to stereotype incongruities, while also replicating response facilitation. Additionally, we recently conducted two studies in which word-pair evaluative incongruities modulated response latencies, but failed to modulate the N400 amplitude (Taylor *et al.*, 2008). When combined with the findings of the present study, these results indicate that only semantic/associative priming modulates the N400 ERP component. Thus the N400 may potentially be developed as an additional tool to study the cognitive mechanisms underlying stereotypes.

The second application is that the N400 component's sensitivity to context may play a role in the progression of stereotype theory. Originally researchers thought of stereotypes as concrete, automatically activated, immutable knowledge structures. However, accumulating research indicates that the activation of stereotypes is rather malleable, depending upon factors such as context (for review, see Blair, 2002). These findings have typically been explained with theoretical footnotes, thereby preserving the original notion that stereotypes are rather impervious to change. Yet, there are those who would argue that this approach has placed a roadblock in the progression of theory, and that *focusing* upon the impact of context on stereotype activation would lead to far more theoretical progression (Smith and Semin, 2007). Because the N400 component is modulated by contextual variations and constraint (Kutas and Federmeier, 2000), it may be a promising choice for studying the impact of context upon stereotype activation.

In summation, the present study demonstrated that the N400 ERP component is modulated by violations of gender stereotypes in a sequential associative priming paradigm. This effect was interpreted as a reflection of facilitated lexical access and context integration. The authors argue that given its sensitivity to context, and responsiveness to semantic/associative relationships rather than evaluative relationships, the N400 may prove to be a useful tool for the progress of social cognitive theory.

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