ARE ALL STEREOTYPES CREATED EQUAL?

EXAMINING GENDER AS A MODERATOR OF EVENT-RELATED POTENTIALS

EVOKED DURING SCHEMA VIOLATION

by

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Abstract

Schema violation has been shown to have an impact on cognition. Previous research using reading tasks has shown that the impact is not the same across male and female characters, and research has shown that men and women hold different view of schemas. The Implicit Association Test (IAT) has been used as a method to investigate schema violation, but no study has effectively investigated gender differences. Therefore, this study specifically investigates the factors of participant and character gender on schema violation during the IAT. Event-related potentials (ERPs) were used to investigate the cognitive impact of schema violation while participants completed gender and sexuality IATs. Significant effects were found for participant gender and character gender in several ERP components (N100, P200, N400, and LPP), but only for the gender-career IAT. This suggests that on a basic cognitive level ERP activity is influenced by gender.

Keywords

Schema violation, gender, sexuality, Implicit Association Test, Event-Related Potentials

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1 Introduction

As we read a text, words and sentences are processed and information is incorporated from the text into a mental model. This mental model contains representations of individuals and events that are relevant to the understanding of the text and provides a mental representation of the content and context in which the discourse is taking place (Carreiras, Garnham, Oakhill, & Cain, 1996; Garnham, 1981). Readers incrementally and continuously update the mental model based on input from the text, and these mental models also include references to previous world knowledge (Garnham, 1981). The resulting mental model forms a symbolic representation of what is being encountered during the discourse. It is formed on-line and is updated as additional information becomes available and becomes integrated into the model. In this way, the mental model can help determine if the text it represents is true or if there is conflicting information that requires additional processing (Garnham, 1981).

Previous world knowledge often comes in the form of schemas, which are mental representations of individuals, objects, or events. Researchers have demonstrated that schemas can be beneficial for processing and may aid in the categorization, organization, and understanding of information in a text by helping to process information more quickly (Bransford & Johnson, 1972). However, certain types of schemas have a negative impact on processing. Schemas in the form of stereotypes, for example, have been shown to interfere with processing the true meaning of a discourse and may hinder comprehension and information processing (Banaji & Hardin, 1996; Carrieras et al., 1996; Oakhill, Garnham & Reynolds, 2005). Certain schemas may cause us to interpret ambiguous information in a manner different from that which the text intends; either by priming or facilitating integration of information that fits the schema into the mental model. If this incorrect (but schema-congruent) information is updated to be included in the mental model, there will later be an increase in time spent updating the mental model to include the correct information.

For example, in a text where a previously introduced *electrician* is later referred to by a female pronoun such as *herself*, a slowdown effect is observed in reading speed (Carreiras et al., 1996; Duffy & Keir, 2004). This is due to the fact that upon encountering the word *electrician*, our mental model is updated to include assumed information about gender that is not explicitly provided by the text (i.e., according to gender schemas of occupational roles, it is assumed that most electricians are male). Therefore, when we later encounter a female pronoun in reference to the *electrician*, we must update the mental model of *electrician* to include the appropriate gender relative to the discourse (in this case, that the electrician is female), so that future encounters of electrician will not be affected by the incorrect information that was originally incorporated into the mental model.

1.1 Gender Schemas

Banaji and Hardin (1996) showed that gender stereotyping is an automatic process that can influence our judgement. In their experiment, participants were shown primes that were either related to gender by definition (e.g., *mother, father*), by stereotypes (e.g., *mechanic, nurse*), or were gender-neutral (e.g., *student, person*). After a 300ms delay following the prime, participants were shown a gender-related pronoun (e.g., *he, she*) and asked to judge whether each pronoun was male or female. Participants were quicker to judge pronouns following gender-congruent primes (e.g., *pilot…he, mother…she*) compared to pronouns following gender-incongruent primes (e.g., *pilot…she, mother…he*). This supported that gender stereotypes are automatic and that gender is often assumed or inferred by ambiguous, but stereotypically-defined roles such as *pilot* or *nurse*. The effect of quicker judgements for congruent primes (vs.

incongruent primes) was stronger where gender was definitional as opposed to stereotypical, and occurred despite instructions for participants to ignore the prime. The effects were also observed regardless of whether participants were aware of the gender-matching primes and pronouns, and occurred independently of participants' explicit beliefs of gender stereotypes (Banaji & Hardin, 1996).

Duffy and Keir (2004) expanded upon these findings by using a reading task where they constructed paragraphs around gender-ambiguous role names. They showed that reading a stereotypical role automatically activates a stereotypical gender, and that reading a gender-incongruent pronoun later in the text interfered with the processing of the discourse. In their study, reading the role "*nurse*" automatically activated a female stereotype. Later in the text when the reader encounters "*himself*" in reference to the previously mentioned nurse, fixation times increased, demonstrating what Duffy and Keir refer to as the "mismatch effect". The mismatch effect was observed in inflated fixation times immediately after the gender of the pronoun mismatched the stereotypical gender for the role. It indicates that the stereotypical gender for the role is automatically activated in the absence of disambiguating information and that this caused processing speeds to slow, resulting in increased fixation times on reading (Duffy & Keir, 2004).

Duffy and Keir were able to eliminate the mismatch effect by providing context and referring to the character's gender prior to mentioning the role. When the sentence began with the phrase, "*The nurse taught himself…*" a mismatch effect was initially observed because the pronoun "*himself*" does not follow the stereotypical gender of a nurse, which is female. However, when encountering the pronoun "*he*" later on in the text, the resulting mismatch effect was eliminated because of the context provided by the first sentence. The elimination of the mismatch is consistent with the Lexical Reinterpretation Model (Hess, Foss, & Carroll, 1995).

The Lexical Reinterpretation Model states that the discourse representation is continually and incrementally updated in order to maintain coherence with the text. Each word is processed as it is encountered and is analyzed according to the global discourse model, which can override local semantic relations. The model was developed after discovering that, in an experiment where participants heard a discourse context and named a target word, they were faster in doing so when the target and role names were semantically related. They also discovered that when sentences were embedded in an irrelevant discourse context, the priming effect was eliminated. The model assumes participants reinterpreted the meaning of the role names to include the new information into the ongoing discourse model. Duffy and Keir (2004) postulate that in their study, the pronoun is integrated into the discourse model upon the first encounter. Though the gender of the pronoun encountered later in the text mismatches the stereotyped gender for the role, it matches the gender that has been integrated into the discourse model. Therefore, there is no difficulty integrating the pronoun into the representation of a discourse where the referent's gender has already been established.

Other studies have examined gender ambiguous role names to test these effects (Carreiras et al., 1996; Kreiner, Sturt, & Garrod, 2008). Some nouns are gender-specific by definition or because they are proper names (e.g., "*father*" and "*Pamela*" are, respectively, male and female by definition). Information about these nouns is encoded in the mental model upon encountering them for the first time. However, sometimes the text does not provide specific information about gender (such as with the ambiguous role name of *nurse*), a gender stereotype provides a default gender to the role. The default gender is determined based on societal stereotypes and is assumed to be correct until proven otherwise. When encountering a reflexive pronoun later in the text that does not match the stereotypical gender already integrated into the discourse model, the resulting mismatch effect is associated with the cognitive cost required to update the referent's gender in the model (Carreiras et al., 1996 ; Kreiner, Sturt, & Garrod, 2008). Disambiguating context is able to eliminate the mismatch effect only for nouns that are stereotypically gender-specific; such as role names (Kreiner, Sturt, & Garrod, 2008). Context was not able to eliminate the mismatch effect for definitionally gender-specific nouns; such as proper names or titles like "*king*" or "*queen*".

The first study in a set of experiments by Carreiras et al. (1996) produced a mismatch effect in Spanish, showing a decrease in reading times when there was a mismatch between the gender of the article and the stereotypical gender of the referent. They also demonstrated that gender stereotypes are activated immediately upon encountering the stereotyped noun and the resulting mismatch effect can be eliminated by providing context and referring to the character's gender prior to mentioning the role.

Original sentences:
(1) [La enfermera/El enfermero] tuvo que suturar la herida.
(2) El corte había sido profundo.
(3) [Ella /El] también puso una inyección para evitar una infección.

English translation:
(1) The nurse had to suture the injury.
(2) It had been a deep cut.
(3) [She/He] also gave an injection to avoid an infection.

When the first sentence was read, reading speeds slowed when there was a mismatch between the article (*El/La*) and the stereotypical gender of the role name. In the first sentence, if participants encountered the word "*El*" (masculine article/pronoun) in relation to the "*enfermero*" (male nurse), reading speeds slowed compared to reading about a female nurse "*La* *enfermera*". Researchers were able to eliminate the mismatch cost in the third sentence by providing context in the first sentence. Third sentences were read faster when the reflexive pronoun (*El/Ella*) matched the article of the noun (*enfermero/enfermera*) in the first sentence, demonstrating the role of context in elimination of the mismatch effect.

The previous research on gender schemas has demonstrated that we often rely on stereotypes and make assumptions when reading a text containing ambiguous gender roles. If reading a text about an electrician, we would assume that the character is male because societal schemas tell us that most electricians are men. Therefore, we update our mental model of the discourse to include this gender stereotype. If we read later on in the text that the electrician is female, we must update our discourse model to reflect this. The cognitive cost associated with reincorporating the new information into the discourse model is seen in the resulting mismatch effect. Previous research has demonstrated that providing context early on in a text can eliminate the mismatch effect, at least for a short period of time; usually two to three sentences (Carreiras et al., 1996; Duffy & Keir, 2004).

Of relevance to the current study, Carreiras et al. (1996) noted that the effect of matching roles to gender may be weaker for female stereotypes. In a pilot study, female stereotyped role names had less bias in the rating data than the male stereotyped role names. When ranking role names as stereotypically masculine or feminine, participants ranked male roles as very stereotypically masculine, but female roles were not ranked as strongly stereotypically female. It was more difficult for researchers to use role names that participants had ranked with a very strong female bias, because participants had not ranked them as strongly as the male stereotyped roles (Carreiras et al., 1996). This suggests that stereotypes may apply more strongly for males than females; however, this was an observational finding and was not directly tested in their series of experiments. It should be noted that none of the studies on gender schemas have taken into account participant gender or the gender of the character in the text when examining the effects of schemas. The current study will be one of the first to examine the effects of gender on schema violation.

1.2 Sexuality Schemas

Just as gender is assumed for certain ambiguous role names, a person's sexuality is often taken for granted as well. It is often assumed that a person's "default" sexuality is heterosexual when there is no information suggesting that they may be homosexual (Nielsen, Walden, & Kunkel, 2000). Dickinson (2011) conducted a study on sexuality schemas and found the activation of sexuality schemas to be an automatic process, very similar to gender schemas. Dickinson discovered that reading speeds slow when readers discover that a character is homosexual (compared to a heterosexual control condition). In this experiment, encountering the phrase "*his husband*" in relation to the previously mentioned male character in the text causes slower reading times compared to encountering the phrase "*his wife*" in relation to the same male character.

In this situation, reading speeds slowed because the "heterosexual norm" (the assumption that individuals are heterosexual unless otherwise stated) was violated. Based on previous knowledge and societal influences, readers update their mental model of the discourse to include assumptions that characters are heterosexual when no information about their sexuality is explicitly stated in the text (Nielsen, Walden, & Kunkel, 2000). When information later in the text violates the "heterosexual norm", there is a cognitive cost associated with updating the schema to include homosexuality, which is evidenced by slower reading speeds (Dickinson, 2011).

In her study, Dickinson (2011) sought to eliminate the mismatch effect that occurred when violating the heterosexual norm. She provided context in the form of a video prime prior to the exposure to sentences containing homosexual characters. The video prime had no effect on eliminating the mismatch cost for homosexual characters that were *male*. On the other hand, providing context prior to sentences containing homosexual *female* characters caused reading times to speed up (compared to heterosexual female characters in the control condition). Since context was not able to eliminate the schematic cost associated with sexuality schema violations, it has been suggested that sexuality stereotypes may be more entrenched than those of gender (Dickinson, 2011) and may require a stronger form of prime in order to override the slowdown effect observed in reading. Priming participants with homosexual content had the opposite impact for male and female characters; reading speeds slowed for homosexual male characters, but sped up for homosexual female characters. It has been suggested that further research address these unexpected findings (Dickinson, 2011).

A second study (Shilhan, 2011) investigated the influence of sexuality schemas on discourse processing and revealed a consistent pattern of results to Dickinson (2011). This study used eye movement measures to determine the precise locations where processing difficulties arise during violation of the "heterosexual norm". This study also sought to determine if the resulting processing difficulty can be mediated by providing prior disambiguating context. Results of this experiment showed that encountering a homosexual male character in a text resulted in longer reading times compared to heterosexual male characters. Similarly, participants fixated target words for longer periods when the character was male and homosexual, demonstrating a delay in processing for homosexual male characters. However, results of this study did not support a bias in favor of heterosexual females over homosexual females; there was no significant effect of the sexuality of female characters on reading time or fixation measures. Male characters, however, caused a slowdown effect in reading speed and increased fixations on target words when they were homosexual compared to heterosexual (Shilhan, 2011).

Both studies examining sexuality schemas demonstrated a similar pattern of results regarding the gender of the character in a text (Dickinson, 2011; Shilhan, 2011). Results suggest that the sexuality schema is applied more strongly to male characters than to female characters. This is observed by the fact that there was a slowdown effect in reading in both studies, but only when the character was male and homosexual (compared to a male heterosexual control). When the character was female and homosexual, there was either no difference compared to the female heterosexual control (Shilhan, 2011) or reading speeds sped up (Dickinson, 2011). Furthermore, in both studies, context was unable to eliminate the mismatch effect observed, lending support to the idea that sexuality schemas are more entrenched than gender schemas (Dickinson, 2011). Neither of the aforementioned studies accounted for participant gender, and included either all female participants (Shilhan, 2011) or a vast majority of female participants (Dickinson, 2011).

In terms of stereotypes regarding sexuality, previous research has discovered that men's attitudes are more negative than women's, especially toward gay men (Kite & Whitley, 1996; Steffens & Wagner, 2002). This research demonstrates that participant gender and character gender have an impact on explicit and implicit attitudes toward homosexuals. One study (Steffens, 2005) further examined these gender differences in attitudes using a version of a sexuality Implicit Association Test (Greenwald, McGhee, & Schwartz, 1998). The IAT involves sorting stimuli into pairs of categories and recording reaction times. For the sexuality IAT, the target categories *heterosexuals, gay men,* and *lesbians* were paired with the attribute categories *positive* or *negative*. Reaction time is an indicator of the strength of association between the pairs of categories. If the pairing of *gay men + negative* results in faster reaction times compared to the pairing of *heterosexuals + positive*, there would be a negative association for gay males compared to heterosexuals (or a strong positive association for heterosexuals compared to gay males).

In her first experiment, Steffens (2005) discovered that participant gender was a moderator of implicit attitudes toward homosexuals measured by the IAT. Overall, compared to female participants, male participants held more negative implicit attitudes of homosexuals. Female participants showed no difference in their views between homosexual and heterosexual female targets. That is, there was no difference in female participants' implicit attitudes between lesbian or heterosexual targets.

Gender of the target also had an impact. In general, homosexual targets were evaluated more negatively than heterosexual targets, and these negative attitudes were stronger for gay male target characters compared to lesbian targets. The evaluation of gay male targets was more negative than that of lesbian targets. The major finding of this study is that male participants held an automatic positive association for heterosexuals compared to homosexuals (regardless of the gender of the homosexual target). With female participants, this was the case only for gay male targets; female participants did not hold a greater positive association for heterosexual targets compared to lesbian targets. Many other studies have used the Implicit Association Test to further investigate implicit associations and attitudes, but very few have taken gender (of either participant or target) into consideration. The current study aims to empirically test for potential gender differences across different types of IATs.

1.3 The Implicit Association Test

The Implicit Association Test (IAT) measures differences in implicit attitudes by investigating participants' automatic association between target and attribute categories (Greenwald, McGhee, & Schwartz, 1998). Implicit attitudes are thought to either be outside of our conscious awareness, or are within our conscious awareness, but are not socially acceptable to express (Coates, 2011). Explicit measures such as questionnaires and surveys can often fall subject to social desirability or masking effects. Because the IAT is able to investigate implicit attitudes, which participants either do not have access to or may be masking, it can provide a better measure of attitudes than most explicit measures by exploring cognitive processes in conjunction with behavioural measures (Greenwald, et al., 1998), and the IAT is less susceptible to faking than explicit measures (Steffens, 2004). Since its development in 1998, the IAT has been used most commonly to examine attitudes towards various groups including: different racial or ethnic groups (Dasgupta, McGee, Greenwald, & Banaji, 2000), different genders (Aidman & Carroll, 2003), as well as different sexualities (Steffens & Buchner, 2003).

During the task, participants are instructed to sort stimuli into the correct categories as quickly and accurately as possible while reaction times are recorded. Each stimulus belongs to one of four categories, of which there are two target and two attribute categories. For the gender-career IAT, the target categories are *male* and *female*, and the attribute categories are *career* and *family*. Stimuli are words related to these categories (male and female names, or career and family related words).

The pairing of target and attribute categories results in two conditions: a compatible and an incompatible condition. The compatible condition is made up of one attribute and one target category paired on a single response key, with words from the other target and attribute categories paired on the other. The pairs of categories are semantically-related in the congruent condition; that is, they are congruent with the schema. For the gender-career IAT, the compatible condition pairs *male + career* and *female + family* together on opposite response keys. For the same IAT, the incompatible condition pairs *male + family* and *female + career* on opposite response keys.

The IAT relies on three basic assumptions. First, reaction times are faster for more closely-associated categories—i.e., the compatible condition. Second, reaction times are slower if information is inconsistent with existing schemas—i.e., the incompatible condition. Third, the underlying cognitive processes of the IAT are automatic (Greenwald et al., 1998).

Most IATs follow a five-step procedure (see Figure 1). The first step is the initial target discrimination. Stimuli are sorted into to their target categories, with one on each side of the screen. For the gender-career IAT, participants must sort stimuli of male and female names; if the *male* target is on the left, then *female* is on the right. The second step is attribute discrimination. For this step, attribute stimuli are sorted into their categories. If *career* words are sorted to the left, then *family* words would be sorted to the right. The third step is the initial combined task. The combined task uses the stimuli from both target and attribute categories. Each response key (left and right) now pairs one target with one attribute. Following the example of the gender-career IAT, *male + career* categories are paired on the left and *female + family* categories are paired on the right. This would make up the congruent condition for the IAT. Participants are expected to complete this condition more quickly and accurately than the incongruent condition (step five). The fourth step is the reversal of targets. In this step, target category labels appear on the opposite sides of the screen from the steps 1-3 and categorization occurs again. The *male* category would now appear on the right and *female* on the left. The fifth and final step is the reversed combined task. Attributes (which have not changed sides) are paired once more with the reversed target categories. In this final step, *female + career* categories are paired on the left and *male + family* categories are paired on the right. This would make up the incongruent condition for the IAT.

The IAT provides a measure of the strength of associations between categories. If target categories are strongly associated with attributes, participants will find one of the combined tasks easier than the other. This is evident when response times from the third and fifth stages of the IAT are compared to one another (steps 1, 2, and 4 of the IAT are considered practice blocks). The measure of the difference between compatible and incompatible conditions, called the IAT Effect, provides the measure of implicit attitudinal difference between the target categories (Greenwald et al., 1998).

The gender IAT, for example, measures the strength of association between the two target categories (*male* and *female*) and attribute categories (*career* and *family*), and participants should find one of the paired conditions easier. The pairings of *male + career* and *female + family* are more highly associated with one another because they fit the schema. This results in faster response times than *male + family* and *female + career*, which are less associated to one another, as they do not fit the usual gender schema. Participants have quicker reaction times when the associations match their existing schemas and have slower reaction times in trails where the information is inconsistent with their existing schemas. For the incompatible condition, reaction times are typically 100-200ms longer than those in the compatible condition. The difference in reaction time between compatible and incompatible blocks is known as the IAT Effect, which provides the measure of implicit attitudinal difference between the target and attribute categories (Greenwald et al., 1998).

1.4 Event-Related Potentials

Event-related brain potentials (ERPs) have emerged as a way to test theories of cognition that were based solely on behavioural measures (Luck, 2005). ERPs are voltage changes in the ongoing electroencephalography (EEG) measured at the scalp; specifically the summed activity of postsynaptic potentials. ERPs are elicited in response to an event or a stimulus and are used as a safe, non-invasive approach to studying the correlates of cognitive processes. Because ERPs reflect very small changes in EEG activity, signal averaging is necessary in order to remove excess "noise" in the signal. If it is assumed that ERP activity is the same for every trial of a specific stimulus and that background noise is random, then by averaging together like stimuli for a specific time period after it is presented, noise is averaged out to zero and the time-locked stimulus emerges (Luck, 2005). We are left with an average waveform for each type of stimulus for each participant. The grand average waveform is the average across all participants for one type of stimulus.

A waveform is made up of a sequence of peaks and troughs, and components used to be defined solely based on the polarity and latency of the waveform. Luck (2005) provides a more recent definition of components in his book; one that has been widely-accepted by the field. Luck (2005) defines components as, "scalp-recorded neural activity that is generated in a given neuroanatomical module when a specific computational operation is performed" (p. 59). By this definition, a component can occur at different latencies and under different conditions, as long as it reflects the same cognitive function and is elicited in response to the same paradigm. Components are still labeled by their polarity and post-stimulus latency. Therefore, a negative-direction component occurring approximately 400ms post-stimuli is known as the N400.

Components are sensitive to experimental manipulation and many are known to be elicited by specific paradigms (Luck, 2005). Furthermore, different components are believed to reflect different cognitive processes (e.g., a larger N400 component reflects increased semantic congruency in one condition compared to another; Kutas & Hillyard, 1980a, b). By manipulating the conditions of a paradigm, we can begin to examine the effect the manipulation has on the ERP activity associated with the underlying cognitive processes associated with a task.

ERP research has examined gender stereotypes in this way, and has also recently been paired with the IAT in order to examine activity associated with cognitive processes underlying the IAT task. Before the creation of the IAT, one study examined the violation of gender stereotypes in conjunction with ERPs. Osterhout, Bersick, and McLaughlin (1997) conducted one of the first studies examining schemas—in the form of stereotypes—and ERPs. For this experiment, researchers recorded EEG activity as participants read texts containing a pronoun that referred to a definitionally or stereotypically male or female antecedent noun, and then analyzed ERPs. A definitional violation occurred when a word contradicted the gender definition of a word (The *man* prepared *herself* for the interview), whereas a stereotypical violation occurred when a word contradicted the gender stereotype associated with the word (The *doctor* prepared *herself* for the operation).

Osterhout et al. (1997) argued that the reflexive pronouns would be perceived as anomalous only if gender occupational stereotypes exist and the presence of an ERP effect would indicate that subjects are sensitive to these stereotypes. A P600 effect, which is typically observed during syntactic anomalies, was hypothesized to be evoked in the definitional violation condition. The P600 is typically elicited in anomalies related to the syntax of a sentence and a significant P600 difference can be elicited by errors in sentence structure, verb tenses, or other grammatical errors. An N400 effect, normally observed during semantic violations, was expected to be elicited in the stereotypical violation condition. In the stereotypical violation condition, there are no errors in the syntax of the sentence, but reflexive pronouns violate the stereotypical gender associated with the role names. Similar semantic violations have been shown to elicit significant P400 components.

Despite differing hypotheses for the semantic and syntactic violation conditions, Osterhout et al. discovered a large-amplitude P600 wave when the gender of a pronoun mismatched the gender of the noun for both definitional and stereotypical nouns. The onset of the wave occurred at about 300ms in the definitional condition and around 400ms in the stereotypical condition and there was a larger-amplitude response in the definitional condition compared to the stereotypical condition wave (Osterhout et al., 1997).

Researchers speculate that in the stereotypical violation condition, readers initially assigned the stereotypical gender to the noun and were forced to assign the less-preferred gender upon encountering a reflexive pronoun that was inconsistent with the stereotype. The cognitive reassignment of gender elicited a measurable ERP effect. This study demonstrates that ERPs are sensitive to the violation of gender-based stereotypes; however, researchers note that the set of underlying cognitive processes remains unclear and further research is needed to gain a better understanding in this area as the N400 was hypothesized but not observed in their results (Osterhout et al., 1997).

Numerous studies have used the IAT in order to study a wide variety of schemas including: gender and sexuality, as well as countless others (Coates, 2011; Greenwald et al., 1998). As discussed previously, the IAT measures the strength of semantic associations between targets and concepts. By pairing the IAT with ERPs, we can gain more insight into the type and timing of processing differences involved during the IAT (Williams & Themanson, 2011). ERP measures allow researchers to examine differences in cognitive processes during different conditions of the IAT. By calculating mean ERPs and RTs for each stimulus type, we can begin to examine the timing of cognitive processes associated with the IAT across different types of stimuli.

O'Toole and Barnes-Holmes (2009) conducted one of the first experiments pairing ERP measures with the administration of an IAT. Researchers measured ERPs from 13 electrode sites while they employed a version of the IAT (using baby or romance related words for positively valenced words, and snake or spider related words for negatively valenced words). Because this study was one of the first to pair ERP with the IAT, it was largely exploratory and its purpose was twofold: to observe if there was differential ERP activity between compatible and incompatible trials, and to determine the latency and location of such activity. Compatible trials were described as those where both negative targets were paired together one side of the computer screen, and both positive targets were paired together on the other. Incompatible trials were those where one positive and one negative were paired together on each side of the screen.

Results of this study found that in the central and parietal regions, incompatible IAT trials generated less positive waveforms compared to compatible trials. This effect occurred during the 300-400ms interval, a timeframe associated with the N400 component in which negative ERP activity is believed to represent semantic priming. Though the waveforms elicited by the incompatible trials in this study were not negative, they were significantly less positive than those elicited by consistent trials, and the resulting ERPs were believed to reflect the semantic incongruity of the incompatible trials encountered during the IAT. This study demonstrated a low degree of expectedness (i.e., low cloze probability) with incongruent words eliciting ERP components in the negative direction around 400ms following target onset, an epoch known as the N400 component (O'Toole & Barnes-Holmes, 2009).

Furthermore, incompatible trials elicited more positive-amplitude waveforms in frontal sites during the 400-600ms interval. Semantic priming does not typically produce activity in frontal sites or during this epoch. As a result, these findings suggest that the IAT draws on higher-order cognitive processes in addition to semantic processing, which was elicited by the N400-like component (O'Toole & Barnes-Holmes, 2009). While this study uncovered activity similar to an N400 effect, the researchers focused the discussion of observed components in relation to semantic priming tasks only. They did not use a group bias IAT (such as a sexuality, race, or gender IAT), which may elicit different ERP components as a result.

Hurtado and colleagues (2009) conducted a study to specifically examine the LPP elicited by a group bias IAT. Using a race-IAT, researchers recorded ERPs while both indigenous and non-indigenous participants performed an IAT consisting of faces and words. Faces were classified as belonging to either the ingroup or outgroup; ingroup if they matched the race of the participant (i.e., indigenous faces for indigenous participants) and outgroup if they did not match the participant's race. Words were either negatively or positively valenced. Researchers predicted that an IAT effect would be present, suggesting ingroup favoritism, and hypothesized that a larger LPP would be elicited for compatible trials compared to incompatible trials.

For the word condition, they discovered a larger LPP effect for the compatible (ingroup/positive; outgroup/negative) versus incompatible (ingroup/negative; outgroup/positive) trials. This component was elicited in the right frontal electrode sites at approximately 350-750ms following the IAT stimulus. Face conditions failed to elicit a significant LPP effect as there is no evaluative judgment present; that is, participants are not judging words to be negative or positive, but simply categorizing faces into indigenous or non-indigenous categories. Furthermore, only the indigenous group reached statistical significance, likely due to a small sample size.

However, despite the fact that this study elicited a larger LPP for compatible trials in the word condition with indigenous participants, the generalizability is questionable due to the small sample size and lack of significance for the non-indigenous group. This study focused on ingroup/outgroup differences despite other IAT research suggesting that participants belonging to a minority group produce a similar IAT effect to non-minority participants (Greenwald et al., 1998). Finally, there are data suggesting that culture has a moderating effect on schema processing and that there may be differences across cultures in the way individuals process schemas (e.g., Lane & Addis, 2005; Schein 2004; Wu & Baer, 1994), a fact this study did not take into full consideration.

Williams and Themanson (2011) measured ERPs while participants completed a gay-straight IAT in order to examine the cognitive processes involved in a group bias IAT. The experiment conducted by Williams and Themanson examined the effects of compatible versus incompatible conditions of a gay-straight IAT on several ERP components and their relationship to response time differences. (Compatible trials were the parings gay/bad and straight/good; incompatible trials were gay/good and straight/bad).

The results of the gay-straight IAT were as predicted with faster reaction times reported for compatible trials (gay/negative, straight/positive) than for incompatible trials (gay/positive, straight/negative). This replicates previous findings of the sexuality IAT (Banse, Seise, & Zerbes, 2001; Boysen, Vogel, & Madon, 2006).

What made this study unique was that it was one of the first studies to compare compatible and incompatible trials in terms of several early and late ERP components. Only a handful of other studies had paired ERP with a group-bias IAT; however, none had explored in as much depth the type of processing differences and the timing of those differences. This study examined multiple ERPs across a range of early and late components (including the N100, P200, N2, N400, and LPP) and their correlations to response time differences on the IAT.

Early components—including the N100 and P200—are elicited by varying attentional and perceptual processes. Because the differences in the IAT conditions reflect more cognitive processing than perceptual cues, it was hypothesized that there would be no differences among these early components, but there would be significant differences in later components. As expected, no significant differences for earlier components were discovered when comparing incompatible to compatible trials; suggesting earlier ERP components, which mainly deal with the attentional and perceptual processes, are not associated with IAT (Williams & Themanson, 2011).

As predicted, several late components elicited significant differences between conditions. The N400 is a late ERP effect that is used as a measure of semantic congruency and sentences containing semantic violations often cause increased N400 amplitude (Kutas & Hillyard, 1980a, b). For example, a sentence such as, "I take my coffee with <u>cream and dog</u>" elicits a larger

N400 wave compared to the sentence, "I take my coffee with cream and sugar", because "dog" is a semantic violation in this sentence.

In terms of the IAT, it is assumed that reaction times in the incompatible condition reflect similar semantic violations because we are forced to sort items against their schemas (e.g., the word "*homosexual*" should be sorted into the gay/good pairing despite the schema being that homosexuality is bad and heterosexuality is good). When we compare the compatible and incompatible conditions, reaction times should be slower for the incompatible trials, reflecting the need for an increase in processing to sort items against the schema. Because of this, Williams and Themanson predicted a larger N400 for the incompatible condition compared to the compatible condition.

Williams and Themanson (2011) discovered larger N400 amplitudes for incompatible trials (compared to compatible trials), reflecting greater semantic incongruency for incompatible trials of the IAT. Furthermore, there existed a significant correlation between N400 and IAT effect scores, with greater N400 amplitudes associated with larger IAT effect scores. The results suggest that the semantic properties of the stimuli contribute to the stronger association of compatible trials (Williams & Themanson, 2011).

The Late Positive Potential (LPP) is a second late ERP effect that increases in amplitude during the processing of emotional or extremely salient stimuli (Cacioppo et al., 1994). There were larger, more positive, LPP amplitudes for compatible trials (compared to incompatible trials), reflecting increased emotional congruency in the compatible condition. There existed a significant relationship between LPP amplitude and IAT effect score in the compatible condition, with greater LPP amplitude associated with smaller IAT effect scores (Williams & Themanson, 2011).

Contrasting previous findings of other research (Williams & Themanson, 2011); Coates and Campbell (2010) discovered significantly larger N2 amplitudes for incompatible trials of the IAT. This occurred in the posterior regions of the scalp at 350-400ms following the stimuli. The N2 component represents a measure of response conflict monitoring and is larger in conditions where participants must inhibit a prepotent, or more dominant, response (Coates & Campbell, 2010). This would occur during incompatible trials where participants are forced to inhibit a prepotent response in order to classify words against their preexisting schemas (e.g., *clarinets* are *bad*, but *grenades* are *good*). Williams and Themanson (2011) expected to find larger N2 amplitude for the incompatible condition compared to compatible condition, but did not find N2 differences between conditions.

One difference between the studies (Coates & Campbell, 2010; Williams & Themanson, 2011) was the type of IAT used. Williams and Themanson used a gay-straight IAT, which reflects group biases, and Coates and Campbell used an object association IAT. It is possible that different types of IATs (or differing schemas) result in differing ERP results. Because the research combining the IAT with ERP measures is sparse, it is impossible to be certain which components will be elicited. However, larger-amplitude N2 and N400 components have been demonstrated in incompatible trials of the IAT (Coates & Campbell, 2010; Williams & Themanson, 2011) and a larger-amplitude LPP has been demonstrated for compatible trials (Williams & Themanson, 2011).

When examining the literature surrounding event-related potentials and the Implicit Association Test, several trends emerge. It is evident that there is little research regarding this topic and that many studies employ varying methodologies and oftentimes report conflicting results. There are conflicting results in regards to the N2 ERP component, which serves as a measure of response conflict monitoring, with one study reporting no differences between incompatible and compatible trials in a group bias/gay-straight IAT (Williams & Themanson, 2011) and another reporting significantly larger N2 amplitudes for incompatible trials in a more basic IAT (Coates & Campbell, 2010). It should be noted; however, that despite Williams and Themanson (2011) not discovering N2 differences between incompatible and compatible trials, they hypothesized that incompatible trails would produce a greater N2 effect. The current study will be able to help clarify the role of N2 during incompatible trials of the IAT, which is important in order to attempt to explain why the gay-straight IAT failed to produce a significant N2 difference.

The first study combining ERP and the IAT produced a larger N400-like effect for incompatible conditions, as well as a later small amplitude waveform, which was larger and more positive for compatible trials (O'Toole & Barnes-Holmes, 2009). These findings were supported by a second study which found significant differences for both N400 and LPP as well, with an increased N400 in incompatible trials and an increased LPP for compatible trials (Williams & Themanson, 2011). These results combined suggest that there not only is semantic priming present during the IAT, but additional evaluative processes are also present. The later, second positive amplitude waveform discovered by O'Toole and Barnes-Holmes (2009) was not statistically significant, likely due to a small sample size. This waveform was also not expected and may have been a result of a leveling-off of the P300 amplitude returning to baseline. It was suggested that future studies should examine waveforms from specific epochs and obtain a larger sample size in order to allow differences in waveforms between conditions to reach significance; the current study attempts to follow these recommendations.

One study (Coates & Campbell, 2010) observed a P300 component, with larger amplitudes in compatible versus incompatible trials. The average peak occurred around 550ms, despite the P300 normally occurring around 300ms post-stimulus. Since there is no other evidence of an observed P300 during the IAT, further research is necessary to verify the latency of this waveform and the significance of these findings.

Early waveforms do not appear to differ between incompatible and compatible conditions of the IAT except in terms of physical characteristics of the stimuli such as pictures versus words (Williams & Themanson, 2011). As a result, many studies only investigate the later, larger waveforms which are a result of semantic and higher-order cognitive processing (Coates & Campbell, 2010; Hurtado et al., 20009; O'Toole & Barnes-Holmes, 2009). As there have been no differences observed in early waveforms between incompatible and compatible trials of the IAT, future research should focus on later waveforms to help clarify some of the inconsistencies in the research, such as whether the N2 is elicited by the IAT and whether there is a P300 effect elicited by the IAT. Furthermore, the N400 and LPP occur in several different studies and should be measured by future research to verify these results and to help clarify the semantic and evaluative processing occurring during the IAT. By utilizing ERP measures, we can better understand the cognitive effects involved in the Implicit Association Test, and will come closer to understanding the neural basis of the IAT effect.

1.5 Overview of the Current Study

ERPs can help us examine underlying cognitive processes associated with the IAT. The current study will investigate differences in ERPs during schema violations on two different versions of the IAT. By comparing male and female stimuli, we can assess whether there are differences in processing during schema violations and, if so, we can begin to outline in which instances schemas are more salient for one gender instead of the other. It is expected that schemas will apply more strongly for male targets than they do to female targets (e.g., Carreiras et al., 1996; Dickinson, 2011; Shilhan, 2011; Steffens, 2005). The current study, which examines gender of the target, will lead to a greater understanding of processing differences for male and female targets during the IAT. This may lead to a better understanding of processing differences for male and female targets during schema violation in general.

By using two versions of the IAT (Gender-Career, Sexuality IAT), we can examine whether these effects are elicited from different kinds of schemas. Previous research has demonstrated that, like gender schemas, the activation of sexuality schemas is automatic. An important distinction between the two; however, is that context is not able to override the mismatch effect observed for sexuality schemas in the same way it can override the mismatch effect in gender schemas (Dickinson, 2011). The current study will serve to further examine the differences between gender and sexuality schemas.

Participant gender will also be examined in this study. Based on previous findings (Steffens, 2005), it is expected that male participants will hold stronger and more traditional views of stereotypes, therefore resulting in larger IAT and ERP Effects across conditions of the IAT.

2 Methods

2.1 Participants

A total of 37 undergraduate students (19 male, 18 female) from Laurentian University volunteered for participation in this experiment. Ages ranged between 18 and 32 years (*M* = 20.6 years; *SD* = 3.0 years). Informed consent was obtained and participants received extra course credit for their participation. Three participants were excluded from analysis due to medication use or neurological illness, two due to English not being their native language, and three due to excessive noise and artifacts in their EEG data.

2.2 Materials

The experiment utilized two versions of the Implicit Association Test. Stimuli were visually presented with E-Prime software (v. 20). All target and attribute categories as well as all stimuli used were originally developed by Greenwald et al. (1998) and have been used in the first IAT studies as well as numerous research studies since. For the gender-career IAT, *male/female* and *family/career* were the target and attribute categories, respectively. Stimuli consisted of male and female names as well as family or career related words. For the sexuality IAT, *gay/straight* and *good/bad* were used as target and attribute categories. Stimuli for the gay and straight categories were presented in the form of words and images. Gay targets were represented by pictures of two women or two men together, whereas straight targets were represented by pictures of a man and a woman together. Stimuli for the good and bad categories consisted of positive and negative adjectives developed by Greenwald et al. (1998) for the IAT. (See Appendix A for a complete list of target and attribute categories, as well as all stimuli used in this study.)

2.3 ERP Recording

Data was collected using a 64-electrode HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, OR) in conjunction with EEG system with Net Station software (v. 4.4.1; Electrical Geodesics, Inc., Eugene, OR) for data collection and analysis. E-Prime (v. 20) was used for presentation of visual stimuli during IAT administration and for recording reaction time data. Electrodes were arranged geodesically in an elastic cap around a midpoint electrode that served as a reference. Electrodes placed above and below the eye recorded electrooculographic (EOG) in order to monitor eye movements. Impedances were kept below 100 kΩ for all electrode sites.

Neural processing of stimulus-locked components was digitized with a sampling rate of 250 Hz using the vertex as a reference. Data were then re-referenced off-line to the average mastoid reference. Raw EEG data were filtered on-line using a 0.1 Hz high pass filter. Data were filtered off-line and underwent low pass filtering (0.3-30 Hz), segmentation into 1200ms epochs, artifact removal (±100 μV for blinks; ±5 μV for horizontal eye movements), bad channel replacement, averaging of segments, re-referencing off-line to average mastoid reference, and baseline correction (200 ms pre-stimulus). Each stimulus was segmented to include an epoch from -200ms to 1000ms relative to stimulus presentation.

Separate, average ERP waveforms were created for each type of stimulus (male names, female names, etc.) and for each IAT condition (compatible, incompatible). In each stimulus-locked average waveform, components were categorized by latency post-stimulus: N100 was measured from 100-170ms post-stimulus presentation, P200 from 170-250ms, N400 from 250-500ms, and LPP from 500-1000ms.

2.4 Procedure

Participants were affixed with the ERP net and seated in an individual sound-attenuating booth equipped with a computer monitor and button box. The experiment lasted approximately 60-75 minutes and was comprised of a modified gender-career IAT followed by a modified sexuality IAT. A break was offered between each testing block—approximately every 15 minutes—and impedance levels were corrected at the halfway point of the experiment.

Participants were tested individually and were instructed to sort stimuli into categories appearing on either the right or left side of the computer screen using a button box. A red “X” appeared in the middle of the screen if an incorrect response was made and participants were not required to correct their mistakes. There was an inter-trial period of 1000ms for all trials.

A word (or image, for target categories of the Sexuality IAT) associated with one of the categories was presented in the center of the screen and participants pressed a button to sort that word into the learned categories on either the right or left side of the screen.

The two blocks of the gender IAT (compatible, incompatible) were always completed first, followed by the two blocks of the sexuality IAT. Incompatible and compatible blocks for each IAT were counterbalanced across participants, and the order of stimuli was randomized. Target and attribute category pairings were counterbalanced across participants as well, with half receiving the congruent condition first and half receiving the incongruent first (e.g., for the gender IAT, half of participants would receive *male+career* and *female+science* as the first category pairings, and half would receive the opposite pairings of *male+family* and *female+career*). The gender and sexuality IATs had the same number of practice and experimental blocks, but the number of trials differed in the experimental block (see Table 1).

There were 96 trials for the gender IAT experimental block, and 192 for the sexuality IAT. This is due to the nature of trials used. In the gender IAT, male and female names were used as targets, with five names for each gender used as targets. In the sexuality IAT, there were only two images representing the male homosexual condition and two images representing the female homosexual condition. Due to the requirements necessary when averaging ERP data, we needed to include extra trials during the experimental block of the IAT.

Participants first completed a practice block of trials where they learned to classify each target category to one response keys. During these practice blocks, category labels were present on the left- and right-hand sides of the screen (e.g., *male* on the left and *female* on the right) and participants were instructed to sort the stimuli to the appropriate categories by pressing either the left or right button on the button box. A second practice block was used to classify the attribute categories (e.g., *career* on the left and *family* on the right). Targets and attributes were then combined into a pair of categories for the third practice block (e.g., *male+career* on the left and *female+family* arts on the right). The fourth practice block involved the same target and attribute categories in the same positions, with the same pairings; however, the labels were removed from the screen in order to reduce eye movements during ERP data collection during the experimental block. Participants then completed the experimental block—which was identical to the fourth practice block but with a greater number of trials (see Table 1)—by sorting stimuli into the correct category. RT and ERP data were only analyzed from the fifth, experimental block, which is consistent with previous studies using the IAT (Coates, 2010; Greenwald et al., 1998; Williams & Themanson, 2011). Removing category labels and providing an extra practice block without the labels present was important to reduce eye movements during ERP data collection (Williams & Themanson, 2011).

Behavioural and ERP data were analyzed for this study. For all analyses, the compatible conditions consisted of the following pairings: *male+career*, *female+family*, *gay+bad*, and *straight+good*. Incompatible conditions were: *male+family, female+career, gay+good,* and *straight+bad*. Reaction times during the IAT were also recorded. We expected an increase in reaction times for incompatible trials across the different versions of the IAT used. For ERP data, we expected effects of congruency for later components (N400 and LPP) with greater N400 for compatible trials and greater LPP for incompatible trials.

3 Results

3.1 Statistical Analyses

Statistical analyses were performed separately for each ERP component. Pairwise comparisons of means were used as post hocs for montage differences (see Figure 2), as all other variables were 2 levels. All mean amplitude ERPs were submitted to a 2 (Compatibility: compatible, incompatible) x 2 (Participant Gender: male, female) x 2 (Character Gender: male, female) x 4 (Montage: frontal, left parietal, right parietal, occipital) mixed methods ANOVA. Post hoc tests were conducted within the General Linear Model (GLM) using Least Significant Differences (LSD). The alpha level was set to .05 for all analyses. For all repeated measures analyses, sphericity assumptions were met. When homogeneity of variance was not met, Wilks' Lambda was evaluated and led to no differing conclusions. Behavioral data were submitted to a 2 (Participant Gender: male, female) x 2 (Character Gender: male, female) x 2 (Congruency: congruent, incongruent) repeated measures ANOVA.

3.2 IAT Performance Data

On the gender-career IAT, participants had an accuracy rate of 94.5% in the compatible condition, compared to 93% in the incompatible condition. Inaccurate responses were excluded from all analyses. A significant IAT Effect for the gender-career IAT was discovered. Reaction times were significantly faster in the congruent condition (M = 622.0ms, SD = 92.1ms) compared to the incongruent condition (M = 698.23ms, SD = 121.1ms), F (1, 36) = 28.18, $p < .05$, η^2 = 0.44.

On the Sexuality IAT, participants had an accuracy rate of 94% in the compatible condition, compared to 92% in the incompatible condition. There was a significant IAT Effect for the sexuality IAT, as well. Reaction times were significantly faster for the congruent condition (*M* = 693.51ms, *SD* = 96.8ms) compared to the incongruent condition (*M* = 750.92ms, *SD* = 151.0ms), F (1, 36) = 11.86, $p < .05$, $\eta^2 = 0.25$.

3.3 Event-Related Potential Data

Based upon visual inspection of the grand average waveforms and upon previous research (Williams & Themanson, 2011), *s*tatistical analyses were performed separately for four ERP components (N100, P200, N400, and LPP). All ERP findings discussed are from the gender-career IAT, unless otherwise specified. This is because there was a sole significant result for the sexuality IAT, which is discussed in the N400 epoch.

N100

N100 analysis revealed a significant effect for *Character Gender*, $F(1, 35) = 8.00$, $p < .05$, partial $\eta^2 = .19$, suggesting that there are attentional differences between male and female names during the gender-career IAT. A larger-amplitude N100 was elicited for male names compared to female names.

P200

The P200 analysis revealed a significant effect for *Character Gender*, $F(1,35) = 6.24$, $p < .05$, partial $\eta^2 = .15$, with a larger P200 for female names compared to male names. The *Montage x Participant Gender* interaction was also significant, $F(3, 35) = 3.25$, $p < .05$, partial $\eta^2 = .09$, suggesting that there were potential perceptual differences across male and female participants. Post hoc comparisons indicated that the effect was being derived from the occipital region in male participants.

N400

Analysis for the N400 revealed no significant effects at the $p < .05$ level. However, one result that could be seen in the grand average waveform images approached significance. According to Luck's (2005) instructions for ERP analysis, if visual inspection of the waveforms shows differences that are not quite significant, they must still be reported. Because of this, we will interpret these N400 findings in the discussion.

In the gender IAT, the *Congruency x Participant Gender* interaction approached significance, $F(1, 35) = 3.96$, $p = .054$. For male participants, there was a larger N400 for incongruent (vs. congruent) trials. Female participants, on the other hand, elicited a larger N400 for congruent (vs. incongruent) trials.

The sexuality IAT revealed a single significant result in the form of a *Congruency x Montage* interaction, $F(3, 35) = 3.63$, $p < .05$, partial $\eta^2 = .09$. Post hoc tests indicated that the congruency effects approached significance in the frontal, left parietal, and occipital regions, but not in the right parietal. There were no other significant results found in the sexuality IAT.

LPP

The LPP analysis revealed a significant *Congruency x Participant Gender* interaction, $F(1, 35) = 7.85$, $p < .05$, partial $\eta^2 = .18$. For male participants, a greater LPP was elicited from congruent trials than incongruent trials. For female participants, incongruent trials elicited a larger LPP compared to congruent trials. The *Congruency x Participant Gender x Character Gender* interaction was also significant, $F(1, 35) = 4.52$, $p < .05$, partial $\eta^2 = .11$. Post hoc comparisons indicated that there was a congruency effect for male names among both male (p=.046) and female (p=.012) participants, but no congruency effect for female names.

4 Discussion

The major purpose of this study was to examine the role of gender on ERPs associated with schema violations of the IAT. Previous research has observed possible effects of gender during schema violation during reading (e.g., Carreiras et al., 1994; Dickinson, 2011; Shilhan, 2011); however, none of these studies directly examined gender. Furthermore, very few studies have accounted for participant and/or target gender during the Implicit Association Test, though one study that did found significant differences between male and female participants and between male and female targets (Steffens, 2005). Recently, studies have begun pairing event-related potentials with the IAT in order to study the underlying cognitive activity associated with the test (e.g., Hurtado et al., 2009; O'Toole & Barnes-Holmes, 2009; Williams & Themanson, 2011). However, none of these studies have considered the potential effects of gender on their results. As this is the case, we examined ERPs of participants completing two versions of the IAT, while accounting for gender of the participants as well as gender of the target stimuli. To our knowledge, this is the first study to empirically test the effects of participant and target gender on ERPs elicited during two versions of the IAT. All results discussed are for the gender-career IAT unless otherwise specified. (The sexuality IAT resulted in only one significant ERP finding in the N400 epoch, which will be discussed later.)

Behavioural data revealed a significant IAT Effect for both the gender-career IAT and the sexuality IAT. The IAT Effect is defined as the reaction time difference between compatible and incompatible blocks of the IAT (Greenwald et al., 1998). This was an important step in the results as we cannot begin to discuss ERP correlates of the IAT, or the potential effects of gender, if we had discovered no significant IAT Effect. Results were as predicted for both versions of the IAT with faster reaction times for compatible conditions than incompatible conditions. This is consistent with previous findings for gender IATs (e.g., Aidman & Carroll, 2003), suggesting stronger associations for the pairings: male+career and female+family. For the sexuality IAT, results are also consistent with previous findings (e.g., Banse et al., 2001; Steffens & Buechner, 2003) and suggest stronger associations for: straight+good and gay+bad.

In terms of ERP findings, consistent with previous research (Williams & Themanson, 2011), we discovered no effect of congruency during early-elicited ERP components including the N100 and P200. Early components are elicited in response to differing physical characteristics of the stimuli and are labeled “exogenous” components as they rely on factors of the stimuli, not on the individual’s processing of meaning (Luck, 2005). On the other hand, later components are highly sensitive to changes in the meaning of stimuli and are therefore labeled “endogenous” (Luck, 2005). During the IAT, congruency has been demonstrated to have an effect only on these later, endogenous components–including the N400 and LPP–as they are involved in processing the meaning of stimuli. Williams and Themanson (2011) discovered significant effects for congruency only in these later ERP components and these results lend support to these findings; in this study congruency was only significant in the N400 and LPP components. However, in the current study, we observed gender effects in both early and late components, despite participant and target gender being variables most previous experiments do not account for.

N100 Despite no expected difference for early, exogenous components, results show increased N100 activity for male names compared to female names on the gender IAT. The N100 is normally associated with early attentional processes, and is believed to represent the processing of physical characteristics of stimuli including colour, size, and shape (Luck, 2005). An increase in N100 activity is observed when attention is directed at the features of stimuli, and increased N100 activity has been observed when examining attentional processes associated with race and gender (Ito & Urland, 2003). To investigate automatic activation of categorization processes associated with social categories such as gender and race, Ito and Urland (2003) measured ERPs while participants were shown photographs of male or female, and Black or White individuals. For the gender category, participants were shown pictures of either male or female individuals and asked to concentrate on the gender of the person. For the race category, they were shown pictures of Black or White individuals and asked to instead concentrate on their race. ERPs were measured in order to examine working memory and attentional processes occurring during this task, and the researchers sought to determine whether gender and race are attended to early on in processing, as evidenced by early components including the N100, P200, and N2.

Results of Ito and Urland (2003) showed that early components were associated with the focusing of attention to gender and race. In their study, a larger N100 was elicited for Black individuals compared to White individuals, a larger P200 was elicited for males, and larger N2 was elicited for females. This demonstrates that in early stages of processing, attention is shifted to race and gender categories, giving individuals access to social category information that can aid in the classification of other individuals. Attention was focused on race very early on, as evidenced by a significant N100, and gender was attended to slightly later (about 60ms after race) in the P200.

The present findings support the larger notion that early components, which are associated with processing physical characteristics of stimuli, can also be observed with stimuli containing social category information, including gender. This suggests that early cognitive processes are involved in the processing of gender, which can aid in classification of individuals very early on during processing. In terms of gender stereotypes or prejudice, the early processing effects discovered may play a role in the activation of stereotypes. It remains unknown whether manipulations that can affect stereotype activation can influence these early processes associated with social categorization processes (Ito & Urland, 2003).

Significant effects for gender in both the N100 and P200 regions partially support the results of Ito and Urland (2003). However, the current study discovered a significant gender effect for the N100, whereas the previous study discovered a gender effect in the P200. This may be due to the nature of the stimuli used. In the present study, we used male and female names instead of photographs. Previous research has demonstrated that there are differences between pictures and words used as stimuli in early components including the N100 (Williams & Themanson, 2011). Thus, future research should examine the role of gender in early components in order to help clarify these unexpected findings.

P200 Results also demonstrate significant P200 effects, lending support to the idea that early attentional processes can be influenced by target gender. We discovered a main effect of character gender, with increased P200 activity for female names. Previous research has shown that the P200 is sensitive to social categories such as gender (Ito & Urland, 2003) and race (He, Johnson, Dovidio, & McCarthy, 2009). Increased P200 activity has been observed when focusing attention to threatening or negative stimuli (Kubota & Ito, 2007), or when focusing attention toward members of an out-group (He et al., 2009; Ito & Urland, 2003). As our results did not uncover a significant interaction with participant gender, we cannot explain our findings in terms of members of the out-group. If the larger P200 for female names could be explained by attention being directed toward members of an out-group, we would expect female names to elicit larger P200 only for male participants. This was not the case in our study as female names resulted in increased P200 activity for both male and female participants. Overall, these findings demonstrate that early components are associated with cognitive processes taking place during gender schema violation, even though these early components did not elicit effects of congruency in this study, or in previous research (e.g., Williams & Themanson, 2011)

One previous study has discovered increased P200 activity for males compared to females (Ito & Urland, 2003). This is opposite to our findings, which discovered a larger P200 for female names. However, the previous study used photographs instead of words for their stimuli, which have been shown to result in different ERP activity especially for early components (Williams & Themanson, 2011). A possible explanation for our findings can be found in an experiment conducted by Amodio (2010). This study examined task engagement in a race IAT and discovered that photographs of Black individuals elicited a larger P200 compared to White individuals. Amodio hypothesizes that this may be due to the fact that when processing images of Black individuals, participants are more concerned about racial stereotypes influencing their responses due to this concern, resulting in an increase of attention (as observed in the P200) toward Black individuals. The idea that participants may be concerned about responding without prejudice was also supported by Ito & Urland (2003). It is commonly believed that our thoughts and emotions are not under conscious control (Wegner, 1994), and further research proposes that low level processing of racial information is guided by automatic top-down processing effects (Amodio, Harmon-Jones, & Devine, 2003). If these ideas are applied to our results on the gender-career IAT, participants are likely more aware of gender stereotypes for females and are concerned about responding without prejudice. In this case, attention would be focused more toward female names, resulting in an increased P200 for female names compared to male names.

We also discovered an effect of participant gender during the P200. We discovered a *Participant Gender x Montage* interaction, with increased activity in the occipital region for male participants. This suggests that male participants had increased perceptual differences compared to female participants, only in the occipital region. Steffens (2005) partially supports these findings as she discovered significant differences between male and female participants; however, her study did not utilize ERP measures. In one study examining ERPs associated with early processing of race (Kubota & Ito, 2007), researchers discovered a significant interaction between Participant Gender and Race in P200 activity. In their study, both male and female participants showed increased P200 activity to pictures of Black individuals compared to White individuals, but this difference was only significant for male participants. Since it has been demonstrated that the P200 is sensitive to the processing of gender as well as race (Ito & Urland, 2003), these findings lend support to our results where male participants in our experiment demonstrated increased P200 activity during the gender-career IAT. This demonstrates that male and female participants process gender information differently, with effects only visible for males. This suggests that males have a stronger association between compatible category pairs on the IAT and are likely to have more rigid schemas compared to females.

N400 The sole significant ERP effect on our sexuality IAT was elicited in the N400 component. The sexuality IAT demonstrated a significant *Congruency x Montage* interaction in all montages except for the right parietal. This effect mainly reflects our discovery of a significant IAT Effect in reaction times on this IAT. As there are no interactions with participant or character gender, we can only speculate that the sexuality IAT used was not an adequate tool used to examine gender in this manner. This concern is further discussed in future directions.

The gender IAT demonstrated a *Congruency x Participant Gender* interaction that approached significance (*p = .054)*. As predicted, male participants elicited a larger N400 for incongruent trials. These results support previous ERP findings, which have elicited larger N400s during incongruent trails of the IAT (O'Toole & Barnes-Holmes, 2009; Williams & Themanson, 2011). Because the N400 is typically elicited in response to semantic incongruency (Kutas & Hillyard, 1980a, b), it was expected that the incompatible trials of the IAT would result in a larger N400 compared to compatible trials, as the incompatible trials violate gender schemas. Our findings suggest that the pairings male+famly and female+career (which make up the incompatible block of the gender-career IAT) lead to higher N400 activity compared to the congruent block, which includes the opposite pairings. Response time slowed and a larger N400 was elicited by the incompatible block, suggesting that there is semantic incongruency present during the processing of these trials.

In terms of results on the IAT, a greater effect of congruency is expected for male participants compared to female participants. Our hypotheses and the previous research were supported by the interaction discovered between congruency and participant gender, as this N400 effect was discovered only for male participants, supporting previous findings (Steffens, 2005). According to the previous research, males hold stronger, more traditional views of stereotypes than females and are more likely to hold negative implicit views toward gay men compared to straight men (Steffens, 2005).

LPP We discovered two significant interactions for the LPP. A significant *Congruency x Participant Gender* interaction was discovered, where male participants had larger LPP activity for congruent trials compared to incongruent trials. The *Congruency x Participant Gender x Character Gender* interaction was also significant. There was a congruency effect for male names among both male and female participants (with congruent trials resulting in a larger LPP), but no congruency effect for female names. These results support previous findings where congruent conditions of the IAT elicit a larger LPP (Hurtado et al., 2009; Ibáñez et al., 2010; Williams & Themanson, 2011), and demonstrate significant effects of gender which support Steffens' (2005) findings. Congruency effects will first be explained, followed by the gender results.

Context is known to have an effect on LPP activity (Hurtado et al., 2009), and a larger LPP is believed to be the result of a variety of stimuli features including social category membership and valence (Banaji, Lemm, & Carpenter, 2001; Hurtado et al., 2009; Ibáñez et al., 2010). Two studies utilizing the same paradigm and pairing the IAT with ERPs examined "contextual blending" on the IAT (Hurtado et al., 2009; Ibáñez et al., 2010). Contextual blending is defined as the blending of effects of several stimulus features including race and valence. In their study, participants completed an "indigenous/non-indigenous IAT" and researchers examined race and valence of stimuli, as well as which ethnic group participants belonged to. They discovered that these stimuli features (race and valence) are associated with early ERP components, but a combination effect between stimulus features is associated with later phases including the LPP. That is to say, race and valence are attended to and aid in categorization early on in processing (as seen in early components), but they also have a combined effect on performance of the IAT. This combined effect can be seen in an increased LPP for compatible trials because the target and attribute pairings fit the schema, resulting in greater congruency while sorting schemas. Gender may play a similar role to race as it is also a social category, resulting in similar effects on the IAT. This would support both our findings for early components including the N100 and P200 as well as the effects of congruency seen in the LPP.

Another explanation for the LPP findings is provided by Williams and Themanson (2011). A larger, more positive LPP has been elicited during compatible trials of the IAT, likely as a result of the emotional congruency between the category pairings. The compatible condition pairs together target and attribute categories that are emotionally compatible or congruent. Sorting stimuli into these categories is compatible with pre-existing schemas, resulting in increased emotional congruency during the compatible block that is observed with an increased LPP (Williams & Themanson, 2011). This suggests that not only is the IAT associated with semantic priming effects, as observed by our N400 findings, but it is also associated with evaluative processes of emotion and valence.

The major finding of the LPP component is that gender played a key role in two different interactions. Both participant and character gender had an effect on the IAT, which can be observed in two significant interactions for the LPP: *Congruency x Participant Gender* and *Congruency x Participant Gender x Character Gender*. These effects were only significant for male participants and for male characters, which supports our hypotheses. Males have been shown to hold different gender beliefs than females including their views of gender roles (Kite & Whitley, 1996) and on explicit measures, it has been demonstrated that male participants held more traditional views of working women (Steffens, 2005). If this is the case, the association between male+career and female+family would be stronger for male participants, and sorting stimuli into those categories would result in a larger LPP as they area congruent with our pre-existing schemas. The lack of findings for female participants also supports this previous research (Shilhan, 2011; Steffens, 2005).

Furthermore, female characters did not elicit the same effects as male characters during the IAT. Both male and female participants demonstrated larger LPP effects only for male characters in the compatible condition. This suggests that the strength of association between target and attribute categories is stronger when applied to male characters than to female characters. This would indicate that schemas apply more strongly to male targets than they do to female targets. Several previous studies have observed similar findings (Dickinson, 2011; Shilhan, 2011), but did not test for gender effects directly. In both of these previous studies on sexuality schemas, slowdown effects were observed in reading for only male characters that violated the schema. Female characters, on the other hand, did not result in a slowdown effect when they violated the schema. The results of this study can help shed light on these findings as we discovered a significant interaction between Participant Gender and Character Gender during the IAT. This suggests that the associations between target and attribute categories were stronger for male participants than for female participants, resulting in a greater N400 effect during incompatible trials of the IAT. This implies that males have stronger, more traditional views of gender role stereotypes compared to females and these findings may shed some light on the difference in how males and females process gender schemas. This is an important first step and future research may help determine what factors play a role during schema processing for females as a way of better understanding how we process and potentially eliminate the detrimental processing effects of schema-incongruent information.

4.1 Future Directions

The current study demonstrated that both participant and character gender play a role in ERP activity during the IAT, and future IAT studies should take these findings into consideration when developing their tasks. Many IAT studies include stimuli containing both male and female targets, yet few studies account for gender of the target in their results. Furthermore, few studies account for participant gender, despite research showing that males and females perform differently certain group-bias IATs (Steffens, 2005). As both of these variables are shown to have significant effects on ERP activity associated with the IAT, future research should ideally include equal numbers of male and female participants and also account for gender of the stimuli in their results.

Previous research has demonstrated that race and gender have an effect on ERP activity associated with the IAT (Amodio, 2010; Ito & Urland, 2003), which is supported by our results. Taken together, these findings demonstrate that social category information can influence ERP activity associated with cognitive processes occurring during the IAT. Previous research has also shown that culture has a moderating effect on schema processing, and that there are cross-cultural differences in the way individuals view gender and process schemas (Lane & Addis, 2005; Schein 2004; Wu & Baer, 1994). Future research should examine whether the results of this study hold true across different cultures, or if these results are more pronounced in some cultures compared to others. If culture is examined as another social category, then perhaps there would be differences in the way individuals of different cultures process gender information during the IAT.

The results of this experiment show that on a basic cognitive level, ERP activity associated with schema violation is influenced by gender. This is an important first step in beginning to understand the complex role that gender plays during schema violation, but how do these findings apply to more difficult cognitive tasks? A future step in this area of research would examine how gender impacts everyday cognitive tasks such as reading. Previous research has already demonstrated that schema violation has a detrimental effect on reading, as observed by a slowdown in reading speeds (Carreiras, 1996; Dickinson, 2011; Duffy & Keir, 2004), and several studies have noted possible gender differences in their results (Carreiras, 1996; Dickinson, 2011; Shilhan, 2011). As previously mentioned, none of these studies accounted for participant gender, and the gender differences observed between male and female characters were not expected. Future research should investigate the role of gender during reading tasks utilizing male and female characters, as well as equal numbers of male and female participants, to empirically test gender differences during schema violation.

One major concern with the methodology of the current study was the absence of any gender effects for the sexuality IAT. The current study found no significant gender differences in the ERP analysis. Our sexuality IAT was constructed from a total of six images, with only four images used to represent the male and female homosexual conditions on the IAT (see Appendix A). These stimuli were the original stimuli used by Greenwald et al. (1998) for their gay-straight IAT; however, they were not developed to necessarily distinguish between gender categories. Several of our participants commented that they were unsure of the gender of the characters in the images we used, and thus, were not able to correctly sort them into categories.

Other studies have used photographs of individuals taken by the researchers in a public location such as a mall (Banse, Seise, & Zerbes, 2001; Williams & Themanson, 2011). These stimuli using real people may be less ambiguous than the images used in our study. To our knowledge, Steffens (2005) was the only study that examined gender differences in a group-bias IAT, and she did so by constructing two separate IATs; one for gay males and one for lesbian females. It is possible that if we had constructed our sexuality IAT similar to the ones used by Steffens (2005), we may have obtained significant effects for gender on the sexuality IAT. Future research should examine the effect of gender on a sexuality IAT as it would allow us to more directly compare our findings to previous research on sexuality schemas (e.g., Dickinson, 2011; Shilhan, 2011).

4.2 Conclusions

To our knowledge, this is the first study to empirically examine the effects of gender on ERPs associated with the IAT, and we have discovered significant gender effects in early and late components in terms of both participant and character gender. This study discovered significant differences between male and female participants in the P200, N400, and LPP during the gender-career IAT. This suggests that there are perceptual differences in the way males and females process gender roles for early and late components, with male participants holding stronger, more traditional views compared to female participants. Furthermore, there are also clear gender differences in terms of character or "target" gender. During the gender-career IAT, male and female names used as stimuli resulted in significant effects for the N100, P200, and LPP. These findings support our hypothesis that schemas do not apply equally to males and females. For early components including the N100 and P200, it is believed that attention is focused on social category information early on in order to aid in categorization of stimuli (Ito & Urland, 2003), resulting in a larger N100 for male names, and attention is focused on female names in the P200 likely due to the salience of gender stereotypes concerning females (Amodio, 2010). For the LPP, our results show that later processing effects only occur for male names, not female names, suggesting the association between targets and attributes is stronger for male names. This again demonstrates that schemas apply more strongly to males than to females. Future studies using an IAT should account for gender differences in participants and stimuli or categories, as well as other social category information including culture. Future research should examine gender differences during schema violation in everyday cognitive tasks such as reading.

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Table 1

Number of Trials for the IATs Used

	Gender-Career IAT	Sexuality IAT
Block	Number of Trials	Number of Trials
Target Discrimination	10	10
Attribute Discrimination	14	14
Paired Practice Block	24	24
Paired Practice Block*	24	24
Experimental Block*	96	192

Note. *Target and Attribute labels were removed during these blocks.

	Category labels	**Example stimuli**	**Category labels**
Step 1: target discrimination	**Male**		**Female**
	●	John	○
	○	Anna	●
Step 2: attribute discrimination	**Career**		**Family**
	●	business	○
	○	relative	●
Step 3: congruent condition	**Male or Career**		**Female or Family**
	●	John	○
	○	Anna	●
	●	business	○
	○	relative	●
Step 4: target reversal	**Female**		**Male**
	○	John	●
	●	Anna	○
Step 5: incongruent condition	**Female or Career**		**Male or Family**
	○	John	●
	●	Anna	○
	●	business	○
	○	relative	●

Figure 1. *Example of a five-block gender-career Implicit Association Test (IAT). Category labels appeared on the top-left or top-right of the screen while participants sorted stimuli into the categories. Black dots indicate the correct response.*

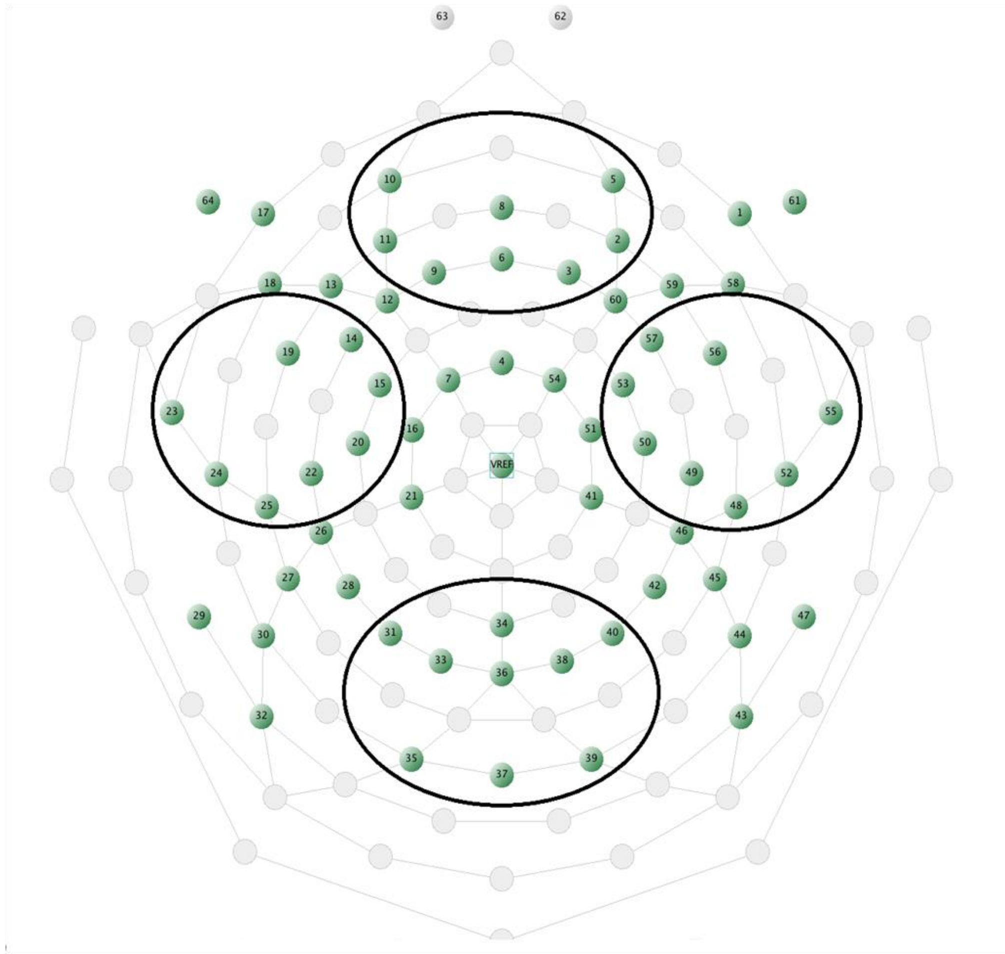

Figure 2. A diagram of the montages used in the current study. Four montages were selected: frontal, left parietal, right parietal, and occipital, each containing at least four sites.

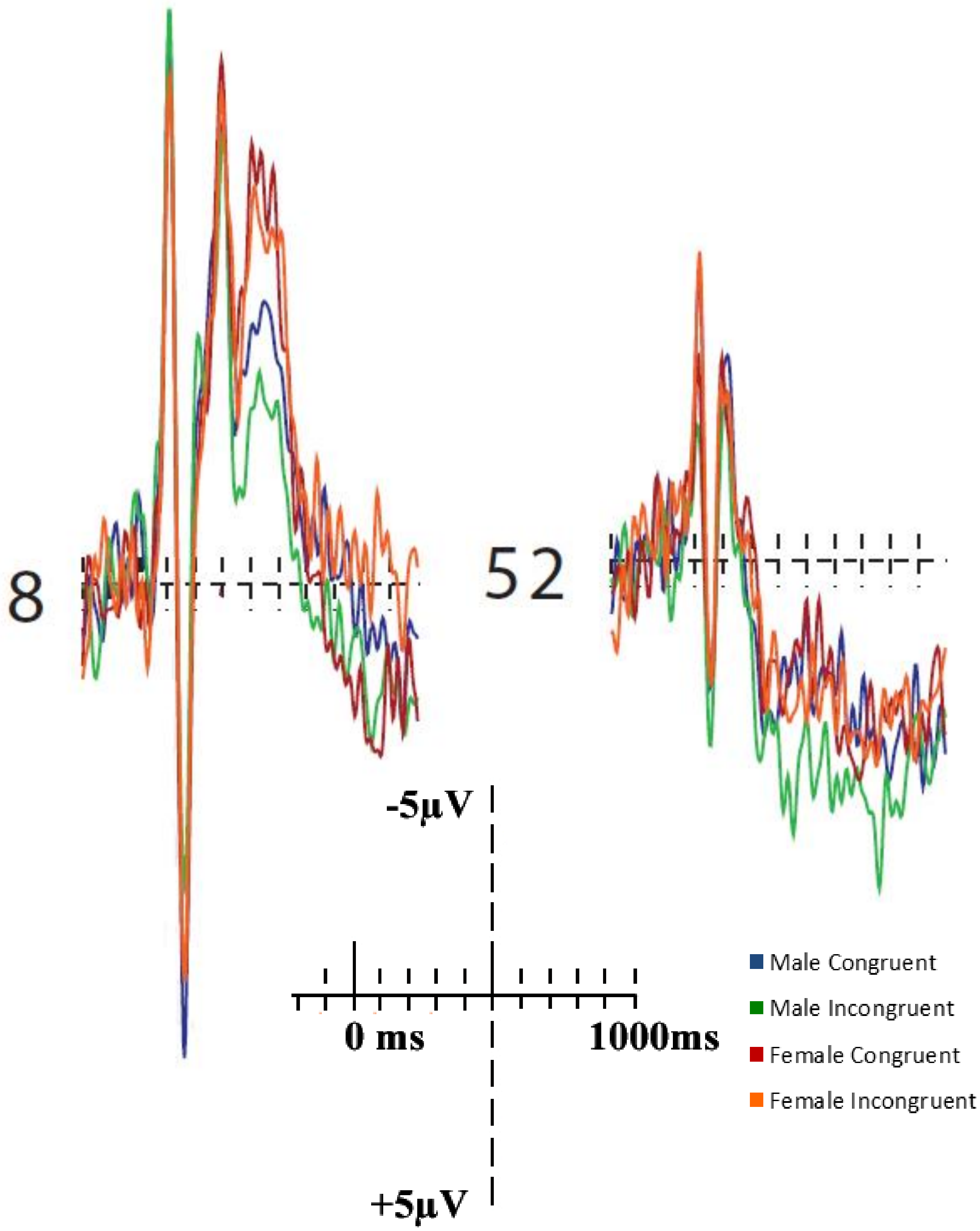

Figure 3. *Grand averaged waveforms for all participants during the sexuality IAT, comparing stimulus type (male, female images) and IAT condition (congruent, incongruent). Comparison of ERPs between Frontal (8) and Right Parietal (52) regions. This highlights the N400 Congruency x Montage interaction for the sexuality IAT.*

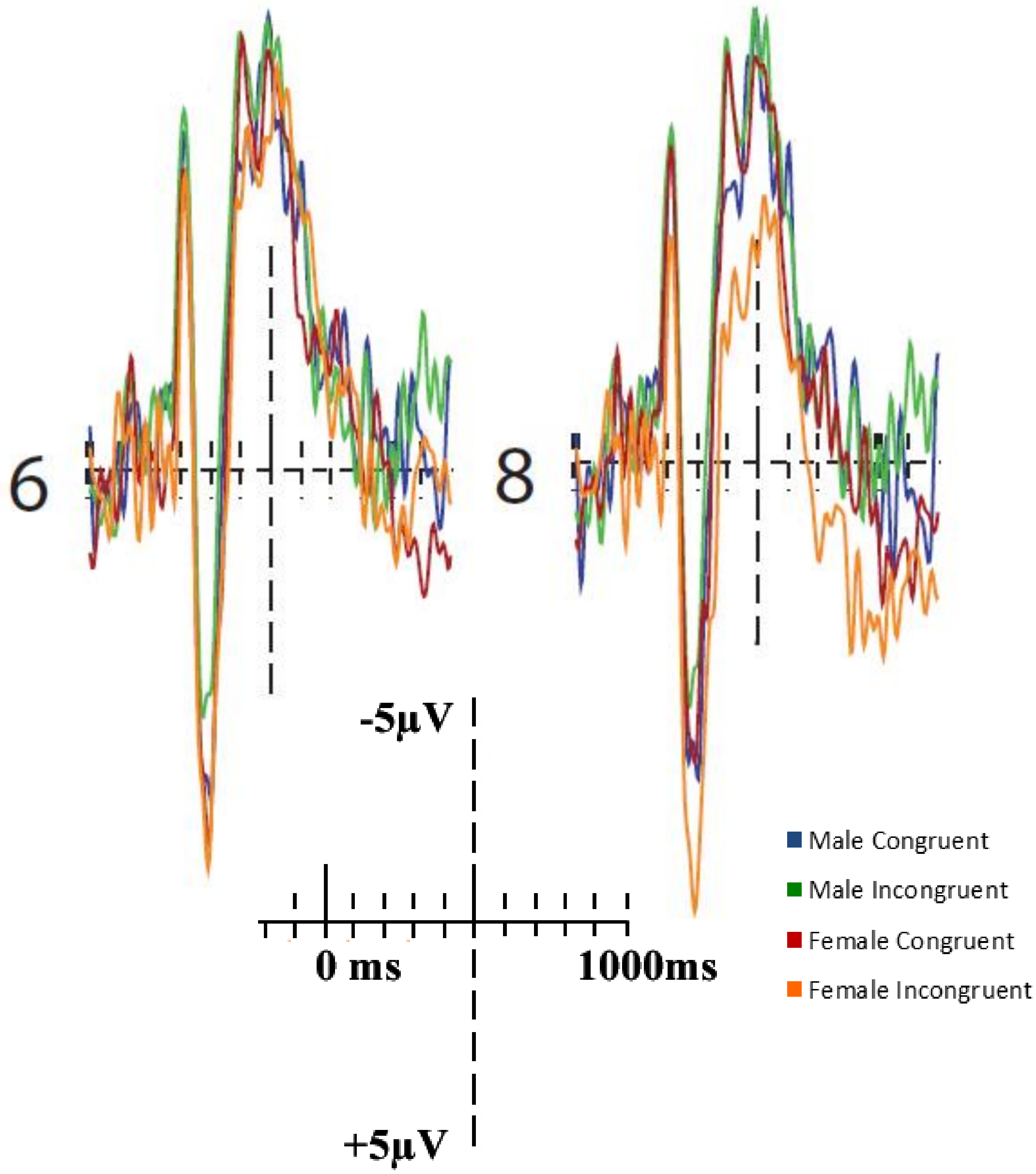

Figure 4. Grand averaged waveforms for all participants during the gender IAT, comparing stimulus type (male, female names) and IAT condition (congruent, incongruent) at two frontal electrode sites (6, 8). This highlights the N100 and P200 Character Gender main effects.

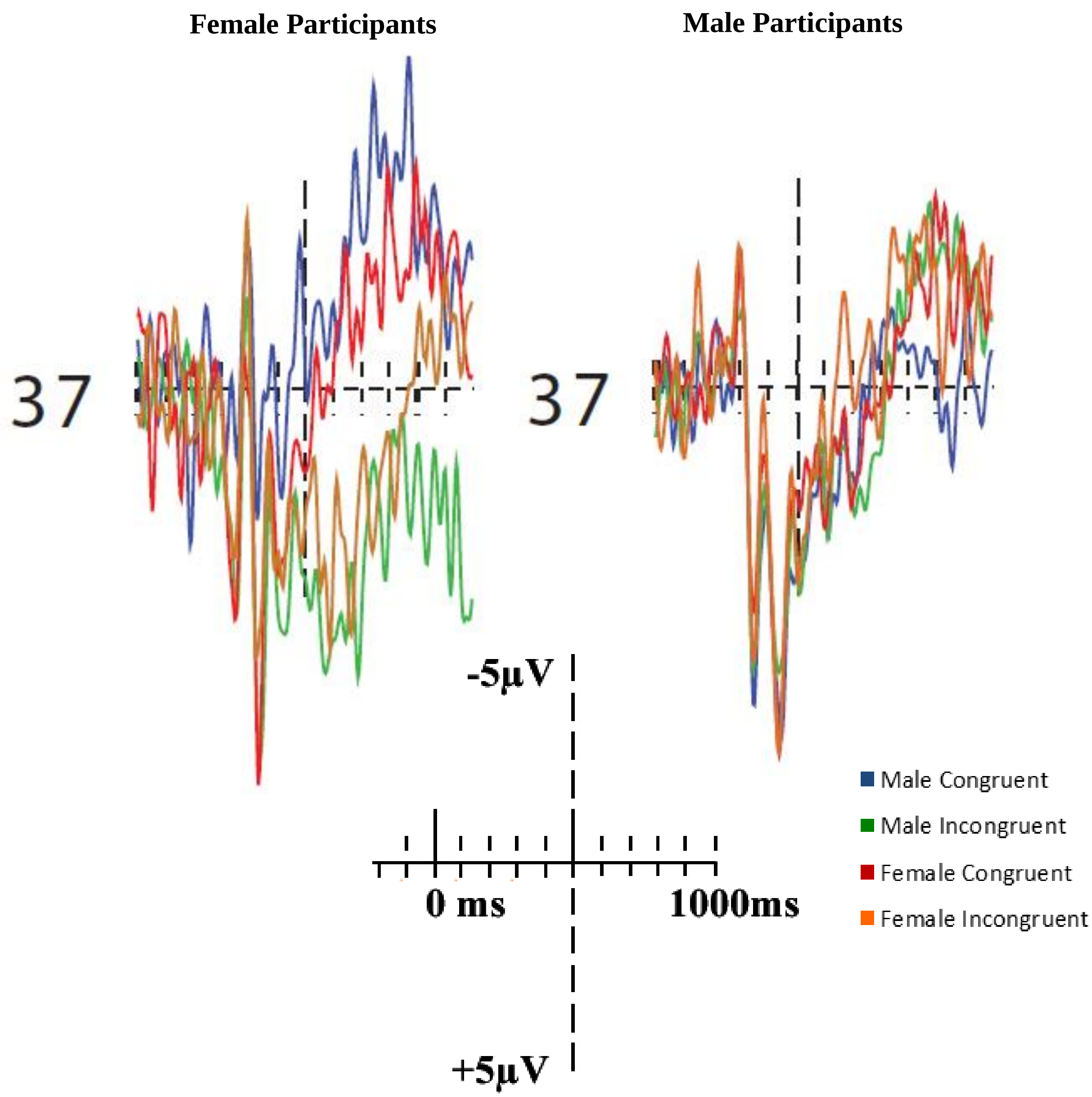

Figure 5. Separate grand averaged waveforms for female participants (left) and male participants (right) during the gender IAT. Images compare stimulus type (male, female names) and IAT condition (congruent, incongruent) at an occipital electrode site (37). This highlights the P2 Montage x Participant Gender interaction.

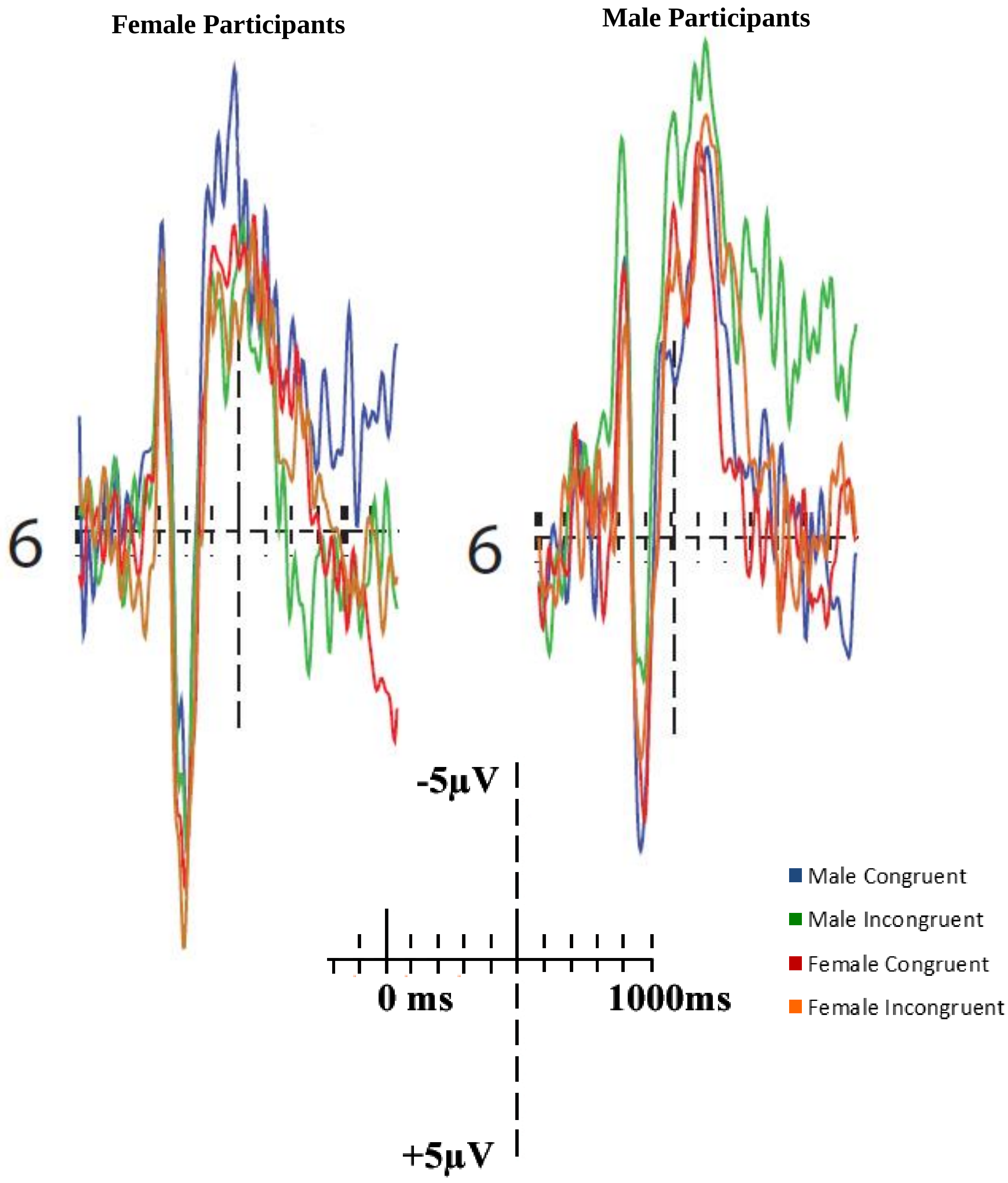

Figure 6. Separate grand averaged waveforms for female participants (left) and male participants (right) during the gender IAT. Images compare stimulus type (male, female names) and IAT condition (congruent, incongruent) at a frontal occipital electrode site (6). This highlights the N4 and LPP findings.

Appendices

Appendix A. Stimuli Used

Gender-Career IAT

Category	Stimuli Used
Male:	Ben, John, Daniel, Paul, Jeffrey
Female:	Julia, Michelle, Anna, Emily, Rebecca
Career:	Management, Professional, Corporation, Salary, Office, Business, Career
Family:	Home, Parents, Children, Family, Marriage, Wedding, Relatives

Gay-Straight IAT

Category	Stimuli Used
Good:	Joyful, Beautiful, Marvelous, Wonderful, Pleasure, Glorious, Lovely, Superb
Bad:	Agony, Terrible, Horrible, Humiliate, Nasty, Painful, Awful, Tragic
Gay:	Gay, Homosexual




Straight:	Straight, Heterosexual


Note: All categories and stimuli were developed by Greenwald et al. (1998).