The Effects of Social Exclusion on Attention to Vocal Tone As Measured by Event-Related Potentials

by

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Abstract

Previous research has shown that social exclusion leads to what Baumeister and colleagues called ‘cognitive concussion,’ a temporary cognitive state that results in suboptimal decisions and judgments. At present, however, not much is known about this interesting phenomenon. In the present work, we used a brain response that marks the detection of word meaning against its background vocal tone as a marker of one’s ability to hold expectations, as incongruity should be increasingly more difficult to detect as one’s ability to hold expected word meanings dissipates. Participants were subjected to a social exclusion manipulation followed by a vocal Stroop task during which electroencephalography (EEG) measurements were recorded. In this task, words with positive or negative meanings were spoken in both positive and negative tones, resulting in congruent and incongruent trials (e.g. ‘happy’ in a sharp, negative tone). The primary ERP component of interest is the N400, which is commonly elicited by semantic incongruity. Results indicate that participants in the social exclusion condition showed significantly less attention to vocal tone, as measured by N400 amplitude, when compared to those in the inclusion condition. This is consistent with previous research and the hypothesis that social exclusion can lead to a state of ‘emotional numbness’ or ‘cognitive concussion’ that would inhibit the ability to process vocal Stroop stimuli.

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Envision a time when you felt perfectly at ease and in the comfort of close friends. Now think about a time when you felt cheated, left out, or ignored. The drastic difference between these two situations illustrates the importance of "belonging". According to Maslow's (1932) hierarchy of needs, these feelings of love and belonging were placed only second in importance to those of survival and safety. One would imagine then that such a vital requirement for well being would have a significant amount of cognitive processing dedicated to it. The present study is one step towards understanding the complexities of these processes by examining how the brain interprets social information after experiencing social exclusion. The primary aims of the study are to examine if a social exclusion affects attention to vocal tone, to explore if gender, mood, or personality mediates this effect, and to connect the behavioral measures to a neurological measure.

Social Exclusion

The idea that people have a basic need to belong is not a new idea. In a review written by Baumeister and Leary (1995), research from as far back as 1930 was cited supporting the author's concluding remark that "human beings are fundamentally and pervasively motivated by a need to belong" (pg. 522). Their major conclusions are the following: humans have a need to continue to form social attachments; satisfaction of this need creates a feeling of well-being, while threats to social bonds create unpleasant feelings; and a deficit in belonging strongly motivates people to reform relations to satiate the need to belong. This need can be better understood by looking more in depth at the negative feelings and other reactions elicited by social exclusion in the following studies.

It is often difficult to replicate social experiences, such as social exclusion, in laboratory settings. Fortunately, Williams & Sommer (1997) showed that after a subject participated in a short and seemingly harmless ball-tossing interaction with two other participants, those participants who were not thrown the ball reported stronger negative feelings of sense of exclusion compared to those who were included. Building on this previous research, Williams and colleagues (2000) conducted a study to see if the effects of social exclusion could be shown even if the manipulation were very remote and artificial. In this study, 1,486 participants from 62 countries participated in a task modeled off of the previous research in which a participant played virtual ball tossing game over the Internet, named ‘Cyberball’, with whom he or she was told were real people. In reality, it was a simple computer program, and the icons that represented people were programmed either to include the participants or exclude them, just as the confederates did in the Williams & Sommer study (1997). Despite the innocuous and detached nature of this task, participants in the exclusion condition still reported feeling negatively, less in control, and less belonging as compared to those who were included.

Social exclusion is such a powerful phenomenon that the brain has been shown to process it via the same pathways as physical pain. In a study conducted by Eisenberger et al (2003), functional magnetic resonance imaging (fMRI) showed that during the Cyberball social exclusion task replicated from Williams and colleagues (2000), increased activation was found in the anterior cingulate cortex (ACC), which is an area involved in conflict monitoring. This pattern of activation parallels results from studies of physical pain. Out of this research has arisen the hypothesis that evolutionarily, responding to a social threat (indicated by social pain) may be as important as responding to a physical threat (indicated by physical pain). The authors conclude that social and physical pain likely developed from the same precursor pathway and that the pain from an injury to social connections is adaptive as it drives restorative measures to reform social bonds to alleviate this pain.

Event Related Potentials

There are many different functional brain-measuring techniques: fMRI, Positron Emission Tomography (PET), and Single Photon Emission Computed Tomography (SPECT). The least invasive and most readily available method, however, is electroencephalography (EEG). EEG measures the minute changes in voltage on the scalp, which provides information about patterns of brain activation. Although EEG does not give very good spatial information (such as the neuroanatomy of the activation), it does give unsurpassed temporal resolution when compared to other brain imaging techniques, including fMRI and PET. Luck (2006) summarized much of the history of research and theory behind event-related potentials (ERP). From the first historic studies by Hans Berger in 1929 to the myriad studies of the present, ERP has evolved tremendously. Citing numerous previous studies, Luck describes many of the patterns of ERP and the stimuli to which they correspond, from the earliest visual sensory responses (C1, P1, N1, etc.), to the late language related responses (N400 and P600). For this review, the focus will be on the language related responses (specifically then N400), though the diversity of stimuli and patterns that they elicit demonstrate the versatility of this brain measure as a whole.

Electrophysiological responses of the brain as measured by ERP are an effective way to quickly and precisely examine attention to vocal tone compared to response time. Research has shown that in a sentence reading task, a large late negativity approximately 400 ms poststimulus (N400) was elicited when a word was placed out of context (Kutas and Hillyard 1980). In that study, the context was simply the other words in the sentence for example 'I went shopping at the *tree*,' where tree is clearly the word out of context. A similar sentence without the out-of-context word, 'I went shopping at the mall', does not elicit a late negativity response. It is important to recognize however, that a comprehension of the words is necessary in order for the subject to notice that something is out of context. Using this language-related late negativity information, combined with research showing that people expect the vocal tone and verbal meaning to be congruent (Grice 1974), Ishii, Kobayashi, and Kitayama conducted a study to examine whether or not the modified 'vocal Stroop-interference paradigm' would elicit late negativity and what might modulate it.

The focus of this study was to examine the interactions between social orientation (interdependence compared to independence) and the attention to vocal cues (Ishii, Kobayashi, and Kitayama, 2009). Forty-three Japanese participants completed the vocal Stroop interference paradigm (Ishii, Reyes, and Kitayama, 2003) along with several surveys, the most important of which was the Implicit Social Orientation Questionnaire (ISOQ) (Kitayama & Park, 2007). Additionally, the participants were run in two conditions, the 'social' condition, which displayed schematic faces on the screen during the trials, and the 'non-social' condition, which did not have faces. Just as in previous studies, only correct responses were analyzed and this time both response times and ERP were recorded. The various differences in late negativity found in the ERP results led the authors to the conclusion that social orientation does modulate the brain response to the meaning-tone incongruity in the vocal Stroop task. Furthermore, this effect was regulated by the use of schematic faces as well gender (females had a greater late negativity than males). This study is a good example of the benefits of using ERP compared to behavioral measures, as analysis of response times did not yield any useful results. This is likely due to the fact that response time is a single number for each trial that is the result of many variables, while ERP is seemingly more 'pure' and upstream.

The Present Study

As discussed above, people have an inherent need to belong, and it is theorized to be a need secondary only to those of health and safety. In order to navigate through the complexities of the human social system, our brains have necessarily developed in such a way to efficiently process social information. Changes in the allocation of attention to social cues (namely vocal tone), can be altered by many factors, including gender, social orientation, and even simple schematic faces. There are many opportunities for research in the fields of social exclusion, social cues, and event-related potentials, but as of yet, no prominent study has been done integrating all three. Modeling primarily off of the studies by Ishii, Kobayashi, and Kitayama (2009) and by Pickett and colleagues (2004), the present study investigates the effects of social exclusion on attention to vocal tone measured via changes in the N400 component of ERP.

Our hypothesis is that an exclusion manipulation will reduce the N400 on average, and that this effect may be modulated by gender or other personality factors. This hypothesis originates from several studies that used procedures that emulate a real, on-line rejection. These studies have shown that social exclusion can induce a state of emotional insensitivity (Blackhart et al, 2009; DeWall & Baumeister, 2006) as well as overall reduced cognitive abilities (Baumeister et al., 2002). Extending this research to the topic of immediate processing, it is hypothesized that not only does social exclusion reduce self-report and behavioral measures of emotional sensitivity, but that it will also directly inhibit that initial processing when the stimuli are inherently emotional or difficult to progress, which incongruent vocal stimuli are. If this is true, the effect will be evident in different patterns of activation, primarily a reduction of the incongruity-related N400, as measured by ERP in the present study.

Method

Participants

Thirty-one American young adults (16 males and 15 females) from a Midwestern university participated in the study in individual sessions. All participants were between the ages of 18 and 21 with a mean age of 19.3. The participants were recruited from introductory psychology classes as well as from postings around the university. Compensation was in the form of money or partial course credit for psychology students. Twelve participants were excluded due to poor performance or an excess of artifacts. The data from the remaining nineteen participants (9 males and 10 females) was analyzed. Participants were required to meet the following criteria in order to participate: right-handed, normal or corrected-to-normal vision, normal hearing, Caucasian ethnicity, and no history of neurological conditions or drug use.

Procedure

Each study began with introductions and appropriate consent and health form, which was followed by a deceptive explanation of the study indicating that the purpose of the research was to examine the effects of mental visualization on the perception of audible words. Participants were briefly informed that they would be completing a mental visualization task (Cyberball) with two other participants.

Following the explanation, electroencephalogram (EEG) set-up began. EEG was recorded from 32 sites using Ag/AgCl electrodes (anterior [FP1, FP2, Fz, F3, F4, F7, F8, FC1, FC2, FC5, FC6, FP2], central [CP1, CP5, Pz, T7, T8, CPz, CP2, CP6, Cz, C3, C4], and posterior [P3, P4, P7, P8, PO3, PO4, O1, O2, Oz]) mounted in an elastic cap according to the modified

International 10-20 system. An electroencephalogram (EOG) was also recorded to monitor horizontal and vertical eye movements, which were positioned above and below both eyes as well as from positions lateral to the left and right outer canthi. EEGs and EOGs were recorded with a bandwidth of DC to 104 Hz (3 dB /octave) using a Biosemi Active Two system (Biosemi, Inc., Amsterdam, Netherlands) and a sampling rate of 512 Hz.

Off-line, The EEG was re-referenced to an average activity of the left and right mastoids and was re-sampled to 256 Hz. The EEG for each trial was corrected for vertical EOG artifacts using the method developed by Gratton, Coles, and Donchin (1983). The EEG was digitally low-pass filtered off-line at 30 Hz with a finite impulse response (FIR) filter. Averaging epochs were 1000 ms, beginning 200 ms before stimulus onset. Waveforms were averaged, such that trials with a response error or those in which the EEG exceeded ±100 μV were rejected automatically.

The social exclusion manipulation was adapted from a study that investigated the effects of ostracism over the Internet (Williams et al 2000). In this manipulation (Cyberball), participants are informed that they will be completing a mental visualization task with two other participants via the Internet. In reality, these two other participants were computer-generated confederates with names that were of the same gender as the participant, whose name also appeared on the screen. In order to increase credibility, the experimenter left the room in order to ‘check-in’ with the ‘other experimenters’ to insure that everyone was ready to begin the task. Each participant was randomly assigned to one of two groups: the exclusion condition, in which participants received only a couple of throws at the beginning and none afterward, and the inclusion condition, in which the participants received one third of the throws. After playing Cyberball for approximately four minutes, the vocal tone identification task was initiated.

Vocal tone identification task (also known as vocal Stroop task) was adapted from Kitayama and Ishii (2002). Participants listened to two blocks of the same 32 words, half of which are pleasant (e.g. calmness) and the other unpleasant (e.g. bitter). Each word was presented via two computer speakers in either a positive (e.g. smooth and round) or negative (e.g. harsh and sharp) tone. The combination of tone and meaning then resulted in four distinct types of stimuli: positive meaning-positive tone (pos-pos), positive meaning-negative tone (pos-neg), negative meaning-positive tone (neg-pos), and negative meaning-negative tone (neg-neg). In describing these stimuli, they will always be in the form meaning-tone. The participants were instructed to indicate whether the *meaning* of the word was pleasant or unpleasant, while ignoring vocal tone. The stimuli were assessed with low-pass filtered stimuli to insure that the perceived extremity of emotional vocal tone was no different as a function of word meaning. In addition to EEG recordings, reaction time and accuracy were also recorded for each participant.

After completing the vocal tone identification task, participants completed a series of several questionnaires on the computer. The first measurement was a ‘need threat’ questionnaire with several subscales (belonging, control, self-esteem, meaningful existence) used to investigate the effects of the social exclusion manipulation (Williams 2000). Additionally, a mood questionnaire adopted from Williams (2000) was modified to include a number of words aimed to examine whether or not the exclusion manipulation elicited an angry as compared to sad mood state. Interdependence compared to independence was measured using Singelis’ self-construal scale (Singelis 1994) as well as a modified version aimed to measure the perceived norm of this factor by asking the participant to respond ‘on behalf of all typical Americans with European Heritage.’ Participants then completed a demographics survey, an after-survey probing for suspicion of the true nature of the study, and were thanked for participating.

Results

Behavioral Data

Accuracy for each participant (including those excluded from additional analysis n=31) was calculated and submitted to a repeated measure ANOVA. There was a significant interaction between word meaning, tone, and gender ($F(1,15) = 6.148$ $p < 0.05$). A comparison of hit rates between males and females can be examined in Figure 1. Female participants showed the lowest hit rate for positive words spoken in a negative tone, which was significantly different from the hit rate for positive words spoken in a positive tone ($F(1,15) = 8.487$ $p < 0.05$). The same interaction was not significant for males. This indicates that females are more sensitive to vocal tone, regardless of condition. No interaction was significant when condition (inclusion as compared to exclusion) was included in the analysis.

Response times were averaged for correct responses only and were analyzed via ANOVA. There was a main effect of tone and a significant interaction between meaning and tone ($F(1,15) = 8.487$ $p < 0.05$). As shown in Figure 2, these results are puzzling. Whereas prior work showed that meaning judgment is slowed down when background vocal tone is incongruous with word meaning than when the two are congruous, (Kitayama and Ishii, 2002; Ishii et al., 2003 and 2009), the present results appear inconsistent. In order to address differences in word length, analysis was conducted using the time between stimulus offset and the response as response time (as compared to the stimulus onset). The interaction between meaning and tone was significant ($F(1) = 22.204$, $p < 0.001$) and is shown in Figure 3; there were no interactions containing gender or condition. Analysis run on males and females separately found significant meaning by tone interactions ($F(1) = 14.102$, $p < 0.01$) and ($F(1) = 8.589$, $p < 0.05$) for males and females respectively. This finding is slightly unexpected, as previous research has indicated that males are generally less sensitive to vocal tone (Schirmer et al 2002), although the social exclusion manipulation undoubtedly plays a role. In future analysis, word length and its effects will need to be further controlled.

ERP Analysis

Previous research has indicated that although N400 can be elicited in multiple locations, it is most pronounced on the Cz, Fz, and Pz sites (Kutas & Hillyard 1980) and therefore we will focus on those sites. Waveforms from each of the three sites are displayed in Figure 4 with the four types of stimuli separated. The incongruence effects that will be discussed below are noticeable in the range of 300-600 ms, and are most noticeable at the Cz site. A negative deflection for incongruent stimuli (neg-pos, pos-neg) around 400 ms will be henceforth called an incongruity-based negativity (N400). As evident in Figure 4, participants in the inclusion condition show a noticeable incongruity-based negativity, but upon inspection of the exclusion waveforms, this effect disappears. This preliminary observation indicates that incongruent stimuli elicited a noticeably larger N400 component in the inclusion condition only.

This finding was then further investigated by calculating the mean amplitudes at each site for six 150 ms epochs beginning from stimulus onset (0 ms). A series of ANOVAs were run with two categorical variables (gender [male versus female] and condition [inclusion versus exclusion]) as between-subjects variables and both word meaning (positive versus negative) and vocal tone (positive versus negative) as within-subjects variables. This analysis was run on all epochs and at the Fz, Cz, and Pz sites. Only significant results are shown in Table 1. Additionally, in order to make some interpretations easier, an ‘incongruity-based negativity index’ (the difference in amplitude between incongruous stimuli [neg-pos, pos-neg] and congruous stimuli [pos-pos, neg-neg]) was calculated for each of the three electrode sites and all time windows.

At Cz three significant effects were found. In the 300-450ms time period, the interaction between word meaning and vocal tone proved significant ($F(1,17) = 6.803$, $p < 0.05$). This effect was further qualified by a significant interaction among word meaning, vocal tone, and condition ($F(1,17) = 7.69$, $p < 0.05$). Figure 6 shows that overall, the significant mean by tone interaction is in fact indicative of the N400, as incongruent stimuli elicited significantly lower amplitudes on average. Figure 5 shows the mean amplitudes separated by condition. As one can see, the mean amplitude in the inclusion condition is much higher, but more notable is that there was a significant interaction between meaning and tone ($F(1, 8) = 11.750$, $p < 0.01$) indicating a significant incongruence effect for participants in the inclusion condition. Comparatively, the interaction between tone and meaning for exclusion participants is not significant ($F(1, 9) = .097$, ns). This is strong evidence that there is a significant difference in the incongruence effect between conditions, and that participants in the exclusion condition are hardly showing this effect, if at all. Further support of this is that a t-test between the groups using the incongruity-based negativity index found significant differences ($t(17)=3.275$ $p<0.01$).

ANOVAs were also conducted on the data from the Cz electrode in the 300-450ms window in order to examine the interaction between meaning and tone with male and female analyzed separately. As predicted, there was no overall significant interaction between tone and meaning for males, although there was a significant interaction for females ($F(1)=6.250$, $p < 0.05$) as shown in Figure 9. This was further supported using a t-test and the incongruity-based negativity index, ($t(17)=2.135$ $p < 0.05$). This particular gender difference replicates the previous research that indicates that females are more sensitive to vocal tone (Ishii et al, 2009; Ishii et al, 2003).

Also at the Cz electrode, in the 450-600 ms time period, the word meaning x vocal tone x condition interaction reached statistical significance ($F(1, 17) = 4.95$. $p < 0.05$). The mean amplitudes are separated by condition and shown in Figure 7. In this instance, the analysis of each condition separately did not give significant results; however, as the graphs display, participants in the inclusion condition showed lower amplitudes for incongruent stimuli, while participants in the exclusion condition did not. This was also analyzed using the incongruity-based late negativity indexes and gave similar results ($t(17)=2.572$, $p < 0.05$). This again supports that social exclusion reduces the incongruence effect, and therefore it presumably reduces attention to vocal tone.

At the Pz site there were two significant interactions. First is an interaction between tone, meaning and condition at the early time window of 0-150 ms ($F(1, 17) = 7.82$, $p < 0.05$) and the results are shown in Figure 8. This is quite an early response to be related to meaning, as the meaning of many of the stimuli cannot be understood by the first 150 milliseconds. This finding does show that an exclusion manipulation may affect early processing of words. It is also possible that since participants did hear the stimuli more than once, that they might have learned to identify them earlier than would be expected. The second interaction at the Pz site is between tone and meaning in the 450-600 ms time window ($F(1,17) = 4.831$, $p < 0.05$). The means are shown in Figure 9 and are puzzling. The proper incongruence effect was shown for negative words; however, the means are in the opposite direction for positive words. This odd pattern can be seen in the waveforms (Figure 4) in the 450-600 time window as a strong negative deflection in pos-pos (meaning-tone) stimuli for participants in the inclusion condition as well as a relatively strong positive deflection for pos-neg participants in the exclusion condition. Future research will determine whether this is a random occurrence or a notable effect.

A correlation analysis was used to examine if any of the personality or mood measures predicted the incongruence effect. This analysis was run on all participants, and then run on the inclusion and exclusion groups separately. All significant correlations are organized in Table 2. Of interest is the result that increased independence correlates with a decreased incongruity response, as measured by the incongruity-based negativity index at the Fz electrode during the 300-450 ms time window ($r=.476$ $p<0.05$), replicating previous work (Ishii et al, 2009). This finding is shown in Figure 4. Overall however, it is clear that correlation analysis would be more meaningful with an increased number of participants, which will be addressed in future research.

Discussion

The present study united, for the first time, ERP, attention vocal tone, and social exclusion in one continuous paradigm and resulted in relevant findings for all three topics of research. First, it is important to recognize that the present study replicated previous research that a vocal Stroop task can elicit the N400 component of ERP. Second, the behavioral data also replicated research that females show higher attention to vocal tone as compared to males (Ishii et al 2000, Schirmer *et al.,* 2002, 2006). Third, and most importantly, social exclusion has been shown to eliminate the presence of the N400, indicating an inhibition of vocal tone processing.

Cognitive Concussion and Emotional Numbing

It was interesting to find that ERP analysis indicated that participants in the exclusion showed almost no incongruity, but the theories of *emotional numbing* and *cognitive concussion* may best address this result. The theory of emotional numbing suggests that events such as social rejection or exclusion may lead to a state of numbness, both physically and emotionally. A meta-analysis done by Blackhart et al (2009) indicates that although there is undoubtedly a significant difference between the emotional states of excluded participants compared to those that are accepted, it may not be as simple as exclusion leads to negative affective states. Blackhart and colleagues argue that instead of leading directly to a negative state, rejection causes a temporary neutral state. Additional research has also indicated that participants who are rejected not only show decreased sensitivity to emotional stimuli, but also to physical pain (DeWall & Baumeister 2006). Standard methods for measuring pain levels were used to find that those participants who were excluded had a significantly higher threshold for sensing pain and tolerance for increased pain. Concerning emotional numbing, participants who were excluded were less empathetic towards the stories of people who had just suffered a relationship loss as well as those who had broken a leg. If a rejection experience leads to a temporary state of reduced overall emotional sensitivity, perhaps that is what explains the reduced incongruity effect. The stimuli used in the vocal tone identification task are inherently emotionally charged since they are spoken in distinctly positive or negative tones. Therefore, a reduction in the ability to process these emotional stimuli would appear as a decreased ability of vocal tone processing. Thus, the results from the present research contribute the theory that social exclusion leads to emotional numbing, and indicates that there may be underlying effects on processing that explain the self-reported and survey measured decrease in emotional sensitivity.

Another possible explanation for the decreased N400 in the exclusion condition is the *cognitive concussion* theory of social exclusion. This term used colloquially represents the immediate after effects of a social rejection experience as concussive, like the hazy state after a head injury. Research has shown that social exclusion can reduce intelligent thought, such as effortful logic or other complex cognitive tasks (Baumeister et al., 2002). Following this theory, it is possible to explain the lack of N400 in the exclusion condition as simply the inability to process complex stimuli, resulting in reduced processing. This would mean that the tone and meaning are not particularly important, but what is important is that incongruous stimuli are harder to process, and in this concussive state after a social exclusion manipulation, the brain has a reduced ability to process them, which appears to be the same as an inattention to vocal tone in this experiment.

Limitations

The most significant limiting factor in this research is the relatively small number of participants. A larger sample size will help clear up many of the results that appeared to be marginally significant during analysis and will solidify or negate the questionable findings presented in the present research, such as the puzzling reaction time results. This unexpected finding that response time did not relate to the findings of ERP analysis lends to the question of which measure is more accurate. Response time is a straightforward measure that generally leads to consistent results, but it necessarily crude when used to examine the quick processing of the brain. Since the manual response to a stimulus is the final outcome of many series of processes, it cannot be the purest measure of the one intended, namely attention. Furthermore, numerous external factors such as motivation to complete the task and conflicting importance of accuracy and speed can dramatically affect response time. Comparatively, ERP measures the immediate brain response to stimuli without the influence of many of those external factors. Future research will show if the results of reaction time are replicable, but their presence does not automatically disprove the results found from ERP.

Future Directions

In order to assess whether or not *emotional numbing* is a reasonable explanation for this reduced incongruity effect in exclusion condition participants, a future study could be conducted with a similar paradigm, but by simply replacing the emotional stimuli with emotionally neutral ones. If the condition effect still exists with neutral stimuli, the theory of *cognitive concussion* will be further supported, as *emotional numbness* is irrelevant if no emotional stimuli are used.

Future research on this topic could also benefit from running a control condition in which participants are neither included nor excluded. It may also be interesting to examine the effects of the many other social exclusion manipulations. Finally, further research on the differences in attention to vocal tone and its effects on social exclusion may benefit by comparing results between different cultures, specifically European American as compared to Asian American and Asian participants. The present study is just one example of how this relatively new trend of integrating social psychology with advanced brain measures will direct research towards an understanding of how the brain processes the complexities of our social world.

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Table 1 –*Results of ANOVA at Cz and Pz*

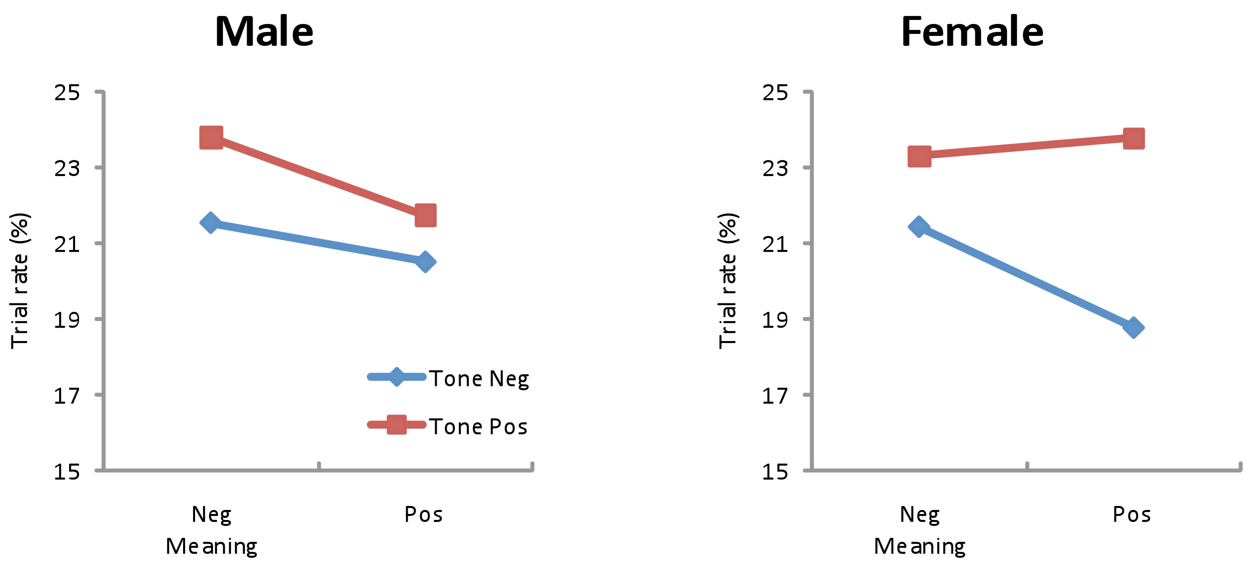
		0-150	*150-300*	*300-450*	*450-600*
Cz					
	ToneXMeaning			6.87	
	ToneXMeaningXCondition			7.69	4.95
Pz					
	ToneXMeaning				4.83
	ToneXMeaningXCondition	7.82			

Significant effects on mean amplitudes of 150-ms time windows from 0 - 900 ms (F values shown) all are $p<0.05$

Table 2 – *Incongruity-Based Negativity Index Correlation Results*

Measure	*Group*	*Site/Time*	*Correlation*	*Significance*
Independence	All	Fz 300-450 ms	0.476	$p < 0.05$
Belonging Need Threat	Exclusion	Fz 300-450 ms	-0.684	$p < 0.05$
Sadness Score	Exclusion	Fz 300-450 ms	0.673	$p < 0.05$
Perceived Norm Independence	All	Pz 300-450 ms	-0.583	$p < 0.05$
Anger	Inclusion	Cz 450-600 ms	0.664	$p < 0.05$

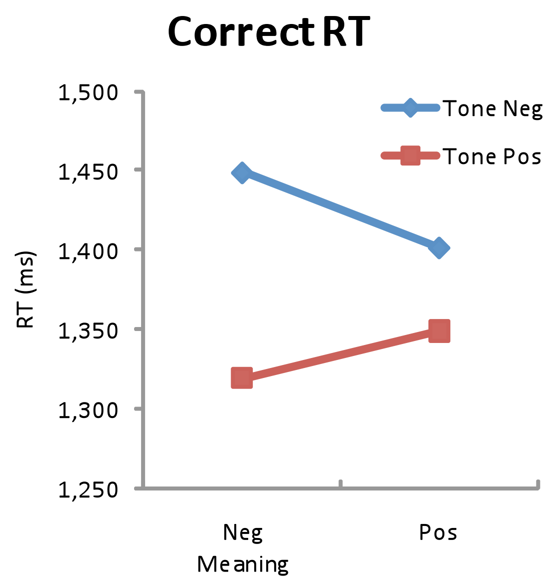
Figure 1 – *Accuracy By Gender*



Not Significant

Pos-Neg < Neg-Neg < Neg-Pos, Pos-Pos (p<0.05)

Figure 2 – *Reaction Time Means from Stimulus Onset*



Neg-Pos, Pos-Pos < Pos-Neg < Neg-Neg ($p < 0.05$)

Figure 3 – *Response time after stimulus offset*

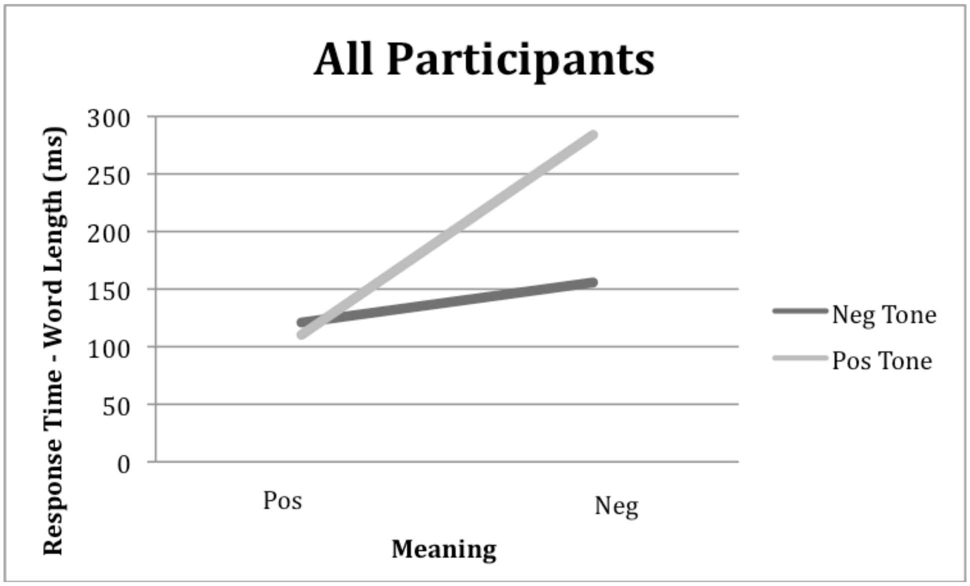


Figure 4 – *Waveforms by Condition*

Inclusion Condition **Exclusion Condition**

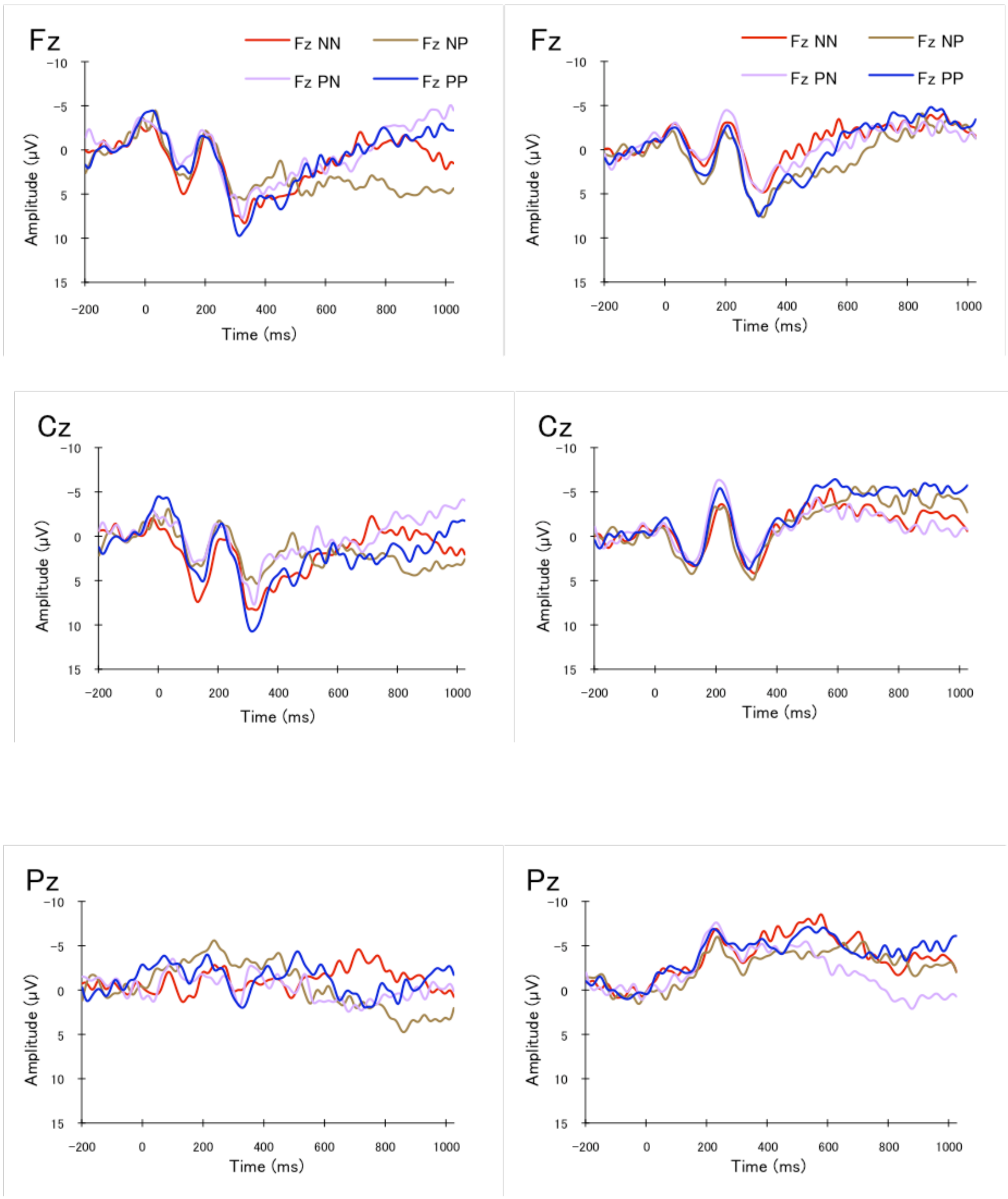


Figure 5 – *Mean amplitudes for the Cz electrode in the 300-450 ms time window by condition*

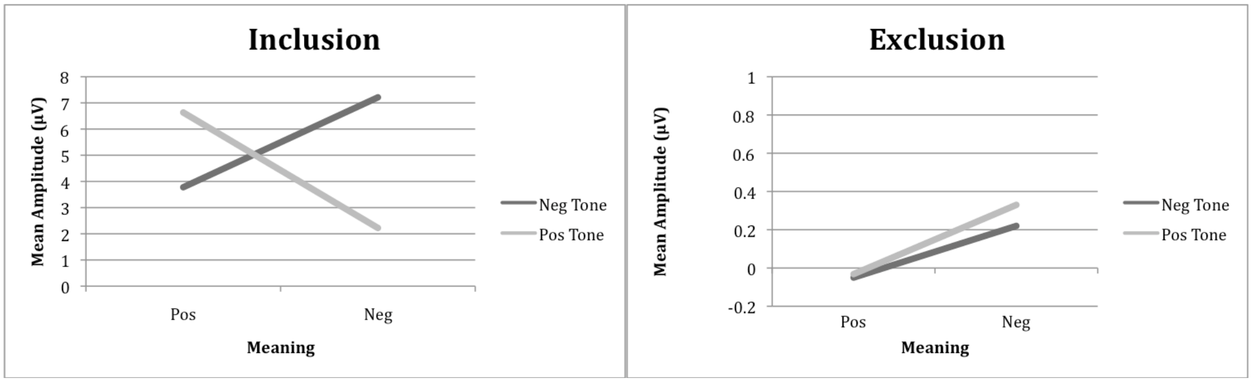


Figure 6 – *Mean amplitude in 300 – 450 ms time window at the Cz electrode*

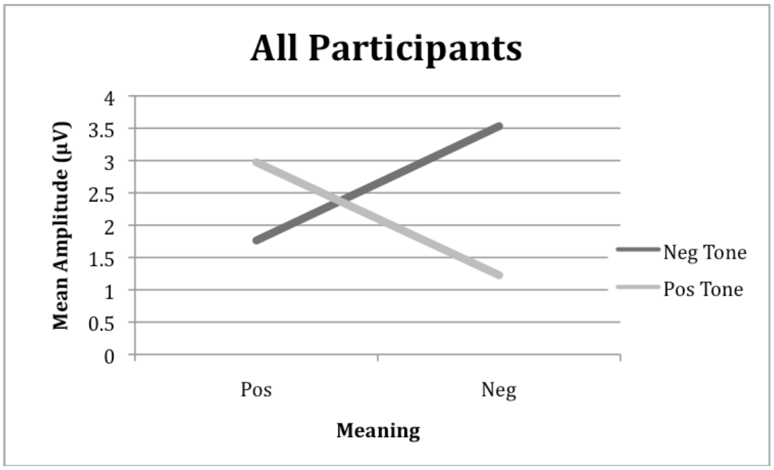


Figure 7 - *Mean amplitudes for the Cz electrode in the 450-600 ms time window by condition*

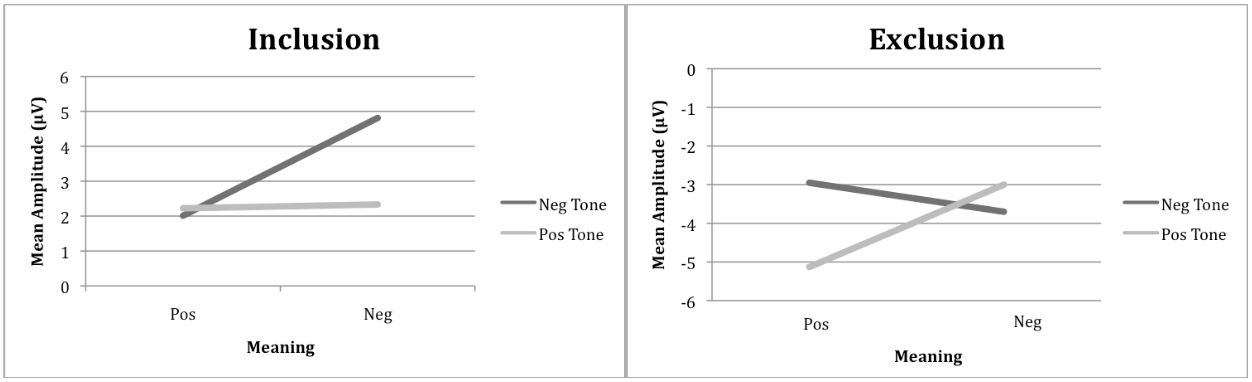


Figure 8 - *Mean amplitudes for the Pz electrode in the 0-150 ms time window by condition*

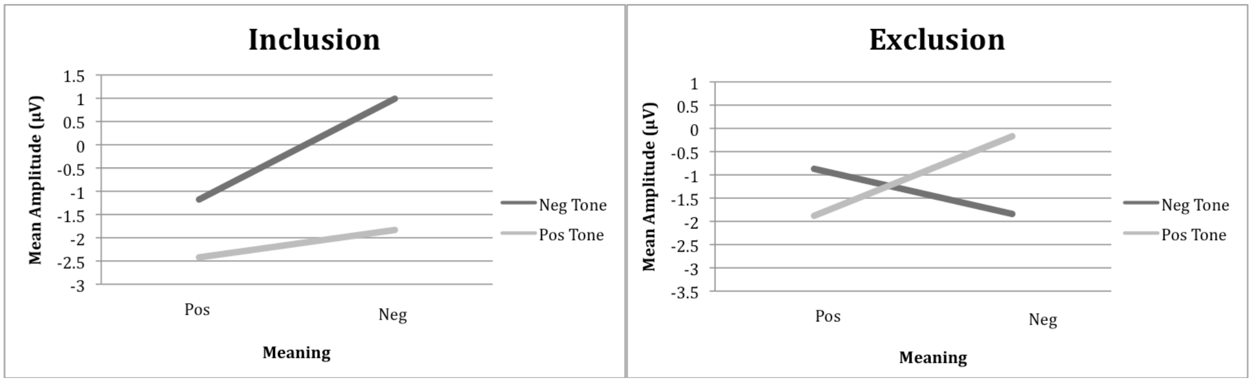


Figure 9 - *Mean amplitude in 450-600 ms window at the Pz electrode*

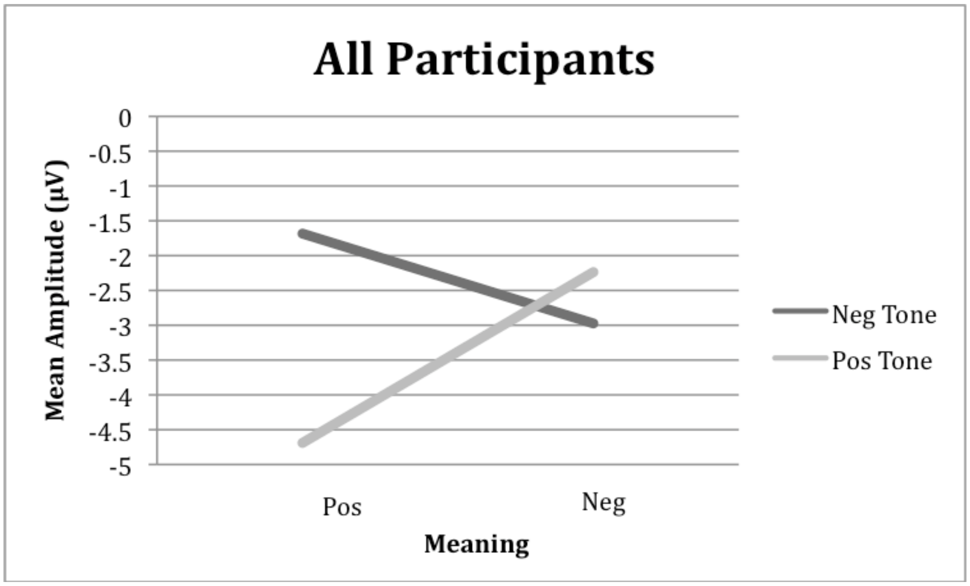


Figure 10 – *Gender differences in incongruence effect at Cz electrode in the 300-450 ms window*

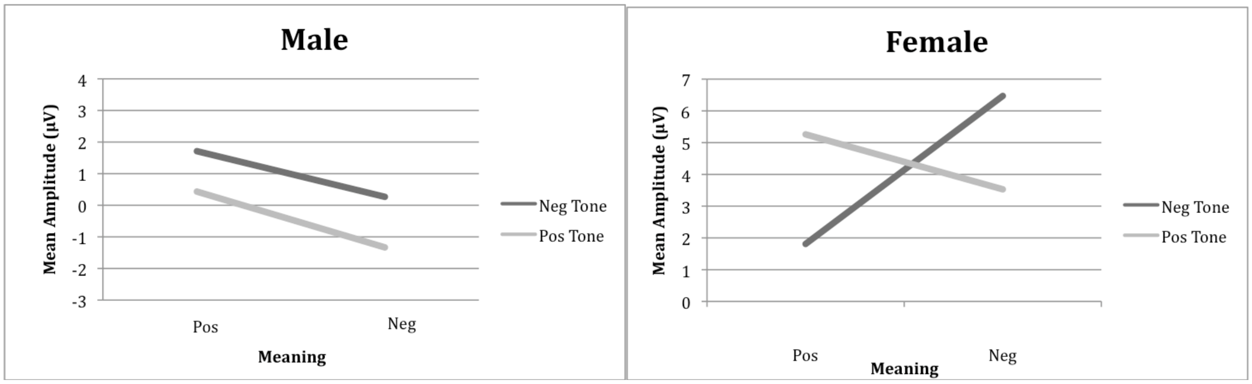


Figure 11 – *Correlation between Independence and Fz 300-450 ms Incongruity Based Negativity*