N100 and P300 components in schizophrenia patients, bipolar patients, and their first-degree relatives

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ABSTRACT

Schizophrenia patients and a subset of patients with bipolar disorder suffer from psychosis. Both disorders have been found to have shared genetic risk factors. In order to assess these claims further, endophenotypes for these disorders need to be established. Electroencephalography provides a means for measuring low level auditory processing through event related potentials. In the study a dichotic listening task was present to participants in 4 blocks of trials, varying tone pitch and attention between trials. The N100 and P300 component amplitudes were examined. Relatives of schizophrenia patients were also included in this analysis to assess the components ability to be classified as endophenotypes. It was found that schizophrenia patients, bipolar patients with psychotic features, and relatives of schizophrenia patients exhibit reduced N100 amplitudes compared to controls and bipolar patients without psychotic features. Reduced P300 amplitudes were observed for schizophrenia patients, their first-degree relatives, and bipolar patients without psychotic features. Trend-level results in regards to this component were also obtained for bipolar patients with psychotic features.
Schizophrenia and bipolar disorder are complex mental disorders that are characterized by severe, global cognitive deficits (see Javitt, 2009; Lesh et al., 2011 for comprehensive review). Shortcomings in current treatment options for people suffering from these disorders has pushed researchers to look at biological underpinnings in order to develop newer treatment options (Deacon, 2013; Weickert, Weickert, Pillia, & Buckley 2013). One approach to this issue has been to develop biomarkers that can be used for developing new diagnostic criteria. Biomarkers, biological markers used to identify a disease state, are advantageous for making a diagnosis, due to physiological parameters having a high reliability and validity compared to self-report of symptomology. As Stanovich (2013) states that reliability and validity are essential for good operational definitions. Using biomarkers for diagnosis therefore may change how many mental disorders are operationalized. Looking for these same biomarkers in the first-degree biological relatives of patients affected with mental disorders also allows researchers to whether a biomarker is an endophenotype, a visible trait of an underlying genetic component of the illness (Gottesman & Gould, 2003).

Historically, schizophrenia and bipolar disorder have been classified as being two distinct and separate disorders. Reaching a diagnosis for patients suffering from either disorder has proven to be difficult however due to the overlap in symptomology; the degree to which this overlap exists is still being explored (Bora, Yucel, & Patellis, 2009; Dickerson, Boronow, Origoni, Cole, & Yolken, 2004; Vohringer et al., 2013). Genetic research now shows that patients suffering from either of these disorders may share genetic risk factors (Lichenstein et al., 2009). This has led researchers to question whether the disorders should be considered separate phenomena or variations of the same underlying dysfunction (Johannesen, O’Donnell, Shekar, McGrew, & Hetrick, 2013). Clinicians classify patients with bipolar disorder as either displaying psychotic symptoms or not displaying psychotic symptoms. Patients with schizophrenia, on the other hand, experience reoccurring bouts of psychosis that can persist for extended periods of time. This suggests that bipolar patients are an ideal clinical comparison group for schizophrenia patients since researchers are able to assess whether the cognitive deficits they observe can be attributed to the entirety of the disorders themselves, or the shared component of psychosis.

Psychologists have classically used clinical interviews and neuropsychological testing to assess the cognitive functioning of their clients. There are many benefits to this approach, but some question
N100 and P300 components in schizophrenia patients, bipolar patients, and their first-degree relatives. How objective patients are in their responses (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). This has led to a push within the psychology to assess neural processing directly, since it should provide an unbiased measure of functioning (Deacon, 2013; Weickert et al., 2013). One way researchers have been able to observe abnormalities in neural processing is by using electroencephalography (EEG), a widely used technique that measures the electrical potentials generated from neural activity (Teplan, 2003). Simple resting-state EEG recordings have shown schizophrenia and bipolar patients display reductions in alpha power-band activity and increases in theta band activity, neural signals that oscillate between 8.125Hz - 13Hz and 3.125Hz - 8Hz respectively (Clementz, Sponheim, Iacono & Beiser, 1994). Studying the electric signals created from low level sensory processing following a simple auditory stimulus has proven to be particularly useful for researchers, however (Luck, 2014). This is because these signals, known as event related potentials, are robust and have been shown to be a reliable measure of basic, early stage neural processing. While EEG is not yet spatially precise enough to reliably localize the sources of these signals within the brain, it does provide better temporal resolution than other available neuro-imaging techniques (Helmholtz, 1853; Michel, Murray, Lantz, Gonzalez, Spinelli, & Peralta, 2004). Furthermore, advanced MRI techniques and single-unit electrode recordings provide more accurate spatial data that can be used alongside EEG (Bai & Wise, 2001; Gullmar et al., 2006).

The current study focuses on two of these event related potentials, the N100 and P300 component. The N100 component is a sharp, negative deflection occurring roughly 100 ms after the presentation of an auditory stimulus. (Luck, 2014) Collaborative research has shown the N100 wave to be generated from the superior temporal gyrus, the part of the brain containing the primary auditory cortex. (Zouridakis, Simos, & Papanicolaou, 1998) It is believed that the N100 component represents the initial reception of auditory stimulus to the auditory cortex. The processes underlying this component are pre-attentive and can display sensory-gating characteristics during repeated stimulus presentation. Previous research has shown the amplitude of this wave to be abnormally decreased for patients with schizophrenia (Domjan, Csifcsak, Drotos, Janka, & Szendi, 2012; Ethridge et al., 2015; Force, Venables, & Sponheim, 2009; Turetsky et al., 2009). This trend has also been observed in the first-degree relatives of these patients, suggesting that these abnormalities may be contributed to genetic factors. (Force et al., 2009) Other studies however have had difficulty replicating these deficiencies in first-degree relatives. (Turetsky et al., 2009) Studies examining the N100 component in bipolar patients are harder to come by. Lijffijt et al. (2009) published a study showing decreased sensory gating for the N100 component with bipolar I patients with psychotic features during a repeated click
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Meanwhile, other studies by Ethridge et al. (2015) and Johannesen et al. (2013) observed decreases in N100 amplitude in bipolar patients that matched that of schizophrenia patients. Other researchers have failed to find the same phenomenon in regards to bipolar patients (Force et al., 2009; Domjan et al., 2012).

The P300 amplitude is a late positive deflection that occurs roughly 300-600ms following the presentation of an unexpected stimulus (Luck, 2014). This component has yet to be localized to any given area of the brain, leading researchers to believe that it reflections several simultaneous cortical processes related to context updating and working memory (Luck, 2014; Polich, 2007 & 2012). Oddball paradigms, tasks that participants to respond to a non-frequent ‘target’ tone, are commonly used to generate this potential. Decreases in amplitude and increases in latency for this component have been very well replicated over time in patients with schizophrenia (Domjan et al., 2012; Jeon & Polich, 2003; Luck, 2014; Polich, 2007 & 2012; Simons, Sambeth, Krabbendam, Pfeifer, Os, & Riedel, 2011; Thaker, 2008 ). Similarly, first-degree relatives display the same deficits in generation of this component.(Bramon et al., 2005) Studies involving patients with bipolar disorder have yielded similar results (Ethridge et al., 2015; Thaker et al., 2008). There have been findings that contradict these findings however, warranting further research on the subject (Domjan et al., 2012; Johannesen et al., 2013).

The evoked potentials that are examined in this study were elicited using a dichotic listening task. This sort of paradigm has previously been used to distinguish schizophrenia and bipolar patients from healthy controls, with a demonstrated test-retest validity (Bozikas et al., 2014; Green, Hugdahl, & Mitchell, 1994; Simons et al., 2011). This dichotic listening task in particular used infrequent target tones to assess participant’s performance. Previous research has noted that attention and tone pitch have modulated both participant’s performance and the nature of evoked potentials on this task. (Force et al., 2009) Taking this into consideration, the task design incorporates multiple blocks of trials, with tone pitch and attentional demands being changed between blocks.

In regards to this study, the results we expect to see will fall into three domains: performance on the task, N100 generation, and P300 generation. It is expected that schizophrenia patients perform significantly worse on this task than healthy controls on this task. Considering the evidence supporting a genetic basis to the disease, it is also expected that the first-degree relatives of schizophrenia patients will perform worse than controls but not as poorly as schizophrenia patients. Bipolar patients with psychotic features should perform roughly as poorly as schizophrenia patients due to their shared factor.
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of psychosis, while bipolar patients without psychotic features will perform worse than controls but better than patients affected by psychosis. The N100 and P300 amplitudes for schizophrenia patients are expected to be smaller than those of healthy controls and their first-degree relatives. Their first-degree relatives will still display amplitudes significantly smaller than those of controls not as reduced as schizophrenia patients. Similar to performance, it is expected that bipolar patients with psychotic features will have reductions in the components similar to that of schizophrenia patients, while bipolar patients without psychotic features will display amplitudes closer to those of the relative group.

METHODS

Participants

Participants were recruited from the Minneapolis VA Medical Center and can be broken into 5 different groups. Probands, participants affected by the disorders being studied, consisted of 62 schizophrenia patients, 25 bipolar II patients with psychotic features, and 21 bipolar II patients without psychotic features. Fifty first-degree relatives of schizophrenia patients were also included in data analysis, as well as seventy-five demographically similar controls, without a familial history of mental illness. All participants were between the ages of 18 and 60 years old. Potential schizophrenia or bipolar patients were excluded if they reported a language besides English as their primary language, an IQ of under 70 or a diagnosis of mental retardation, a history of substance dependency, current alcohol or drug abuse or dependence, current or past central nervous system disease, a history of head injury resulting in a skull fracture or loss of consciousness (LOC) of more than 5 minutes, presence of a physical problem that would create significant problems with the administration, collection, or interpretation of study measures, a DISCUS score of greater than 5, being adopted or having no immediate family available for interview, or a history of electro-convulsive therapy. Each consenting proband provided a comprehensive list of first and second-degree relatives; a reliable family member was asked to verify the accuracy of this list. First-degree relatives living with a 250 mile radius of the Minneapolis VA Medical Center were invited to take part in the study. Relatives were only excluded if they presented medical problems that would impede the administration, collection, and analysis of study measures. See Table 1 for sample characteristics.

A sample of nonpsychiatric controls was recruited to contrast the patient and relative groups. Controls were excluded using the same criteria as for proband exclusion. In addition to this, controls were excluded if they reported a personal history of a psychotic or affective disorder, a biological first-
N100 and P300 components in schizophrenia patients, bipolar patients, and their first-degree relatives. A first-degree relative with a past or present psychotic disorder, an affective disorder requiring hospitalization or medication, or drug dependency. Before inclusion into the study, controls were administered relevant portions of the Structured Clinical Interview for DSM - IV (SCID-I) and the Family interview for Genetic Studies (FIGS).

Probands were assigned diagnoses by a trained clinical psychology doctoral student, doctoral-level psychologist, or psychiatrist following the administration of the Diagnostic interview for Genetic Studies. A trained research assistant conducted a medical chart review and interview in order to obtain supplementary information that was used to reach a diagnosis. Symptomology of probands was assessed through the administration of the Scale for the Assessment of Negative Symptoms (SANS) and the Scale for the Assessment of Positive Symptoms (SAPS). Psychiatric functioning was assessed using the Brief Psychiatric Rating Scale. Premorbid functioning and age of disease onset was assessed with the Premorbid Assessment Scale (PAS). A consensus on overall functioning was reached by at least two clinical psychologists or psychiatrists using the Global Assessment Scale (GAS).

Relatives of probands were assessed for DSM-IV Axis I and Axis II disorders by a trained clinical psychology graduate student or doctoral-level psychologist or psychiatrist using the Structured Clinical Interview for DSM-IV (SCID) and the Structured Clinical Interview for DSM-IV Personality Disorders (SCID-II). The clinician administered Structured Interview for Schizotypy to assess schizotypy in relatives. The Schizotypal Personality Questionnaire (SPQ), Physical Anhedonia Scale, Social Anhedonia Scale, Magical Ideation Scale, and Perceptual Aberration Scale were also administered to further assess proneness to psychosis and signs of schizotypy. Nonpsychiatric controls completed the same interviews as the relatives of probands did. Cognitive functioning amongst participants was assessed with a one-hour battery of cognitive tests. The Wide Range Achievement Test III and Vocabulary and Block Design subtests of the Wechsler Adult Intelligence Scale III provided a profile of intellectual ability.

**Dichotic Listening Task**

A dichotic listening task was employed to assess participants for abnormalities in auditory processing. The task was presented in four blocks, with each block consisting of 200 trials. During trials, two different sets of auditory stimuli were presented simultaneously between ears for 100ms, with an inter-stimulus period that was randomly selected to range between 1070ms and 1480ms. The two sets of auditory stimuli each consisted of two beeps and differed from each other in terms of pitch both within and between groups. The lower pitched set consisted of tones at 747 Hz and 983 Hz, while the
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A higher pitched set had tones at 1121 Hz and 1475 Hz. For both sets, the higher of the two tones was considered the ‘target’ tone and occurred at a tenth as often as the lower ‘non target’ tones. When a trial occurred, the participant was instructed to attend to only one ear at a time. Only target tones that played in this ear would signify the need for a response. Responses were recorded by the participant by pressing a button box. The attended ear was switched after each block with the order of attention as follows: block 1 – left, block 2 – right, block 3 – right, block 4 – left. During the first two blocks the left ear received the lower set of tones; this was reversed for the third and fourth blocks. The tones were pseudo-randomized so that target tones occurred 10% of the time in the attended ear and 10% of the time in the non-target ear. The remaining 80% of tones consisted of the two non-target tones. This task design allowed for the separate assessment of pitch and attention of electrophysiological response.

Electrophysiological data collection and processing

EEGs were recorded using Ag/AgCl electrodes that were attached to an elastic cap and to a Biosemi Active-Two System. Electrode locations were placed over scalp locations in ordinance with the 10-20 system. Either 128 or 64 channel configurations were used, with all files being standardized to 81 channels using BESA. The recording files were downsampled from 1024 Hz to 256 Hz. A high pass filter was applied at 0.5 Hz and a low pass filter at 256 Hz. Trials were epoched, or broken up into time segments, from 300 ms pre-stimulus to 900 ms post-stimulus. Non-neural artifacts were rejected by visual inspection and independent component analysis within Seung Suk Kang’s ICA preprocessing pipeline. Individual subject’s average waveforms were computed for each condition within Matlab. N100 was defined as the peak negative amplitude occurring between 80 ms and 175 ms post-stimulus at electrode position FCZ. P300 was defined as the mean amplitude occurring between 290 ms and 625 ms post-stimulus at electrode position PZ. Grand average waves for each group were then generated by averaging the ERP components of all the participants within their group.

Statistical Analyses

Differences in ERPs were examined with a series of multivariate analyses of covariance (MANCOVA) for patient groups and their relatives. These analyses included one between-subject factor (Group: schizophrenia patient, first-degree relative of schizophrenia patient, bipolar I patient with psychotic features, Bipolar I patient without psychotic features, or non-psychiatric control) and two within subject factors (Attention: attended, unattended; Frequency: rare, frequent). Behavioral
N100 and P300 components in schizophrenia patients, bipolar patients, and their first-degree relatives. Performance on the task was also assessed with another MANCOVA that looked at 2 within-subject factors (Ear attended: left, right; Pitchgroup: high pitchgroup, low pitchgroup). All statistics were performed using IBM’s SPSS.

RESULTS

N100 amplitude

Following analysis, a significant main effect of group (F(4, 222)=3.69, p<0.01) was found, showing that schizophrenia patients (M = -2.73, SD = 0.18), bipolar patients with psychotic features (M = -2.67, SD = 0.27) and relative of schizophrenia patients (M = -2.89, SD = 0.17) exhibited significantly small N100 peak amplitudes compared to controls (M = -3.47, SD = 0.17). A main effect of attention by group (F(4, 222) = 2.13, p<0.08) reached trend levels with controls, relatives of patients with schizophrenia, and bipolar patient without psychotic features showing modulation of performance as a function of attention, displaying larger N100 amplitudes for attended tones compared to those unattended. A robust main effect of pitch by group (F(4,222) = 3.44, p<0.001) was found for schizophrenia patients, who displayed larger N100 amplitudes for rare tones (M = -2.85, SD = 0.18) compared to target tones (M = -2.61, SD = 0.18). A trend level main effect of attention by group was found for relatives of patients with schizophrenia, displaying larger N100 amplitudes for attended rare tones versus attended frequent tones. The opposite trend was seen for unattended tones, with unattended rare tones eliciting a smaller N100 amplitude than unattended frequent tones. A significant interaction effect of group by pitch by attention (F(4, 222)=2.76, p<0.05) was found across all four tones, with schizophrenia patients, bipolar patients with psychotic features, and schizophrenia patient’s relatives have significantly lower N100 amplitudes for each individual subtype of tone compared to controls. See Table 2 for detailed statistics.

P300 amplitude

A significant main effect of group (F(4,222) = 4.99, p = 0.001) was found for P300 mean amplitudes, with schizophrenia patients (M = 0.56, SD = 0.06), bipolar patients without psychotic features (M = 0.46, SD = 0.08) and relatives of schizophrenia patients (M = 0.66, SD = 0.05) all exhibiting lower P300 mean amplitudes than controls (M = 0.82, SD = 0.04). It should be noted that effect sizes for P300 amplitudes between controls and bipolar patients with psychotic features (M = 0.67, SD = 0.08) (d
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= 0.4) and controls and relatives of patients with schizophrenia (d = 0.4) were the same, suggesting that a larger sample size of bipolar patients with psychotic features would have produced results similar to the other proband groups. An interaction effect of group by pitch by attention \[\text{F}(4,222) = 1.65, p < 0.05\] was found for schizophrenia patients (M = 1.47, SD = 0.14), bipolar patients without psychotic features (M = 1.32, SD = 0.24), and relatives of patients with schizophrenia (M = 1.62, SD = 0.13), producing lower P300 mean amplitudes for target tones compared to controls (M = 2.03, SD = 0.10).

An interaction effect of group by pitch by attention \[\text{F}(4,222) = 2.45, p < 0.05\] was found with all groups showing larger P300 mean amplitudes for rare tones compared to frequent tones \((p < 0.001)\). Another interaction effect of group by pitch \(\text{F}(4,222) = 2.20, p < 0.05\) was found, with all groups exhibiting larger P300 mean amplitudes for attended tones compared to unattended tones \((p < 0.001)\).

Behavioral Performance

Participant’s ability to correctly respond to rare tones in the attended ear was calculated. It was found that schizophrenia patients performed significantly worse on the task than controls or relatives of schizophrenia patients. The reaction time was defined as how many milliseconds it took for participants to respond after the presentation of a target stimulus. Schizophrenia and all bipolar patients were found to have significantly longer reaction times compared to controls. Relatives of schizophrenia patients did not differ in regard to reaction time compared to controls. Is should be noted, however, that schizophrenia patients and bipolar patients with psychotic features also had significantly longer reaction times compared to the relatives of schizophrenia patients. Correlations between behavioral performance and event related potentials is summarized in the Figure 3.

DISCUSSION

A reduction N100 amplitude for schizophrenia patients, their first-degree relatives, and bipolar patients with psychotic features is consistent with the hypothesized results from this experiment. The similarities in these reductions between the clinical groups with psychosis were consistent with findings from Ethridge et al. (2015). This suggests that genetic risk factors shared by patients with psychosis and their first-degree relatives may be responsible for the deficiencies in sensory processing that underlies
the N100 component. The lack of N100 suppression for bipolar patients without psychotic features warrants future research with more non-psychotic clinical populations to strengthen these findings. Modulation of the N100 amplitude by both pitch and attention by the relatives of schizophrenia patients was unexpected since the control group did not exhibit these same characteristics. This suggests that the relatives of schizophrenia patients may be utilizing compensatory mechanisms to overcome their genetically inherited deficits. Again, further research may be necessary to explore this phenomenon further.

All of the clinical groups and the relatives of schizophrenia patients showed decreased P300 amplitudes. It is believed that the P300 component reflects higher level cognition compared to earlier components. (Polich, 2007, 2012) This may result in this component being more susceptible to general cognitive dysfunction rather than only psychosis, explaining the inclusion of the bipolar patients without psychotic features. The lack of truly significant findings for bipolar patients with psychotic features in regards to P300 amplitude reductions is slightly concerning, since it contradicts the expected findings. As previously stated though, the sample size for this bipolar patients with psychotic features was the smallest of all the groups, and the effect size suggests that a larger sample size could reach significance.

Taking this into consideration, neither of the analyzed components were able to distinguish between the schizophrenia patients and bipolar patients with psychotic features. This provides good empirical evidence that psychosis may be the underlying factor responsible for auditory processing deficits seen in both of these groups. Furthermore, reductions in amplitude seen in the relatives of schizophrenia patients provides evidence that these deficits are genetically related. The reduction in P300 for bipolar patients without psychotic features suggests that this component may be sensitive to cognitive dysfunction in general. While these findings don’t provide concrete answers as to whether schizophrenia and bipolar disorder might be variations of the same underlying dysfunction, it does provide thought provoking evidence that warrants further research on the subject.
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REFERENCES


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Supplementary Tables

### Sample Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>SCZ N = 62</th>
<th>BP-PSY N = 21</th>
<th>BP-NP N = 25</th>
<th>SCZ-REL N = 50</th>
<th>CON N = 75</th>
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</thead>
<tbody>
<tr>
<td>Age (years)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Mean(SD) = 40.8 (10.9)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Mean(SD) = 49 (8.7)</td>
<td>Mean(SD) = 43.1 (12.7)</td>
<td>Mean(SD) = 43.7 (10.7)</td>
<td>Mean(SD) = 45.8 (10)</td>
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<td>Years of Education</td>
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<td>14.2 (1.9)</td>
<td>14.3 (1.9)</td>
<td>14.6 (2.3)</td>
<td>14.9 (2.5)</td>
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<td>13</td>
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<td>8</td>
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</table>

<sup>a</sup> SCZ are significantly younger than CON and BP-PSY, F(4, 228) = 3, p=0.01
<sup>b</sup> SCZ and BP-NP have significantly more men, X<sup>2</sup> (4, 233) = 21.1, p<0.00
<sup>c</sup> Age and gender included as covariates and factors in subsequent analyses

### N1 Group by Pitch by Attention, pairwise comparisons by pitch

<table>
<thead>
<tr>
<th>SCZ</th>
<th>BP-PSY</th>
<th>BP-NP</th>
<th>SCZ-REL</th>
<th>CON</th>
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<tr>
<td>Attended</td>
<td>Unattended</td>
<td>Rare</td>
<td>Frequent</td>
<td>Rare</td>
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<tr>
<td>SCZ</td>
<td>M = -2.88, SD = 0.2</td>
<td>M = -2.63, SD = 0.2</td>
<td>M = -2.81, SD = 0.19</td>
<td>M = -2.59, SD = 0.19</td>
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<td>BP-PSY</td>
<td>M = -2.60, SD = 0.29</td>
<td>M = -2.66, SD = 0.29</td>
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<td>M = -2.63, SD = 0.29</td>
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<td>BP-NP</td>
<td>M = -3.41, SD = 0.35</td>
<td>M = -3.15, SD = 0.35</td>
<td>M = -2.82, SD = 0.34</td>
<td>M = -3.10, SD = 0.35</td>
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<td>SCZ-REL</td>
<td>M = -3.10, SD = 0.19</td>
<td>M = -2.93, SD = 0.19</td>
<td>M = -2.64, SD = 0.18</td>
<td>M = -2.89, SD = 0.18</td>
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<tr>
<td>CON</td>
<td>M = -3.54, SD = 0.15</td>
<td>M = -3.52, SD = 0.15</td>
<td>M = -3.33, SD = 0.14</td>
<td>M = -3.48, SD = 0.15</td>
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### Behavioral Performance Correlates

<table>
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<th>Group</th>
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<tr>
<td>SCZ-REL</td>
<td>N100 amplitude was negatively correlated with accuracy</td>
</tr>
<tr>
<td>BP-PSY</td>
<td>N100 amplitude was positively correlated with accuracy</td>
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<td></td>
<td>P300 amplitude was negatively correlated with reaction time</td>
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<tr>
<td>BP-NP</td>
<td>P300 amplitude was negatively correlated with reaction time</td>
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Appendix

I’ve been very grateful for the time that I’ve spent working as a research assistant in Dr. Scott Sponheim’s research laboratory at the Minneapolis VA. The laboratory utilizes a wide range of research techniques including neuroimaging, clinical interviews, and genotyping to search for robust biomarkers of mental illness. I believe that biomarkers are key for developing a better diagnostic criteria based on the physiological etiology of severe mental disorders, so this experience has provided me with a great opportunity to see how this type of research is conducted.

When I initially started working in the lab I mainly was transferring our old participant information collected from previous studies onto an online database. This sort of work was tedious but allowed me to see the importance in recording good data that could be read and understood years later. I also began using R and MySQL to organize the database and manipulate data, which has helped me become a more efficient researcher.

Once I gained more experience I began preprocessing EEG files using a processing pipeline created by one of the co-investigators in our lab, Seung Suk Kang. As I became more familiar with the intricacies of the process I’ve been able to grasp how independent component analysis works and why it is helpful for separating brain signal from noise in EEG signals. Processing in this style has been very helpful in teaching me the fine line a research has to walk between overprocessing data and cleaning it up enough to be useful. I have also recently had the opportunity to administer EEGs to participants coming into the lab. I really enjoy the patient interaction and this sort of work is something I’m interested in exploring more in the future.

The most recent area of work that I’ve started in the lab has been running a small wetlab that we use to genotype our participants. I have a strong concentration in biology and chemistry coursework from my time here at the U, so it has been nice to find ways to apply these technical skills to psychological research. I am also the only person in our lab with this skill set, meaning that I’ve had a great deal of authority when it comes to making decisions in this area of our research. This has added a
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great deal of responsibility to my lab duties which I really enjoy as it makes me feel like I have my own little niche in the lab. It was also challenged me several times in regards to having to do quite a bit of research to find what course of action we should take in regard to some of our research techniques.

Overall I’m very happy with the time that I’ve spent in Dr. Sponheim’s lab. When this semester is finished I will be accepting a fulltime position in the lab and I am excited for the new opportunities this will bring me.

Revision Note

Most of the peer review that I received from Ally and my other classmates was directed towards formatting, evidence supporting my claims, spelling errors, and how I presented my statistics. I reformatted my paper to match up better with APA style. This included alphabetizing my citations, changing my headings, and moving my tables. I ended up rewording some of my introduction to better assert my claims and background research. I added a few more sources to support these changes. I corrected spelling errors and also changed some of my wording in my statistics.

The way I edited my introduction builds a stronger argument as to why this research was necessary and includes more, relevant background literature. My rewording also makes the paper flow more smoothly for the reader. The major limitation in this paper is that I was unable to include the revised statistics using a truncated data set. While I had to SPSS output file generated, there were a few issues I ran into that I need to talk with my P.I. about. Unfortunately he is currently unavailable, so I stuck with the old stats instead. The truncated dataset only excluded about one member from each group, so the new statistics aren’t expected to be significantly different.