Peer Observation and Error Monitoring in First-Year Students: An Examination of Associations with Internalizing Symptoms

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Abstract

Because of the unique factors impacting the first year of college, specifically the potential for increased comparison to and evaluation by peers and risk of anxiety and depression, making a mistake can be very distressing. Using electroencephalogram (EEG) and focusing on an event-related potential (ERP) known as the error-related negativity (ERN), we examined how perceived observation, symptoms of anxiety, and symptoms of depression affected neural and behavioral error responses in first-year college students. Participants were more accurate in the observation than control condition. There was a significant difference in the ERN between error and correct responses in both conditions, but there was not a significant difference in error response in the observation compared to the control condition. Symptoms of anxiety and depression were not significantly related to error responses. Despite the nonsignificant results, this study is an important first step in understanding how multiple factors may affect error responses so that we can intervene to improve adjustment for first-year college students.

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For many students, the first year of college is an exciting new chapter in their lives because they get the chance to experience a new sense of independence and freedom. However, along with this excitement, the first year of college can also be stressful because of the transition it entails (Brandy et al., 2015). Leaving for college is the first time many young adults are away from home, forcing them to become acclimated to a new environment where they are no longer surrounded by the people they grew up with. Because almost every student is in the same position of social adjustment, social interactions during this first year often carry even more weight than they do in other developmental time frames (Friedlander et al., 2007), leading many students to feel as if they are stuck under a sort of magnifying glass. They may be judged differently, and often more harshly, by their parents, their professors, and especially their peers, pushing many to feel like they need to achieve perfection and avoid mistakes in order to fit in and feel confident (Speirs Neumeister, 2004).

Making a mistake in this new college environment can be very distressing, whether it is minor or more serious, and the stress accompanying these mistakes can take a toll on the individual and how they interact with the world around them. Concern over making a mistake is often exacerbated in social contexts, such as being observed by peers (Voegler et al., 2018). Similarly, this worry over making mistakes is also related to symptoms of anxiety and depression. The presence of internalizing symptoms, especially symptoms of anxiety, has been found to increase error preoccupation (Voegler et al., 2018). Further, there is evidence that increased concern over making mistakes can predict the later development of social anxiety

(Buzzell et al., 2017). The relationship between internalizing symptoms and error preoccupation is an important one to understand because of its implications for mental health.

With all the changes that happen at once during the transition to college, students generally experience more stress than they do during the periods before and after, which can lead to the development of internalizing disorders (Auerbach et al., 2018). College students also experience a unique set of stressors, with some of the most prevalent being the need to make friends, the pressure to succeed, and their self-esteem (Beiter et al., 2015). Previous research on the relationship between stress and depression has found various factors that contribute to the association between the two. The transition to college is a time where the relationship between stress and depression is particularly prominent, and is often a time where individuals begin to show symptoms of depression (Beiter et al., 2015). Lack of control, entrapment, and humiliation also play an influential role in the link between stress and depression, particularly in the experience of a first depressive episode (Pizzagalli, 2014).

The effects of the relationship between stress and depression can become even more prominent in social situations because they affect the way people process social information. Individuals with depression are more likely to have a negative view of other people's thoughts and feelings, and this bias is present both in interactions they are involved in and in interactions that only involve other people (Johnson & DiLorenzo, 1998). People have a tendency to make judgments in a way that is consistent with their own thoughts and beliefs, which leads individuals with depression to have a negative bias toward the world (Johnson & DiLorenzo, 1998). In this way, depression can paint social interactions in a more negative light. However, this relationship could work the other way as well, with individuals who view social interactions more negatively finding themselves at higher risk for the development of depression.

Research on the relationship between stress and anxiety has shown a similar connection, especially related to the relationship between stress and social anxiety. In a sample of college students, social anxiety was found to be significantly associated with increases in perceived stress (Cohen et al., 1983). Students who had a harder time integrating into their college community felt more perceived stress (Cohen et al., 1983), demonstrating how anxiety and perceived stress can work together to make college adjustment more difficult. Negative affect and rumination can also play a role in this relationship between stress and anxiety. One study found that both negative affect and stress predicted social anxiety symptoms, and when rumination was added as a factor, rumination and stress significantly predicted social anxiety symptoms (Valena & Szentagotái-Tatar, 2013). These different factors that influence the relationship between stress and anxiety can have effects on both mental health and social interactions.

Self-monitoring of performance, or the process of assessing, evaluating, and recording performance (Reid & Harris, 1993), is another area where mental health plays an impactful role, especially related to individual achievement. Previous research has found that self-monitoring of performance has a positive effect on academic performance (Reid & Harris, 1993), and college students especially rely on self-monitoring in their academic achievements because they no longer have the direct guidance of their parents. Students with high metacognitive skills, which include the ability to self-regulate performance, have been found to perform better in academic settings than those with low metacognitive skills (de Carvalho Filho, 2009). Similarly, students who feel good about themselves tend to have more effective strategies for dealing with the various pressures of college (Buote et al., 2007). Self-monitoring is important for regulation in students (de Carvalho Filho, 2009), helping them reach the achievement they crave especially at prestigious universities. However, excessive focus on this achievement, and the avoidance of making mistakes that accompanies a desire for perfection, can also lead to many negative mental health outcomes. Despite the desire to perform well, many first-year students experience varying degrees of new academic stressors (Perry et al., 2001). Even though students who were highly preoccupied with their past failure have been found to outperform those with low failure preoccupation (Perry et al., 2001), excessive rumination on these failures has been found to lead to disorders like depression and anxiety (Constantin et al., 2017). Self-monitoring of performance plays a large role in success in college because how effectively students do so helps determine effects on their mental health.

Many first-year college students may experience fear of failure or making mistakes, and they often need to do so with the added stress of believing they are almost constantly being observed. Because of the nature of living in residence halls and being surrounded by their peers, first-year college students may live in an environment with less privacy than they are used to, leading to the stress of perceived observation and evaluation. Observation has been found to lead to various changes in behavior and brain activity due to attempts to avoid making mistakes and the distress that follows (Buzzell et al., 2017). One objective neural measure of this sensitivity to making mistakes is the error-related negativity (ERN), which is an event-related potential (ERP) derived from electroencephalogram (EEG) that is enhanced, or more negative, when an individual makes a mistake compared to a correct response (Kujawa & Burkhouse, 2017). There have been several theories proposed about the source and function of the ERN, and in this case, one of the most relevant theories is that the ERN arises when there is a difference between the representation of an action and the actual action, leading to a withdrawal of dopamine in the brain (Weinberg et al., 2015). The ERN is a stable response occurring 0-100 ms after the commission of an error (Weinberg et al., 2015), and it can be reliably elicited through tasks like the Flanker Task, Stroop Task, and Go/No-Go Task that are designed to test an individual's ability to inhibit prepotent responses or distracting information (Meyer et al., 2013). The ERN's stability as a neural response makes it a reliable measure of the saliency of errors, and also makes it an important factor for understanding error preoccupation and the resulting behavior adaption (Weinberg et al., 2015).

Even though it is a stable response, the magnitude of the ERN appears to be sensitive to a variety of individual differences, as well as environmental and contextual factors. Depression has generally been associated with a blunted ERN (Kujawa & Burkhouse, 2017; Weinberg et al., 2015), but others have found no effect of depression on the ERN (Voegler et al., 2018). These findings contrast with those of social anxiety, which has mainly been associated with an enhanced ERN (Voegler et al., 2018; Weinberg et al., 2015). Like anxiety, social observation has also been associated with an enhanced ERN (Buzzell et al., 2017; Voegler et al., 2018). Studies by Barker et al. (2015) and Smith et al. (2019) found that the ERN increased during observation for individuals with social anxiety, and the degree of this increase was dependent on the severity of the symptoms. Within these studies, observation has been manipulated in different ways. Barker et al. (2015) and Voegler et al. (2018) used in-person observation, where participants completed a task while a confederate was in the room taking notes on their performance. However, Buzzell et al. (2017) and Smith et al. (2019) also found significant results using perceived observation where the participant was led to believe they were being observed through a webcam. Little research has considered how different factors work together to impact the variability of the ERN, and these methods have yet to be extended to consider how internalizing symptoms in the first year of college relate to students' error-related brain activity under peer observation.

Studying how these different factors affect error response in first-year college students specifically will help elucidate the effects of the stress of adjusting and transitioning into the first year of college. Understanding how error-related brain activity in college students is uniquely affected by multiple factors is important because the first year of college combines these circumstances in a more impactful way than almost any other environment. For many individuals, anxiety and depression develop during the first year of college, or if symptoms are already present, they may be exacerbated by the various stressors of the experience (Auerbach et al., 2018). Furthermore, social interactions almost always carry more weight during this first year because it is a new environment without the safety and comfort of already established relationships (Robbins et al., 1993). For this reason, students are much more focused on forming new relationships and establishing some form of social support than during other times of their lives. Because of these different elements, these first-year students ultimately make up a population that is vulnerable for the development of internalizing disorders in a very unique way.

To address the gap in the literature related to error-related brain activity, the goal of this project was to study error response in first-year college students, using changes in the magnitude of the ERN to determine whether symptoms of anxiety and depression influence the effect of social observation on error monitoring. Participants completed a Flanker task, once alone and once under perceived peer observation, to elicit the ERN as a measure of error response and examine effects of observation on the ERN. In addition, participants completed self-report measures of current anxiety and depression symptoms. We hypothesized that, consistent with previous findings, perceived observation would lead to an enhanced ERN and the magnitude of this effect would be positively related to anxiety symptoms (Buzzell et al., 2017; Voegler et al., 2018; Weinberg et al., 2015), whereas the ERN magnitude would be negatively associated with symptoms of depression (Kujawa & Burkhouse, 2017; Weinberg et al., 2015).

Method

Participants

For this study, 44 participants were recruited. The sample included first-year students at Vanderbilt University who started their first semester of college within six months of the date of the lab session. Participants were mainly recruited through an online SONA advertisement for the study, but some participants were also recruited in person through psychology classes at Vanderbilt University. The sample was made up of both domestic and international students, specifically students from Asian countries, including 42 domestic students and 2 international students. Of the 44 total participants, 3 were excluded for not completing the Flanker task due to time constraints, and 8 were excluded for not having enough errors to reliably calculate the ERN.

The final sample included 33 participants with an average age of 18.35 years ($SD = 0.49$). There were 23 female participants, and 10 male participants. In terms of ethnicity, 12.1% of participants identified as Hispanic or Latinx ($n = 4$). In terms of race, 57.6% of participants identified as White/Caucasian ($n = 19$), 18.2% identified as Asian ($n = 6$), 12.1% identified as Black/African American ($n = 4$), 9.1% identified as more than one race ($n = 3$), and 3.0% identified as another race ($n = 1$).

Procedure

When participants arrived at the lab, they were informed of the goals, methods, and risks of the study, and consented to participating in the experiment. Before completing the computer tasks and EEG assessment, participants completed a set of questionnaires that included the IDAS while the experimenters prepared the EEG. Once the EEG was prepared and the questionnaires were complete, participants began the computer tasks that included the Flanker Task.

In the perceived observation condition of the Flanker Task, participants first watched a video of a peer completing the Flanker Task, and they were told it was a live stream of another participant completing the task. To increase the believability of the deception, they were then asked to provide feedback on the other student's performance. Before the participant completed the task themselves, the experimenter placed their phone in a tripod and told the participant they were being recorded for a live stream that the other student would be watching. In the control condition, participants completed the Flanker task with no added elements. The perceived observation and control conditions were completed in a counterbalanced order, and EEG and behavioral data were collected for each condition. Once all four EEG tasks were completed, participants were debriefed about the deception used in the study. They were informed that they were not being observed by a peer, and that the "live stream" video was pre-recorded. Participants finished each session by answering few questions about the believability of the observation and the stress the task caused.

Measures

Depression and Anxiety

Symptoms of depression and anxiety were assessed using the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007). The IDAS is a self-report questionnaire that assesses specific symptoms of depression and anxiety individuals have experienced in the past two weeks, and it has been established as a valid and reliable measure of these symptoms (Kahn et al., 2019; Stasik-O'Brien et al., 2019; Watson et al., 2007). The questionnaire includes twelve subscales, and we specifically looked at the subscales related to general depression and social anxiety. The questionnaire includes a total of 64 statements, and participants rated how true each statement was to their recent experiences from a scale of 1 (*Not at all*) to 5 (*Extremely*).

Flanker Task

To elicit the ERN, participants completed an arrow version of the Flanker task (Eriksen & Eriksen, 1974) as part of a set of four, counterbalanced computer tasks while EEG data were recorded. On each trial, participants were presented with five horizontally aligned arrowheads as shown in Figure 1. The arrows were presented for 150 ms and were followed by a fixation cross presented in between every trial. The task contained congruent trials, where all the arrows faced the same direction, and incongruent trials, where the center arrow faced the opposite direction as the surrounding arrows. Participants were asked to indicate the direction of the middle arrow by pressing the corresponding mouse button: they were asked to press the right mouse button when the arrow faced the right, and to press the left mouse button when the arrow faced the left. The task began with two slow practice trials, after which the participant completed 180 trials. Participants received performance-based feedback throughout the task, where they received the message “Please try to be more accurate” if their performance was 75% correct or lower and the message “Please try to respond faster” if their performance was 90% correct or higher. This feedback was provided to make sure there were enough error trials to calculate the ERN. Participants needed to make at least six errors for the ERN to be calculated, so those with fewer than six errors were excluded from data analysis. If performance was in between these parameters, participants received the message “You’re doing a great job.” Participants completed the task twice, once while under perceived observation by a peer and once without this perceived observation. The order of these two conditions was counterbalanced.

EEG Data Processing

EEG data were recorded using a 32-channel BrainProducts actiCHamp system (Munich, Germany). To measure eye movement and blinks from electrooculogram, electrodes were placed on either side of each eye as well as above and below the right eye. A reference electrode for these auxiliary electrodes was also placed on the back of the neck. Impedances were lowered to levels below 30 kΩ. Online data collection was referenced to Cz and re-referenced offline to TP9 and TP10. Recordings were digitalized with a 1000 Hz sampling rate. EEG data were processed with BrainVision Analyzer (Brain Products, Munich, Germany). Data were band-pass filtered with cutoffs of 0.1 and 30 Hz. Data were segmented -200ms before and 600ms after response to incongruent or congruent cue. Data were ocular corrected using Gratton's algorithm (Gratton et al., 1983). Artifact rejection was conducted using semiautomatic procedures: voltage step >50 μV/ms between sample points, maximum voltage difference of 175 μV within trials, a minimally allowed amplitude of−200 μV and maximally allowed amplitude of 200 μV, and lowest allowed activity of 0.5 μV within 100 ms intervals. Data were then visually inspected to remove any remaining artifacts. Before scoring the data, the ERP data were further segmented, averaged, and baseline corrected to the -200 to 0 ms time window separately for correct and error responses. Using a time window of 50-150 ms, the ERN and any changes that occurred across the perceived observation and the control conditions were analyzed at Fz, which is shown in Figure 2.

Data Analysis

To analyze the behavioral data, we conducted correlations between the accuracy and reaction times for the observation and control conditions. We also used a paired t-test to determine if there was a difference in accuracy and reaction times across these two conditions. For the primary neural analysis, we used a repeated measures ANOVA with two levels, response (correct vs error) and condition (observed vs alone), to analyze changes in the magnitude of the

ERN. This ANOVA was used to test whether participants had a greater response to making an error when being observed. In the secondary analysis, we ran a bivariate correlation between the residual score of the ERN (partialing out error trials in the control condition from error trials in the observation condition) and the two IDAS symptom subscales we were interested in (general depression and social anxiety). Independent samples t-tests were also conducted to determine if there was a difference in error response in either condition between participants that did and did not reach the clinical cutoffs for social anxiety and depression. A final independent samples t-test was used to measure if there was a difference in error response based on the ERN residual score for participants with and without clinical social anxiety or depression.

Results

Table 1 presents correlations between behavioral, neural, and IDAS symptom data. Behavioral (reaction time and accuracy) data were collected throughout the Flanker task. Due to data collection error, behavioral data for two participants were lost. The average reaction time in the observed condition was 318.29 ms ($SD = 37.94$ ms), and the average reaction time in the control condition was 323.55 ms ($SD = 44.66$ ms). The average accuracy in the observed condition was 89.4% ($SD = 5.1\%$), and the average accuracy in the control condition was 86.0% ($SD = 10.0\%$). The reaction times in the observed and control conditions were significantly correlated, $r(28) = 0.78$, $p < 0.001$, and participants' accuracy in the observed and control conditions was also significantly correlated, $r(28) = 0.56$, $p < 0.001$. A paired samples t-test did not reveal a significant difference in reaction time between the two conditions, $t(29) = 1.12$, $p = 0.137$, $d = 0.20$ (one-tailed), but accuracy was significantly higher in the observation condition in comparison to the control condition, $t(29) = -2.01$, $p = 0.027$, $d = -0.37$ (one-tailed).

To test the hypothesis that there would be a difference in neural response to errors when participants were under perceived observation in comparison to a control condition, a 2 (response: correct vs error) x 2 (condition: observed vs control) repeated-measures ANOVA was conducted. Following our hypothesis, the test revealed a significant main effect of response type on the magnitude of the ERN, $F(1,32) = 30.32$, $p < 0.001$, $\eta p^2 = 0.49$. However, contrary to our hypothesis, there was not a significant main effect of condition, $F(1,32) = 0.19$, $p = 0.664$, $\eta p^2 = 0.01$, and the response x condition interaction was also not significant, $F(1,32)= 0.19$, $p = 0.667$, $\eta p^2 = 0.01$. Post-hoc tests revealed that error response was significantly more negative compared to correct response in both the observation (error: $M = -3.89$, $SD = 6.12$; correct: $M = 2.07$, $SD = 9.25$; $F(1,32) = 25.76$, $p < 0.001$, $\eta p^2 = 0.45$) and control conditions (error: $M = -3.72$, $SD = 6.16$; correct: $M = 2.56$, $SD = 9.49$; $F(1,32) = 27.97$, $p < 0.001$, $\eta p^2 = 0.47$). Figure 2 shows ERP waveforms and scalp distributions for error activity in the observed and control conditions.

To isolate response to errors while under observation compared to being alone, a residual ERN score was calculated where the unstandardized residuals were saved from a regression in which the neural response to errors in the control condition was entered as the predictor and neural response to errors in the observed condition was entered as the outcome variable. More negative residual scores reflected a larger response to errors in the observation condition than would be expected based on error response in the control condition. To test whether individual differences in symptoms were associated with an increase in response to errors in the observation compared to the control condition, bivariate correlations were conducted between general depression and social anxiety symptoms and the ERN residual score. There were no significant correlations between the ERN residual score and the general depression, $r(28) = 0.27$, $p = 0.147$, or social anxiety, $r(28) = 0.12$, $p = 0.519$, symptom subscales.

Additional exploratory analyses were examined to determine whether participants with clinical levels of social anxiety and/or depression differ from those without clinically significant symptoms in the ERN during observation, when alone in the control condition, or the ERN residual score described above. To determine which participants met the clinical characteristics for social anxiety, a cutoff score of 11.5 on the IDAS social anxiety symptom subscale was used (Stasik-O'Brien et al., 2019). The scores on the social anxiety subscale ranged from 5.00 to 22.00, and 21.2% of participants met the clinical cutoff score (n = 7). An independent samples t-test conducted to determine if there was a difference in neural response to errors between those who met the clinical cutoff for social anxiety (M = -1.98, SD = 7.64) and those who did not (M = -3.96, SD = 5.91) was not a significant in the observation condition, $t(28) = 0.72$, $p = 0.238$, d = 0.31. However, there was a significant difference between those who met the clinical cutoff for social anxiety (M = 0.28, SD = 7.60) and those who did not (M = -4.51, SD = 5.12) in the control condition, $t(28) = 1.93$, $p = 0.032$, d = 0.83, revealing a more negative ERN in participants who did not meet the clinical cut off for social anxiety (one-tailed). Another independent samples t-test was conducted to determine if there was a difference in the ERN residual score between those with (M = -0.48, SD = 5.09) and without clinical levels of social anxiety (M = 0.38, SD = 5.19), but it was not significant, $t(28) = -0.38$, $p = 0.352$, d = -0.17 (one-tailed).

Similarly, to determine which participants met the clinical characteristics for depression, a cutoff score of 55.5 on the IDAS general depression subscale was used (Stasik-O'Brien et al., 2019). The scores on this subscale ranged from 19.00 to 69.00, and 12.1% of participants met the clinical score (n = 4). An independent samples t-test conducted to determine if there was a difference in neural error response between those meeting the clinical cut off for depression (M = 0.01, SD = 7.34) and those who did not (M = -4.03, SD = 6.07) was not significant in the observation condition, $t(28) = 1.21$, $p = 0.119$, $d = 0.65$ (one-tailed). There also was no significant difference between those who met clinical depression levels ($M = -0.49$, $SD = 14.38$) and those who did not ($M = -3.84$, $SD = 3.93$) in the control condition, $t(3) = 0.46$, $p = 0.337$, $d = 0.56$ (one-tailed). An independent samples t-test to determine if there was a difference in error response on the ERN residual score for participants with ($M = 1.96$, $SD = 3.31$) and without clinical depression ($M = -0.10$, $SD = 5.31$) was also not significant, $t(28) = 0.75$, $p = 0.231$, $d = 0.40$ (one-tailed).

Discussion

The goal of this study was to examine error-related brain activity in first-year college students and to determine if the presence of perceived peer observation impacted error response in a Flanker task which requires speeded responses while inhibiting incongruent information. Furthermore, we aimed to examine whether the presence of symptoms of anxiety and depression impacted the effect of peer observation on error response. There was no significant difference in reaction time between the two conditions, but participants were significantly more accurate in the observation compared to the control condition. This finding suggests that even though participants did not have an increased neural response to making an error in the observation condition, they were aware they were being observed and performed to meet the challenge. Our sample consisted of Vanderbilt University undergraduate students, which likely played a role in this increased performance. Vanderbilt students are very high performing, which may have led them to perform better under pressure than would normally be expected. Following our hypothesis, participants had a significantly more negative neural response (i.e., ERN) to errors compared to correct response in both conditions. However, contrary to our hypothesis, there was not a significant difference in error response between the observation and control conditions.

This result contrasted with those in previous literature, where the presence of observation was found to enhance neural error response (Buzzell et al., 2017; Voegler et al., 2018).

Surprisingly, the ERN residual score was not significantly correlated with continuous measures of social anxiety or depressive symptoms. Previous literature has shown a relationship between error response and symptoms of internalizing disorders and/or those at high risk for internalizing disorders (Kujawa & Burkhouse, 2017; Voegler et al., 2018; Weinberg et al., 2015). Further, work by Barker et al. (2015) and Smith et al. (2019) specifically revealed a relationship between error response under social observation and social anxiety, but our results did not support these previous findings. It is possible the nonsignificant results were due to the small sample size, as well as the relatively small percentage of the sample that met clinical levels of internalizing disorders. Similarly, it is possible that for participants with nonclinical symptoms of anxiety and depression, the symptoms they reported were not severe enough to significantly affect the ERN. The nonsignificant result could also be due to the perceived observation that we used, rather than an in-person observation manipulation.

Furthermore, looking at clinical levels of anxiety and depression, there was not a significant difference in error response between those with and those without clinical social anxiety in the observation condition. There also was not a significant difference in error response between those with and without clinical depression in either the observation or control condition. These results differ from prior studies indicating a significant relationship between clinical levels of internalizing symptoms and neural error response (Smith et al., 2019; Voegler et al., 2018). Contrary to prior work (Smith et al., 2019; Voegler et al., 2018), there was a significant difference between those with and without clinical social anxiety in the control condition, such that participants who did not meet clinical criteria for social anxiety had a more negative neural response to making a mistake. However, a relatively small proportion of the present sample met the clinical cutoff for social anxiety (21.2%), which may have led to this difference in results. This result could also be due in part to comorbidity between depression and social anxiety, as depression may blunt the ERN (Kujawa & Burkhouse, 2017; Weinberg et al., 2015). The observation condition of our study was established using a "livestream" video and telling the participants that they were being recorded as they completed the task. This paradigm was different from previous studies that used in-person observation (Barker et al., 2015; Voegler et al., 2018), as well as different from studies that created perceived observation using a webcam on the computer and communication between the two participants (Buzzell et al., 2017; Smith et al., 2019), and this distinction may also have contributed to the inconsistent results.

One strength of the present study was the consideration of both the effects of social observation and internalizing symptoms on error-related brain activity, rather than addressing each factor individually. Social observation was analyzed both on its own and in relation to symptoms of anxiety and depression, creating an environment of observation and social comparison that many first-year college students find themselves in every day. Similarly, measuring symptoms of anxiety and depression rather than focusing solely on clinical diagnoses allowed for a more in-depth analysis of the relationship between internalizing symptoms, observation, and error response. Symptoms of anxiety and depression are prevalent in college students (Auerbach et al., 2018), so assessing the relationship between these symptoms and error response provided the opportunity to reach a wider sample and understand error response in a more representative way. Another important strength of the study was the collection and analysis of both neural and behavioral data. Analyzing the behavior that accompanied the participants' neural activity throughout the task, including how fast and how accurate they were, gave us a clearer picture of how error-related activity is present in multiple areas.

Along with these strengths, there were some limitations to the present study as well. One of the biggest limitations in this study was the small sample size. With only 33 participants included in the final data analysis, we were not able to get as clear or accurate picture of the processes underlying error response as we hoped. The portion of our sample meeting clinical cutoffs for internalizing disorders was even smaller, meaning it did not provide a representative demonstration of the relationship between social observation and error response in individuals with clinical diagnoses. Previous research assessing the different ways that the magnitude of the ERN can be impacted by internalizing disorders has focused on assessing changes in clinical samples (Voegler et al., 2018), and that difference in the present study likely played a role in the lack of significant results. Our use of a perceived, video observation instead of an in-person manipulation may also have played a role in the lack of a change in error response across the two conditions. While Buzzell et al. (2017) and Smith et al. (2019) found significant results using perceived observation, it is possible that our video set up was not convincing or strong enough to create the same level of worry that in-person observation would.

Some important future directions include focusing on in-person social observation and symptoms of anxiety and depression to determine how the direct presence of another person can make a difference in error response. Having an in-person observation would more closely replicate the types of situations college students find themselves in almost every day, providing a more accurate depiction of the stressors that may have the biggest impact. Based on the significant difference in accuracy between the two conditions, another area of future research could be examining the impact of social observation and symptoms of anxiety and depression on error response with a focus on changes in behavior. Participants showed a significant change in behavior across the two different conditions where brain activity remained the same, revealing that behavior could be another important factor in the relationship between error response and observation, symptoms of anxiety, and symptoms of depression. Post-error slowing, or the extent to which an individual slows down their response after making an error, could be a potential area to study as a behavioral indicator that is sensitive to peer observation. Future studies in these areas should also include a larger sample, as well as a sample that includes a better mix of participants with both clinical and nonclinical levels of internalizing disorder symptoms. A larger sample will provide more conclusive results, and will similarly lead them to be more generalizable. Having a larger percentage of the sample meeting the clinical cutoff for both anxiety and depression will also provide a clearer connection between social observation and error response in these groups, highlighting more definitively how these clinical groups are impacted by the observation of mistakes. Future studies should recruit clinical samples using clinical interviews to verify diagnoses and assess whether there are differences in error response with higher levels of clinical anxiety or depression.

Overall, error-related brain activity is an important area to continue exploring because of the stress that first-year students face with social observation and comparison, as well as the possibility of symptoms of anxiety and depression. Because these different conditions are often present at the same time, it is important to understand the way these different factors together may have a different effect on error response than each does on its own. While the present study did not find significant differences in neural error responses, likely because of the small sample size, the study does provide a foundation for studying error-related brain activity in relation to behavior, social observation, and clinical and nonclinical levels of anxiety and depression. As the first year of college continues to be a difficult transition for young adults, it is important to understand the ways that their environment impacts the way they think and act. This study highlights the potential for future studies in discovering the aspects of the transition to college that are most stressful, providing an opportunity to mitigate this effect and treat it more effectively in the future.

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Table 1

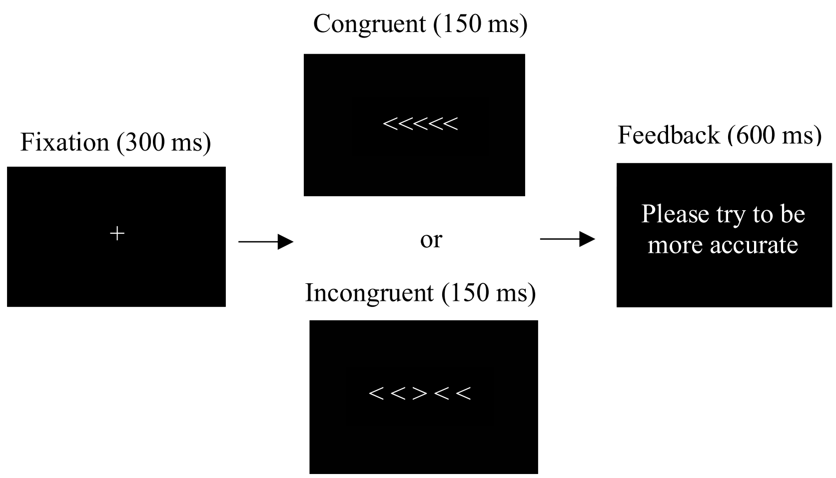
Correlation Matrix for Behavioral, Neural, and Symptom Data

Variables	*M* (*SD*)	1	2	3	4	5	6
1. Reaction Time (control)	323.55 (44.66)	--					
2. Reaction Time (observed)	318.29 (37.94)	0.797**	--				
3. Accuracy (control)	0.86 (0.10)	-0.110	-0.215	--			
4. Accuracy (observed)	0.89 (0.05)	0.152	0.275	0.564**	--		
5. ERN Residual Score	0.00 (4.92)	-0.027	-0.084	0.180	0.317	--	
6. Depression Symptoms (IDAS)	42.73 (12.29)	0.358	0.201	-0.206	0.036	0.271	--
7. Social Anxiety Symptoms (IDAS)	9.70 (3.88)	-0.015	-0.024	0.114	0.363	0.123	0.460*

Note: **p* < .05, ***p* < .01; ERN = error related negativity; IDAS = Inventory of Depression and Anxiety Symptoms

Figure 1

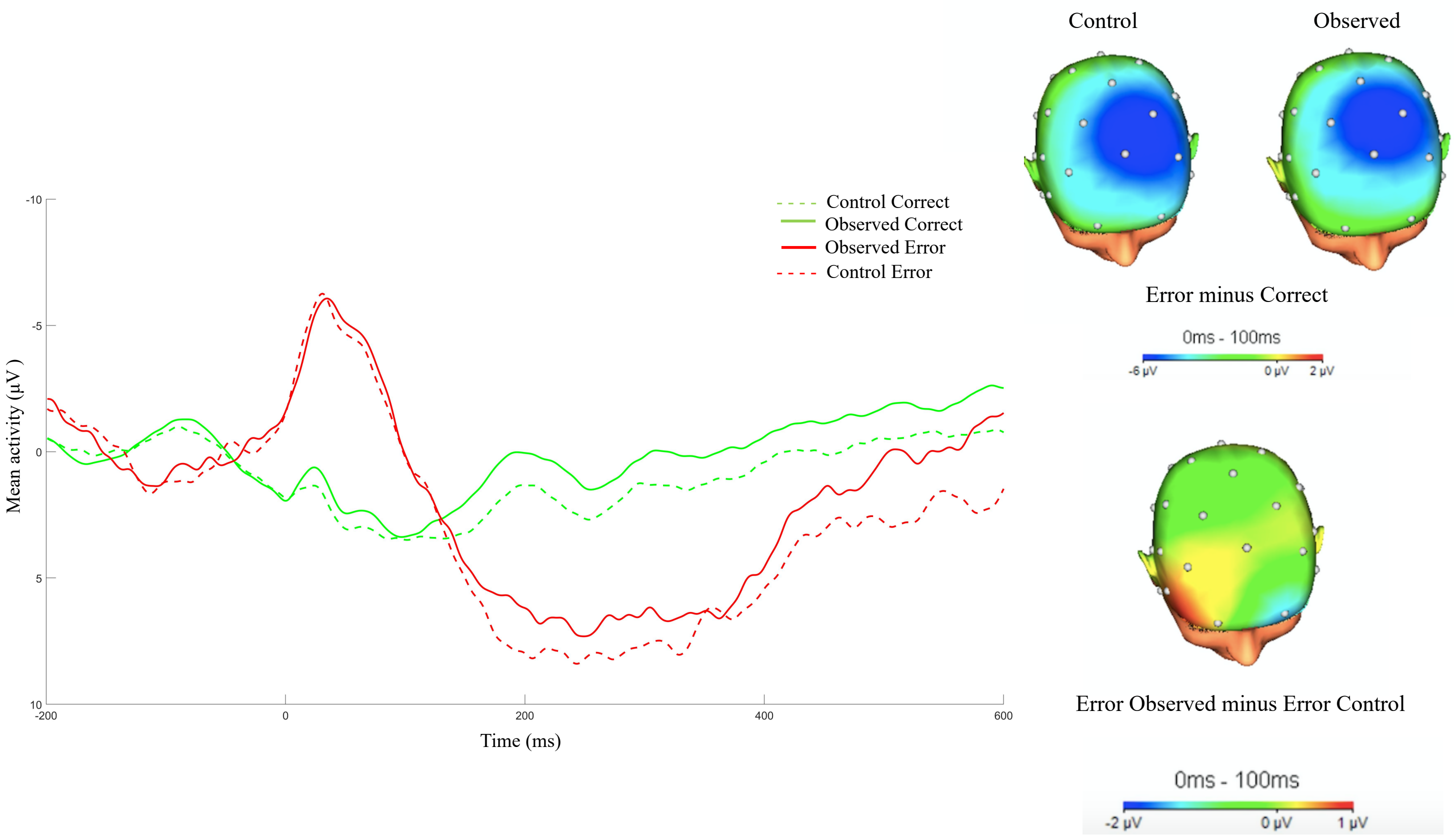
Flanker Task Design



Note. Participants first see the fixation cross, then are presented with either a congruent or incongruent trial. Based on their performance throughout the task, participants are presented with feedback that tells them to be more accurate, respond more quickly, or that they are doing a good job.

Figure 2

ERP Wave Form and Scalp Distributions



Note. ERP wave form demonstrates difference in activity for correct vs error responses. The top two scalp distributions reflect error minus correct activity in each condition, and the bottom scalp distribution reflects error activity in the observed condition minus error activity in the control condition.