Emotional Facial Expression Perception and Processing in AUD Subgroups:
A Behavioral and Electroencephalographic Investigation of Polysubstance Use

Riley Bohan
Mentors: Ben Lewis, PhD & Sara Jo Nixon, PhD
University of Florida Bachelors of Health Science Honors Program

Author Note
Riley Bohan, College of Public Health and Health Professions, University of Florida
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Correspondence concerning this thesis should be addressed to Riley Bohan.
Contact: rbohan1@ufl.edu
Abstract

Deficits in emotion processing among individuals with AUD are well accepted, however the potential impact of polysubstance use in this population remains uninvestigated. The current work begins to fill this gap by analyzing affective perception and processing in community controls (CCs) and two AUD subgroups differentiated by presence (Alc-Drug) or absence (Alc-Only) of polysubstance use. Behavioral task performance and electroencephalographic (EEG) indices (N170, P3) were measured for an emotion judgement task where participants classified emotional facial expressions (EFEs) morphed to 65 or 95 percent intensity. Mixed model analyses detected deficits in emotion classification accuracy among Alc-Drug relative to other groups. Although there was a main effect of emotion (greater accuracy for positive vs. negative emotions), there was no group by emotion interaction. N170 amplitude analyses found only a main effect for emotion (greater amplitude for negative vs. positive emotions). P3 amplitude analyses detected differences between control and AUD individuals, but no difference between AUD subgroups. No correlation was found between accuracy and event-related potential (ERP) amplitudes. These findings contribute to the developing literature on emotional processing deficits in AUD, including highlighting the importance of considering polysubstance use in characterizing these deficits.

Keywords: Alcohol Use Disorder, polysubstance use, emotional processing, affect, emotional face expression
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Introduction

Alcohol Use Disorder (AUD) is a dynamic public health concern affecting over 15 million Americans (National Institute of Alcohol Abuse and Alcoholism, 2018). About 10% of those diagnosed with AUD are also diagnosed with another Substance Use Disorder (Substance Abuse and Mental Health Services Administration, 2018), not including those undiagnosed or using substances at a subclinical level. Although substantive literature has explored the manifestations of AUD, there is a lack of investigation of the large portion of this population using additional psychoactive substances. In the context of AUD, one factor that has captured the literature’s attention is affective perception, as it has a substantial impact on social health as well as rehabilitation (Foisy et al., 2007). Though measures such as vocal prosody, tone, and body language have been used, most studies focus on emotional facial expression (EFE) perception given its saliency and everyday relevance. The affective perception deficits currently being characterized in AUD studies typically do not consider groups using additional substances. The current study looks to address this gap by utilizing AUD samples with (Alc-Drug) and without (Alc-Only) polysubstance use in EFE classification tasks.

Behavioral Indices

Previous EFE perception studies with AUD samples have largely been conducted excluding other Substance Use Disorders (SUDs), but ignore significant subclinical use of other substances. The observed EFE deficits in AUD samples seem to be specific to emotion, as AUD samples and control samples are statistically similar when expressions are neutral (e.g. Fein, Key, & Szymanski, 2010). Samples with AUD tend to have decreased accuracy, consistently overestimate emotional intensity, and demonstrate increased reaction time in EFE classification (e.g. Foisy et al., 2005). Such deficits have been hypothesized to directly
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contribute to this population’s known increased risk for interpersonal problems (Hoffman, Lewis, & Nixon, 2019), as interpretations of others’ emotions is vital in social interactions.

Electroencephalographic (EEG) Indices

The current study utilizes N170 and P3 amplitudes as outcome measures. N170 is a measure of early visual perception and is specifically sensitive to face processing (Luck, 2014). The P3 component reflects higher order processing and is linked to stimulus categorization and allocation of neural resources (Luck, 2014). Existent literature demonstrates equivocal N170 amplitude deficits in AUD groups in emotional tasks. Some studies have found decreased amplitudes for angry stimuli (e.g. Maurage et al., 2008b) while others have found no difference from controls regardless of stimuli emotion (e.g. Maurage et al., 2008a). Further, AUD groups have decreased P3 amplitudes in a wide array of tasks (Mumtaz, Vuong, Malik, & Rashid, 2018), yet recent EFE literature is inconsistent with findings of a group by stimulus emotion interaction for this measure. Some studies (e.g. Maurage, 2008a) demonstrate exaggerated P3 deficits in AUD samples for sad stimuli, yet other studies (e.g. Hoffman, 2019) find no emotional effect. The current study clarifies AUD effects on event-related potential (ERP) amplitudes in EFE tasks while expanding investigation to include the potential impact of polysubstance use on these effects.

Aims and Hypotheses

The current study contributes characterization of both behavioral and ERP outcomes, advancing current understanding of emotion perception and processing. Consideration of polysubstance use in AUD groups is novel and addresses a gap in the literature. Based on current literature, we expect individuals with AUD will A) be less accurate than controls; B) demonstrate decreased N170 amplitude, with more pronounced differences for negative stimulus emotions; C) demonstrate decreased P3 amplitudes relative to controls, without contingency on stimulus emotion. For these outcomes, we hypothesize polysubstance using
individuals with AUD will demonstrate the greatest behavioral deficits and electroencephalographic differences.

Method

Participants

All procedures were approved by the University of Florida Medical IRB. Due to length restrictions, further details of methods can be found in recently published work (Lewis, Price, Garcia, & Nixon, 2019; Hoffman et al., 2019).

Participants (N=93) included 49 community controls (CCs) and 44 treatment-seeking individuals with AUD, composed of two subgroups (Alc-Only, Alc-Drug). All participants completed self-report questionnaires documenting demographics, substance use history, depression and anxiety measures, and brief medical history. General exclusionary conditions included neurologic disorder/injury, current medical/psychiatric conditions or use of medications that could compromise neurobehavioral interpretation, and report of any psychotic or bipolar disorders in medical history. Inclusion required age between 25-59 years and education between 10-16 years. Treatment-seekers were recruited from residential treatment facilities and were at least 21 days abstinent (excluding nicotine) at the time of participating in the study. Alc-Only participants (n=22) endorsed use of no additional substances, with the exception of nicotine and up to weekly marijuana use, in the six months prior to treatment. Alc-Drug participants (n=22) endorsed weekly or greater use of at least one substance in addition to any nicotine or marijuana use in the six months prior to treatment.

Emotional Judgement Task

The Emotional Judgement Task (EJT; see Figure 1) utilized EFE stimuli depicting one of three emotions (happy, angry, sad), morphed with neutral faces to create emotional intensities of 95% and 65%. Participants were asked to select one of two possible emotions the EFE stimulus was depicting by pressing a button. Participants completed 15 blocks of 48 trials each.

EEG Processing
EEG was recorded on each participant using a 64-electrode array (Electro-Cap International, Eaton, OH). Impedances were maintained below 10 kOhms. Data cleaning and analyses were conducted with EEGLAB toolbox and ERPLAB plugin within MATLAB. Artifacts (e.g. blinks) were removed. Epochs began 200ms prior to EFE stimulus onset and ended 1500ms after. Epochs were only analyzed for trials where the participant answered correctly. N170 ERPs were analyzed via the O2 electrode in a 130-200ms window. P3 ERPs were analyzed via the Pz electrode in a 300-850ms window.

Data Analysis

Potential group differences in demographic, affective, and alcohol use variables were analyzed using t-tests. Planned accuracy and ERP analyses were completed using mixed models in which emotion and morph level were repeated factors and group (CC, Alc-Only, Alc-Drug) was a fixed factor. Models included group by repeated factor interaction terms. Where main effects were detected, differences were clarified with t-tests. Possible confounding demographic variables (e.g. age, education) were included in the above mixed models analyses as covariates. To add clarity and facilitate interpretation of results, relationships between task accuracy and ERP amplitudes were analyzed using correlations.

Results

Participants

All descriptive statistics and t-test results are presented in Table 1.

Accuracy

Differences of group (F(2,87)=8.17, p=.0006), emotion (F(2,174)=108.53, p<.0001), and morph level (F(1,87)=7.04, p=.0095) were detected. The Alc-Drug group was less accurate than the CC (t(87)=3.58, p=.0006) and Alc-Only (t(87)=3.60, p=.0005) groups, which did not differ. Happy EFE stimuli were classified more accurately than angry stimuli (t(174)=7.36, p<.0001), which were classified more accurately than sad stimuli (t(174)=3.74, p=.0002). In accordance to preliminary analyses, age and years of education were included as covariates. Only education
was found to have a main effect (F(1,84)=5.70, \( p=.0192 \)), but it did not change the presence of the previously stated main effects nor the significance of the Alc-Drug group’s lower accuracy score. Results are depicted in Figures 2 and 3.

**ERP Amplitudes**

Mixed models for N170 amplitude revealed a main effect for face emotion (F(2,122)=5.62, \( p=.0046 \)), but not group or morph effects. Trials with happy EFE stimuli resulted in significantly lower amplitudes than both angry (t(122)=3.02, \( p=.0031 \)) or sad (t(122)=2.42, \( p=.0169 \)) trials, which did not differ. Results are depicted in Figures 4 and 5. Mixed models for P3 amplitude detected a main effect for group (F(2,63)=8.38, \( p=.0006 \)). The CC group showed significantly larger P3 amplitudes than both Alc-Only (t(63)=2.85, \( p=.006 \)) and Alc-Drug (t(63)=3.67, \( p=.0005 \)) groups, which did not differ. Depression and years of education were included as covariates in models due to preliminary analyses, but neither showed a significant effect or altered aforementioned results. Results are depicted in Figures 6 and 7.

**Accuracy and Amplitude Correlations**

Overall task accuracy and mean amplitudes for N170 and P3 were not significantly related. Similarly, emotion-specific (happy, angry, sad) correlations failed to reach significance.

**Discussion**

This study highlights the importance of considering polysubstance use in assessments of EFE perception and processing among individuals with AUD. While the behavioral findings are provocative, the inconsistency between behavioral and electrophysiological patterns of group differences suggest complex relationships, potentially including differential patterns of compensation for neural insults associated with alcohol and polysubstance use.

With regard to behavioral findings, individuals with AUD and polysubstance use demonstrated significant deficits in classifying EFEs. This group’s decreased accuracy was consistent across all three emotions (see Figure 8). The equivalence of performance between controls and non-polysubstance using individuals with AUD was surprising, but not
unprecedented. A review found over 25% of facial expression recognition studies fail to find deficits in accuracy among those with AUD (Donadon & Osorio, 2014). The inconsistencies in findings tends to be attributed to differential task difficulty. With average task accuracies above 84% for all groups, the task used in this study was relatively easy. Thus, this task may have been insensitive to relatively subtle deficits among the Alc-Only group despite sensitivity to the more severe deficits in the Alc-Drug group.

Across groups, performance was sensitive to emotion, with classification accuracy being greatest for happiness, followed by anger then sadness. However, no group by stimulus emotion interaction was present. While this finding is consistent with other investigations using a similar task (Maurage, 2008a), equivocation is still present in current literature with others finding emotion-specific classification deficits (e.g. deficits in identification of sadness; Townshend, 2003). Whether these inconsistencies are related to task difficulty, intensity of stimulus emotion, or response demands remains unclear.

N170 results failed to support our hypotheses regarding AUD effects, subgroup differences, or group by emotion interaction. N170 amplitude was only predicted by the stimuli emotion. This finding disagrees with some previous studies documenting reduced amplitudes in AUD samples (e.g. Maurage, 2008b). However, variability in our N170 amplitude data was large (Mean=1.75, SD=3.40), making it difficult to interpret any meaningful conclusion.

The P3 amplitude differences between groups in the current study are in line with previous observations of greater P3 amplitudes among controls (e.g. Maurage et al., 2007). The noted effect of emotional intensity was consistent with observations that P3 amplitudes increase with response confidence (Ye, Lyu, Scodnick, & Sun, 2019). In contrast with behavioral performance, stimulus emotion did not impact amplitude. The marked difference between behavioral and electrophysiological results with respect to stimulus emotion sensitivity may suggest that the observed P3 differences reflect processes utilized in general, but not emotion-specific, stimulus discrimination. The equivalence of the AUD groups' P3s suggests a more
general consequence of substance abuse instead of being pharmacologically-specific, given the large variability in AUD participants’ use patterns (see Table 1).

Finally, task accuracy was not found to correlate with amplitudes of either ERP component. These analyses were conducted using data from trials where participants classified stimuli correctly. There is a possibility that analyses using EEG data from both correct and incorrect trials could find different results. Correlating behavioral and ERP outcomes seems to be uncommon in the existent literature. Of the few recent studies investigating this relationship, some find insignificance (e.g. Recio, Wilhelm, Sommer, & Hildebrandt, 2017) while others document strong relationships between accuracy and P3 (Maurage, 2008a). Further investigation into this possible electrophysiological and behavioral relationship is warranted.

Limitations of the current study include its cross-sectional nature, preventing any untangling of predisposing characteristics and substance use effects as well as any investigation into long term effects of sobriety. Further, the polysubstance use in the Alc-Drug group was heterogeneous and included several drug classes, challenging substance-specific interpretations. In the context of design, our EJT task offers greater ecological validity than others given the levels of emotional intensities. However, the mixing of only three emotions and goal of discriminating between two given options separates the task performance from the everyday ability to socially interpret facial expressions.

The current study highlights the importance of polysubstance use considerations in emotion processing in populations with AUD. Behavioral results suggested polysubstance-associated increases in susceptibility to emotional processing deficits. Although our electrophysiological results did not reflect a similar susceptibility, our measures represent only a limited set of indices with which to assess alcohol-associated neural consequences. Nonetheless, these findings contribute to the developing literature on emotional perceptive effects of AUD, polysubstance using AUD subgroup characterization, and possible targets for novel rehabilitation efforts in these populations.
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References


Appendix

Figure 1

Trial Example of the Emotional Judgement Task

1500 ms  300 ms
Sad or Angry?

Table 1

Demographic, Affective, and Alcohol Use Variables of Groups

<table>
<thead>
<tr>
<th></th>
<th>CC n=49 M (SD)</th>
<th>Alc-Only n=22 M (SD)</th>
<th>Alc-Drug n=22 M (SD)</th>
<th>T-Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Yrs)</td>
<td>42.2 (12.5)</td>
<td>46.5 (8.6)</td>
<td>37.7 (7.7)</td>
<td>** Alc-Only &gt; Alc-Drug, p&lt;.01</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Female</td>
<td>55.1%</td>
<td>36.4%</td>
<td>18.2%</td>
<td></td>
</tr>
<tr>
<td>% Male</td>
<td>44.9%</td>
<td>63.6%</td>
<td>81.8%</td>
<td></td>
</tr>
<tr>
<td>Education (Yrs)</td>
<td>14.8 (1.4)</td>
<td>13.3 (1.6)</td>
<td>12.9 (1.6)</td>
<td>*** CC &gt; Alc-Only, Alc-Drug, ps&lt;.001</td>
</tr>
<tr>
<td>Race *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% White/Caucasian</td>
<td>73.5</td>
<td>68.2</td>
<td>72.7</td>
<td></td>
</tr>
<tr>
<td>% Black/African American</td>
<td>14.3</td>
<td>18.2</td>
<td>22.7</td>
<td></td>
</tr>
<tr>
<td>% American Indian</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>% Pacific Islander</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
## % Other | 2.2 | 4.8 | 9.1
---|---|---|---
### % Hispanic Ethnicity | 4.4 | 9.5 | 13.6
### Depression Symptoms † | 4.9 (5.1) | 15.3 (9.9) | 15.0 (9.4) | ***CC < Alc-Only, Alc-Drug, ps<.001
### Anxiety Symptoms ‡ | 43.0 (7.2) | 56.1 (19.6) | 56.3 (13.3) | ***CC < Alc-Only, Alc-Drug, ps<.001
### Average Standard Drinks per Day | 0.3 (0.5) | 34.3 (20.5) | 20.8 (14.5) | ***CC < Alc-Drug < Alc-Only, ps<.001
### Maximum Standard Drinks per Day | 3.5 (2.3) | 57.2 (58.2) | 36.0 (20.5) | ***CC < Alc-Only, Alc-Drug, ps<.001
*Alc-Drug < Alc-Only, p<.034

Note. • Participants could choose more than one race. † Scores from Beck Depression Inventory II (Beck, 1996). ‡ Scores from Spielberger State Anxiety Index with age-adjustment (Spielberger, 1983).

### Figure 2

**Accuracy by Group**

![Accuracy by Group](image)

* * p<0.05
** ** p<0.01
*** *** p<0.001
Figure 3

Accuracy by Face Emotion

* $p<0.05$
** $p<0.01$
*** $p<0.001$
**Figure 4**

*N170 Amplitudes by Face Emotion*

![Bar chart showing N170 amplitudes by face emotion (Happy, Angry, Sad) with statistical significance indicated by asterisks: *

- $p < 0.05$
- $p < 0.01$
- $p < 0.001$
Figure 5

*N170 Grand Average Plots by Group*

![Graph showing N170 grand average plots by group with corresponding statistical significance markers.](image-url)
Figure 6

P3 Amplitude by Group

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$
Figure 7

P3 Grand Average Plots by Group

- CC
- Alc-Only
- Alc-Drug

* $p<0.05$
** $p<0.01$
*** $p<0.001$
Figure 8

Accuracy by Group for Three Emotions

- **p < 0.01
- ***p < 0.001

Legend:
- CC
- Alc-Only
- Alc-Drug