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Influence of Emotion Processing and Affect Intensity on the Engagement of Inhibitory Control in Young Adults with Attention-Deficit/Hyperactivity Disorder

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INFLUENCE OF EMOTION PROCESSING AND AFFECT INTENSITY ON THE
ENGAGEMENT OF INHIBITORY CONTROL IN YOUNG ADULTS WITH
ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

A Thesis Presented

by

ZACHARY B. SALANDER

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
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ABSTRACT

INFLUENCE OF EMOTION PROCESSING AND AFFECT INTENSITY ON THE ENGAGEMENT OF INHIBITORY CONTROL IN YOUNG ADULTS WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

SEPTEMBER 2019

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How individuals process different affective cues, as well as how intensely they experience different emotions, may influence how efficient they are at engaging inhibitory control. To date, it is unclear if these influences differ among young adults with and without ADHD. The current study tested the variation in young adults' inhibitory control to three affective cues (i.e., fear, happy, and neutral) in an Emotion Go/Nogo task. Results suggest better inhibitory control in response to more distinct cues (i.e., fear Nogo/happy Go). The order in which cues were presented also mattered, such that participants displayed enhanced inhibitory control when first presented with expressions that had similar valence. This task order was particularly helpful for inhibitory control engagement among young adults with ADHD. Furthermore, self-report measures suggest that young adults with ADHD were associated with higher levels of affect intensity. However, no additional relations were found in the processing of affective cues, affect intensity, and inhibitory control between young adults with and without ADHD. Results provide evidence for how affective cues and contexts differentially influence behavioral responses in young adults. Individuals with and without ADHD also appear to differ in the intensity with which they experience different

emotions. Overall, the current study provides a framework for how to further explore how emotional cues and affect intensity influence inhibitory control.

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CHAPTER 1

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is characterized by symptoms of hyperactivity/impulsivity and/or inattention (American Psychiatric Association, 2013). Emerging early in childhood, ADHD is quite stable over time (Lahey et al., 2016; Riddle et al., 2013), affecting 4-7% of adults and roughly twice as many males (Kessler et al., 2006; Ramtekkar, Reiersen, Todorov, & Todd, 2010). Among adults, those living with ADHD tend to struggle when processing emotions (e.g., Ibáñez et al., 2011) and when engaging inhibitory control (IC; e.g., Stevens, Quittner, Zuckerman, & Moore, 2002). Adults with ADHD also have a difficult time with social interactions (e.g., trouble making/maintaining friendships; American Psychiatric Association, 2013; Murphy & Barkley, 1996). When engaged in social interactions, occasionally it is necessary for adults to use certain affective cues (e.g., fear or anger) to communicate with observers to inhibit their ongoing behavior (Blair, 2003). For observers with ADHD, they may struggle when processing those cues and fail to adapt and correct their social behavior accordingly (i.e., improperly use their adaptive functioning skills). The current study was conducted to better understand how emotion processing influences IC engagement in young adults with ADHD. To date, very little research has explored this influence, despite the potential relevance of emotion processing to IC and adaptive functioning more broadly.

Furthermore, prior research also suggests adults with ADHD display higher levels of affect intensity (AI), which reflects the intensity of experiencing different emotions, relative to typically developing (TD) adults (e.g., Diener, Larsen, Levine, & Emmons, 1985; Rapport, Friedman, Tzelepis, & Van Voorhis, 2002). However, to the best of our

knowledge, no research has explored whether differences in AI impact the engagement of IC as a function of an ADHD diagnosis, particularly when processing different affective expressions. Therefore, the current study examined AI in relation to emotion processing and IC engagement in a sample of young adults with and without ADHD symptoms.

Emotion Processing and ADHD

In order to properly process emotions, one must be skilled at recognizing affective expressions (Lemerise & Arsenio, 2000). Compared to TD adults, adults with ADHD have displayed deficits in this skill. Specifically, early behavioral studies suggest that adults with ADHD are worse at recognizing static affective images of fearful, happy, and angry expressions (Miller, Hanford, Fassbender, Duke, & Schweitzer, 2011; Rapport et al., 2002). Recent behavioral studies also found similar recognition deficits in adults with ADHD who observed dynamic presentations of affective expressions. For example, Schönenberg and colleagues (2019) morphed neutral expressions into angry, happy, fearful, sad, surprised, and disgusted expressions and found ADHD adults were worse at detecting the fearful and sad expressions. Bisch and colleagues (2016) presented affective expressions (i.e., neutral, happy, erotic, angry, and disgusted) as dynamic video clips and also revealed poor affect recognition among adults with ADHD for all affective expressions examined.

Additional evidence via electrophysiological (EEG) measures further supports impaired emotion processing among adults with ADHD. When presented with angry, happy, and neutral expressions, adults with ADHD not only appear to abnormally allocate their attention to the affective expressions (i.e., reduced P300), but they also appear hypervigilant to angry and happy faces relative to TD adults (i.e., enhanced P100; Raz & Dan, 2015). In contrast to some behavioral findings (e.g., Miller et al., 2011), neural

evidence suggests adults with ADHD are hypersensitive to negative affective expressions (i.e., larger N170 to angry faces) and less reactive to positive affective expressions (i.e., reduced EPN & N170 to happy faces; Dimberg, 1982; Herrmann et al., 2009; Ibáñez et al., 2011; Raz & Dan, 2015).

Overall, researchers have repeatedly found significant differences between adults with and without ADHD on emotion processing skills, regardless of how affective expressions are presented (i.e., statically or dynamically). Evidence also suggests unique processing differences to negative and positive expressions. However, *why* such differences exist remains unclear. Some researchers have proposed that symptoms of inattention, or abnormal attentional allocation, contribute to these emotion processing differences (e.g., Miller et al., 2011; Raz & Dan, 2015; Shin, Lee, Kim, Park, & Lim, 2008). However, Da Fonseca and colleagues (2009) found that increasing the attentional demand of one experiment by using a context-based emotion recognition task relative to a simple facial emotion recognition task affects individuals with and without ADHD similarly. Furthermore, because adults have not shown issues processing all kinds of affective expressions, researchers argue that it is difficult to attribute emotion processing differences to symptoms of inattention alone as adults do preferentially attend to some types of affective expressions (for a review, see Uekermann et al., 2010).

Additionally, abnormal activation among different neural circuits suggests bottom-up (e.g., the orientation to/perception of emotional stimuli or reward evaluation) and top-down (e.g., attention control to emotion stimuli) cognitive processes may *both* contribute to emotion processing differences among individuals with ADHD (for a review, see Leppänen & Nelson, 2009; Shaw, Stringaris, Nigg, & Leibenluft, 2014). Research also argues that emotion processing differences are unrelated to general

behavioral limitations (e.g., impulsivity). For instance, after using an inhibitory scaffolding method (i.e., discouraging impulsive responding), individuals with ADHD performed similarly to those without ADHD on a non-emotion situation-matching task yet, on an emotion situation-matching task, individuals with ADHD performed worse (Yuill & Lyon, 2007). Altogether, the current literature highlights the need to better unpack factors that may be contributing to emotion processing differences among individuals with ADHD. One possible alternative factor that may be contributing to emotion processing differences among individuals with ADHD is a unique emotion-based construct: AI.

Affect Intensity and ADHD

Individual differences in affect evaluation indicate people consistently experience emotions either more or less intensely than others, independent of whether emotions are positive or negative, or the level of affective stimulation. Interestingly, this pattern seems to hold regardless of lifestyle differences (e.g., accounting for a more or less stimulating life; Diener et al., 1985; Larsen, Diener, & Emmons, 1986).

Among individuals diagnosed with ADHD, findings are mixed regarding levels of AI. In particular, some researchers have found that adults with ADHD tend to experience significantly greater levels of AI compared to healthy controls, which in turn interfered with their affect recognition abilities and sensitivity toward the emotions of others (Rapport et al., 2002). This diminished sensitivity to emotions may partly explain why adults with ADHD struggle so much with communicating their own emotions, as well as recognizing others' emotions when engaged in social interactions (Friedman et al., 2003). In contrast, other research has not found any differences in AI between young adults with and without ADHD (Braaten & Rosén, 1997; Ramirez et al., 1997). However, a key

difference in these studies that did and did not find a relation between AI and ADHD is the self-report questionnaires used to measure AI: Affect Intensity Measure (AIM; Larsen, 1984) versus the Emotional Intensity Scale (EIS; Braaten & Bachorowski, 1993). Whereas the AIM assesses both AI level and frequency of experiencing AI, the EIS only assesses AI level (Bachorowski & Braaten, 1994).

Although the relation between ADHD and AI is currently unclear, more research would help illuminate whether such a relation exists. In the current study, the AIM provided the opportunity to test if young adults with ADHD differed on level and frequency of AI, with the latter being of interest as recent work has focused on exploring the relation between ADHD and other emotion-related concepts, like emotion regulation (e.g., Reimherr et al., 2005; Surman et al., 2013). In addition, AI may also be related to patterns of affect processing. Among healthy controls, Rapport and colleagues (2002) found a positive relation between AI and accurate affect recognition, suggesting that moderate levels of AI may actually facilitate one's sensitivity to the emotions of others. Thus, the current study was interested in examining if AI facilitated emotion processing in young adults with and without ADHD and in turn, whether the use of emotion cues helped guide more regulated behavior such as IC.

Inhibitory Control

IC refers to an individual's ability to intentionally suppress an elicited behavior in favor of a more appropriate behavior to accomplish a specific goal (Nigg, 2017). Behaviorally, IC has been measured with an assortment of tasks, including the Stop-Signal Task (SST), Continuous Performance Test (CPT), and Go/Nogo task (GNG). On the SST, adults with ADHD have a more difficult time engaging their IC, as evidenced by significantly longer Stop Signal reaction times (e.g., Murphy, 2002). Poorer IC has also

been identified in adults with ADHD on the CPT, with higher levels of commission errors, as well as on the GNG task, with longer Go reaction times and an increased frequency of false alarms (e.g., Dinn, Robbins, & Harris, 2001; Epstein et al., 2001; Neely et al., 2017).

In standard GNG tasks, participants are instructed to “Go” (i.e., press a button) to certain stimuli and “Nogo” (i.e., do not press a button) to other stimuli. Following this framework, in an Emotion GNG task, specific affective expressions are assigned as the “Go” and “Nogo” stimuli, such that participants may be told to respond when they see a fearful face and withhold their response when they see a happy face. Comparatively, the Emotion GNG measures IC the same way a traditional GNG task would (i.e., by the number of commission errors), but it also permits researchers to analyze how individuals are responding to stimuli with different affective valences when different goal states are instructed (i.e., “Go” versus “Nogo”; Schulz et al., 2007). For example, happy expressions are thought to elicit more approach-like behaviors and thus make stopping more challenging, whereas fearful expressions are thought to elicit more freezing and withdrawal-like behaviors, thus making Go responses more challenging (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; LeDoux & Pine, 2016). Indeed, a small but growing literature supports these patterns by showing that typically developing individuals were more successful at withholding their responses when instructed to “Nogo” for fearful expressions and initiating responses when instructed to “Go” for happy expressions (e.g., Albert, López-Martín, Tapia, Montoya, & Carretié, 2012; Hare, Tottenham, Davidson, Glover, & Casey, 2005).

To date, only one study has used the Emotion GNG paradigm to examine how emotion processing differences influence the engagement of IC in adults with ADHD

(Köchel et al., 2012). Specifically, Köchel and colleagues (2012) had adult participants complete four blocks of an Emotion GNG task using four affective expressions (i.e., anger, sad, fearful, and happy), along with one block composed of only neutral expressions. For the affective blocks, the participants were instructed to respond to three of the four faces (e.g., anger, sad, and fearful) and withhold their response for the fourth face (e.g., happy). For the block with only the neutral expressions, participants were instructed to discriminate between male and female faces. The neurophysiological findings from this study imply that adults with ADHD, relative to TD adults, struggle when attending to anger, sad, and fearful expressions. Researchers posited this finding was a result of reduced attention allocation and/or less sensitivity to those types of expressions (i.e., diminished LPP). However, the researchers also noted that the complexity of their task may explain this difference, which is also noticeable in their behavioral findings. All participants, regardless of an ADHD diagnosis, had more trouble inhibiting responses to affective expressions relative to neutral expressions. Outside of the neutral expression block, all affective expressions were included in every block, thus adults were asked to discriminate the four expressions differently (i.e., follow the GNG rules of “Go” versus “Nogo”) with each new block they experienced. It is possible adults experienced a cognitive “processing overload” of affective information, skewing their GNG performance. Thus, researchers may have only found neural differences in how adults with and without ADHD engage in IC. However, it is important to explore differences in behavioral measures of IC by only prompting participants to “Go” to one affective expression and “Nogo” to another expression within each block of an Emotion GNG task. This is an important approach because it provides insight as to how adults engage in IC to one affective expression (e.g., fearful) when only having to discriminate

from another affective expression (e.g., happy). By using this approach, we expected to observe differences in behavioral measures of IC.

Despite strong evidence indicating that adults with ADHD struggle with their engagement of IC, which may be related to issues in processing affective cues, less is known about whether this struggle is associated with different levels of AI. In Pessoa's (2009) dual competition model, when emotional stimuli are highly threatening or highly arousing, more cognitive resources (e.g., executive functions) are allocated toward processing those stimuli. This allocation of resources is thought to result in dramatic behavioral effects (e.g., worse IC). In fact, more recent research has demonstrated that when fearful and happy stop signal expressions were paired with an electric shock (characterized as a high-intensity stop signal), more cognitive processing resources were consumed resulting in longer Stop Signal reaction times and worse IC compared to when fearful and happy stop signal expressions were not paired with any additional stimulation (Pessoa, Padmala, Kenzer, & Bauer, 2012). Similar effects may occur in individuals high in AI, such that a more intense experience with emotions could lead to more cognitive processing resources being consumed. With fewer cognitive processing resources readily available, it will be more difficult for those individuals to engage IC.

The Present Study

Among young adults with ADHD, prior research underscores significant impairments in their ability to process emotions and engage IC relative to TD young adults. However, very little research has explored whether emotion processing skills in young adults with ADHD influence their ability to engage IC. Furthermore, more research is needed in order to better understand if adults with ADHD differ in their level of AI, and, to the best of our knowledge, no research has explored whether level of AI

and ADHD group interact to influence engagement of IC. Therefore, the current study investigated whether affective cues influence IC in young adults and also explored the role of AI in these patterns by testing the following hypotheses:

- **Hypothesis 1:**

- **a)** Within an Emotion GNG task (i.e., Happy, Neutral, and Fear cues), the magnitude of IC engagement was predicted to vary by Emotion Cue for all participants. Specifically, participants were expected to show better IC on Fear Nogo trials and worse IC on Happy Nogo trials. Regarding the magnitude of general task engagement, young adults were expected to be least engaged (i.e., worse accuracy and slower RT) on Go trials with Fear expressions and more engaged on Go trials with Happy expressions.
- **b)** A main effect of ADHD Group (ADHD vs. TD) was also predicted based on prior literature indicating impaired IC among individuals with ADHD (e.g., Neely et al., 2017). Namely, young adults with ADHD were expected to show worse IC (when collapsing across all cue types) relative to TD young adults. Young adults with ADHD were also expected to be least accurate on Go trials.
- **c)** Based on prior research suggesting that adults with ADHD struggle when processing Fear cues (e.g., Miller et al., 2011), an interaction between Emotion Cue and ADHD Group was hypothesized for engagement of IC such that TD young adults were expected to benefit more from Fear Nogo cues relative to young adults with ADHD. Specifically, accuracy to Fear Nogo cues (compared to Neutral and Happy Nogo cues) was hypothesized to be greatest for TD young adults whereas

individuals with ADHD were not predicted to vary significantly in IC accuracy across the Emotion Cue types. Between groups, the largest difference in IC accuracy was expected for Fear Nogo cues.

- **Hypothesis 2:**

- **a)** Corresponding to recent research suggesting that adults with ADHD show higher levels of AI relative to TD adults (e.g., Rapport et al., 2002), young adults with ADHD were predicted to be associated with high levels of AI relative to TD young adults.
- **b)** Following Pessoa's (2009) dual competition model, we expected that more cognitive processing resources would be consumed when processing affective cues in the Emotion GNG task resulting in fewer cognitive processing resources being readily available to engage IC. Thus, a main effect of AI group was predicted, such that young adults who experienced emotions more intensely (i.e., higher AI scores) would be worse at engaging IC in the Emotion GNG task.
- **c)** An interaction between ADHD group and AI group (high vs. low) was also expected. Young adults with and without ADHD were expected to display better IC at low levels of AI, however, relative to young adults with high levels of AI, the difference in IC engagement was expected to be larger for young adults with ADHD.
- **d)** Finally, we predicted there would be a three-way interaction between ADHD group, AI group, and Emotion Cue. However, with a scant amount of research that has examined the different relations between ADHD,

emotion processing, and IC, as well as between ADHD, AI, and IC, we did not formulate hypotheses about the interaction.

CHAPTER 2

METHOD

Participants

One hundred forty-seven young adults (90 females, 56 males, 1 other), with and without ADHD (74 with ADHD), between the ages of 18 and 24 were recruited from the University of Massachusetts, Amherst. Young adults diagnosed with any learning or emotional disorders were excluded from participating. For this study, young adults taking ADHD medication (32 total) were not asked to stop taking any medication(s) prior to participating and whether or not medication had been taken prior to participation was recorded on the day of their visit. Medications included amphetamine, dextroamphetamine, methylphenidate, lisdexamfetamine dimesylate, guanfacine, bupropion hydrochloride, and a gamma-amino butyric acid supplement. Participants were recruited through a posting on the University of Massachusetts, Amherst online SONA research participation system, from SONA prescreen survey results that asked: “Have you been diagnosed with ADD/ADHD?”, and through fliers posted across the university’s campus.

Procedure

The study protocol was approved by the Institutional Review Board of the University of Massachusetts Amherst. For each assessment, researchers began by explaining the details of the study. Then, participants were given an opportunity to read the consent form and ask questions prior to agreeing to participate. Once consent was obtained, participants filled out an ADHD medication questionnaire. After completing the questionnaire, participants were seated at a desk and given instructions for the first computer task. In total, participants completed two computer tasks, however, only the

results from Emotion GNG task are reported below. Following the computer tasks, participants filled out a series of questionnaires that asked about their behavior, emotions, and sleep. Only responses from the Adult Self-Report (ASR; Achenbach & Rescorla, 2003) and Affect Intensity Measure (AIM; Larsen, 1984) are reported below.

Upon completion of both the computer tasks and questionnaires, participants were debriefed and compensated. Compensation was in the form of either SONA credits or \$12 (i.e., a rate of \$4 for every half hour of participation; $n = 11$), depending on whether they were recruited through the SONA system, or from a flier, respectively. Altogether, each visit lasted 90 minutes.

Measures

ADHD medication questionnaire. This questionnaire was created to determine whether participants were taking any medication related to symptoms of attention or hyperactivity, the names and dosage of those medications, and when they last took their medication. Participants were also asked to confirm whether they had been diagnosed with ADHD, and if they had, who diagnosed them and at what age.

Emotion GNG Task. The Emotion GNG task was presented on a laptop computer using E-Prime software. It was adapted from Hare et al. (2005) and maintained the total number of task blocks, number of different affective expressions (i.e., Fearful, Happy, and Neutral), as well as the assignment of each expression as the Go/Nogo cues. The current version differed by using 16 colored face stimuli (eight females, eight males), compared to 12 gray-scaled face stimuli, from the NimStim Face Stimulus Set (identities: 1, 6, 7, 11, 12, 15, 16, 18, 20, 21, 32, 37, 38, 39, 42, and 45; <http://www.macbrain.org/resources.htm>; Tottenham et al., 2009). The current version also used more trials per block (i.e., 64 versus 60) and a different pseudorandom

presentation of stimuli with a range of 1-13 Go trials in-between each Nogo trial. For each of the 16 faces, each affective expression was presented an equal number of times throughout the task.

During the task, each trial began with a fixation cross for 300 ms, followed by a single face stimulus for 500 ms, and then a blank screen for 500 ms. Responses could be made anytime from when the stimulus appeared up through the 500 ms blank screen for a total response window of 1000 ms. Participants were instructed to press one of two buttons (depending on their dominant hand) on a game controller for all faces that appeared except for the faces they were instructed not to press the button for within each block. Participants were given instructions and example images of affective expressions (i.e., consisting of face stimuli that were not used in the test trials; identities: 7, 18, 37, and 38) at the beginning of every block and were told which emotion faces were the “Go” (press) or “Nogo” (don’t press) cues.

First, participants completed a short practice block of 12 trials (75% Go stimuli, 25% Nogo stimuli). Next, participants completed eight test blocks of 64 trials per block (75% Go stimuli, 25% Nogo stimuli). The task consisted of two blocks of Fear Go/Happy Nogo stimuli, followed by two blocks of Happy Go/Fear Nogo stimuli, two blocks of Fear Go/Neutral Nogo stimuli, and two blocks of Neutral Go/Fear Nogo stimuli (see Table 1). The order of stimuli was counterbalanced to account for order effects. At the end of each block, participants were given an opportunity to take brief, self-paced, breaks where they could quickly stretch or rest their eyes before continuing the task. To minimize fatigue, participants were required to take a 3-5-minute break halfway through the task. All breaks were monitored by the research assistants conducting the experiment. Participants took approximately 25 minutes to complete the Emotion GNG task.

Adult Self-Report. The ASR was used to assess the number of ADHD symptoms for each participant. The ASR contains 126 items that asked participants to rate their adaptive functioning, problem behaviors, and substance use over the past six months. Almost all items are rated on a 3-point scale: 0 (*Not True*), 1 (*Somewhat or Sometimes True*), and 2 (*Very True or Often True*). The last three items asked participants to provide a numerical response. A participant's ADHD symptoms were assessed using the scored items on the Attention Deficit/Hyperactivity (AD/H) Problems subscale, which is under the DSM-oriented scale (i.e., the scale that identifies the presence/absence of DSM diagnoses). The AD/H Problems subscale and the DSM-oriented scale have shown good one-week test-retest reliability ($r = 0.84$) and internal consistency (Cronbach's alpha = 0.84; Achenbach & Rescorla, 2003). Reports from both the ASR and ADHD Medication Questionnaire were used to group participants in the appropriate ADHD Group (i.e., participants that did not self-report an ADHD diagnosis and were not in the clinical range for ADHD symptoms on the ASR were considered TD).

Affect Intensity Measure. The AIM was used to assess AI for each participant. The AIM contains 40 items that asked participants to rate their emotional reactions to typical life events. A participant's total score (i.e., the average response, accounting for certain reverse coded items, across the 40 items) is meant to reflect the intensity in which that individual experiences their emotions. Items are rated on a 6-point Likert scale: 1 (*Never*), 2 (*Almost Never*), 3 (*Occasionally*), 4 (*Usually*), 5 (*Almost Always*), and 6 (*Always*; Larsen, 1984). Prior research has found good test-retest reliability (i.e., correlations of 0.80, 0.81, and 0.81 for 1-, 2-, and 3-month retests, respectively) and internal consistency (i.e., a Cronbach alpha ranging from 0.90 to 0.94 across four samples) for the AIM (Larsen, Diener, & Emmons, 1986).

Data Analytic Plan

The data were examined in SPSS to determine if variables were normally distributed, and any potential outliers (i.e., ± 3.29 *SD* from the mean; Tabachnick & Fidell, 2013) were further assessed using descriptive statistics. The first hypothesis was tested using a repeated measures multivariate analysis of variance (RM-MANOVA). ADHD Group and Task Order (see Table 1) were entered as between-subjects variables. Emotion Cue (Fear, Happy, Neutral) was entered as the within-subjects variable. IC engagement was assessed via two dependent variables reflecting performance accuracy: 1) percent correct on Nogo trials and 2) *d*'-prime (*d*'), a measure that assesses a participant's ability to properly detect and respond to both Go and Nogo stimuli. Specifically, *d*' is calculated by subtracting a participant's standardized miss rate (i.e., failing to inhibit when instructed to "Nogo") from their standardized hit rate (i.e., pressing a button when instructed to "Go"; $z\text{HitRate} - z\text{MissRate}$). Data were inspected to determine whether any participants displayed a negative total *d*' score across the GNG task (symbolizing the inability to properly distinguish between the Go and Nogo stimuli) and no participants in the current study had this issue. To test Hypothesis 2, the same RM-MANOVA was run with AI level (high vs. low) added as an additional between-subjects variable. For all RM-MANOVAs, significant main effects or interactions (*p* of less than .05) were further analyzed with appropriate post hoc *t*-tests. Greenhouse-Geisser corrections were applied to both RM-MANOVAs due to violations of sphericity, and, when necessary, Bonferroni corrections were applied to post-hoc analyses.

In addition to examining IC engagement, patterns of general task engagement were explored using the same pair of RM-ANOVAs. The two dependent variables used

to assess general task engagement were: 1) percent correct on Go trials and 2) RT on Go trials.

CHAPTER 3

RESULTS

Descriptive Statistics

Twenty-eight participants were excluded due to incomplete data for the AIM or Emotion GNG, and four participants were excluded at the conclusion of the study for self-reporting additional diagnoses that fell under the exclusion criteria. An additional 18 participants were identified and removed as outliers (i.e., $\pm 3.29 SD$ from the mean; Tabachnick & Fidell, 2013). Final analyses consisted of 97 young adults (59 females; 45 with ADHD, ASR T -scores: $M = 66.10$, $SD = 11.07$; 52 without ADHD, ASR T -scores: $M = 54.46$, $SD = 4.63$). Descriptive statistics are presented in Table 2, and bivariate correlations are presented in Table 3.

Influence of Emotion Processing Skills on IC Engagement

Results from the RM-MANOVA revealed significant main effects of Emotion Cue for both measures of IC engagement. For percent correct on Nogo trials [$F(2.73, 253.98) = 18.32$, $p < .001$, $\eta_p^2 = .17$], post-hoc analyses showed that young adults displayed better IC on Fear Nogo/Happy Go trials ($M = 83.63$, $SD = 10.16$) relative to all other Emotion Cue trials ($ps < .001$; see Figure 1). Similar patterns were found for d' [$F(2.72, 252.82) = 26.87$, $p < .001$, $\eta_p^2 = .22$], such that young adults exhibited better IC on Fear Nogo/Happy Go trials ($M = 2.99$, $SD = 0.97$, $ps < .001$; see Figure 1). Young adults also exhibited better IC on Happy Nogo/Fear Go ($M = 2.54$, $SD = 0.83$) trials compared to Fear Nogo/Neutral Go trials [$M = 2.28$, $SD = 0.59$, $t(96) = 3.00$, $p = .02$].

Significant main effects of Task Order were also found for both measures of IC engagement [percent correct on Nogo trials: $F(1, 93) = 7.28$, $p = .01$, $\eta_p^2 = .07$; d' : $F(1,93) = 7.33$, $p = .01$, $\eta_p^2 = .07$], such that young adults had better IC when Fear and

Neutral expressions were presented first (percent correct on Nogo trials: $M = 81.15$, $SD = 8.28$; d' : $M = 2.69$, $SD = 0.59$) compared to when Fear and Happy expressions were presented first (percent correct on Nogo trials: $M = 76.23$, $SD = 10.43$; d' : $M = 2.41$, $SD = 0.56$; $ps < .05$; see Figure 2).

There was also a significant interaction between Emotion Cue and Task Order for percent correct on Nogo trials [$F(2.73, 253.98) = 12.46$, $p < .001$, $\eta_p^2 = .12$]. Between Task Orders, post-hoc analyses indicated young adults displayed better IC when Fear and Neutral expressions were presented first, specifically on Fear Nogo/Neutral Go trials [$M = 81.45$, $SD = 10.23$; $t(89.32) = 3.97$, $p = .001$] and Neutral Nogo/Fear Go trials [$M = 81.72$, $SD = 9.66$; $t(89.65) = 3.64$, $p = .002$; see Figure 3]. Within Task Orders, when Fear and Happy expressions were presented first, young adults exhibited the best IC on Fear Nogo/Happy Go trials ($M = 81.75$, $SD = 11.26$, $ps < .05$), followed by Happy Nogo/Fear Go trials ($M = 78.44$, $SD = 10.13$, $ps < .05$). There was no significant difference in IC between Neutral Nogo/Fear Go trials ($M = 73.19$, $SD = 13.23$) and Fear Nogo/Neutral Go trials [$M = 71.56$, $SD = 14.12$, $t(49) = 1.10$, $p > .50$; see Figure 3]. Similarly, when Fear and Neutral expressions were presented first, young adults displayed the best IC on Fear Nogo/Happy Go trials ($M = 85.64$, $SD = 8.51$, $ps < .05$). However, in contrast to when Fear and Happy expressions were presented first, young adults had the worst IC on Happy Nogo/Fear Go trials ($M = 75.80$, $SD = 13.58$, $ps < .05$; see Figure 3).

Furthermore, results revealed a significant interaction between ADHD Group and Task Order for d' [$F(1, 93) = 6.68$, $p = .01$, $\eta_p^2 = .07$]. Between ADHD Groups, no significant difference in IC was found when Fear and Happy expressions were presented first [$t(48) = 1.49$, $p = .14$; see Figure 4]. When Fear and Neutral expressions were

presented first, a marginal difference was observed such that young adults with ADHD ($M = 2.90$, $SD = 0.72$) exhibited better IC than TD young adults [$M = 2.54$, $SD = 0.43$; $t(28.99) = 1.99$, $p = .056$; see Figure 4]. Within ADHD Groups, young adults with ADHD displayed better IC when Fear and Neutral expressions were presented first ($M = 2.90$, $SD = 0.72$) than when Fear and Happy expressions were presented first ($M = 2.29$, $SD = 0.56$; $t(43) = 3.20$, $p = .003$; see Figure 4]. There was no significant difference in IC between Task Orders for TD young adults [$t(50) = 0.10$, $p = .92$; see Figure 4].

The interaction between ADHD Group and Task Order was also marginally significant, though underpowered, for percent correct on Nogo trials [$F(1, 93) = 3.80$, $p = .054$, $\eta_p^2 = .04$]. Between ADHD Groups, no significant differences in IC were found for either Task Order ($ps > .15$). Within ADHD Groups, young adults with ADHD displayed better IC when Fear and Neutral expressions were presented first ($M = 83.01$, $SD = 5.64$) than when Fear and Happy expressions were presented first ($M = 74.13$, $SD = 10.69$; $t(37.82) = 3.58$, $p = .001$). There was no significant difference in IC between Task Orders for TD young adults [$t(50) = 0.53$, $p = .60$].

No significant main effect of ADHD group was found for either measure of IC engagement ($ps \geq .50$), nor any interaction between Emotion Cue and ADHD group ($ps > .40$) or between Emotion Cue, ADHD group, and Task Order ($ps > .70$). With the addition of AI level to the analyses, results from the second RM-MANOVA did not alter or reveal any additional significant findings for either measure of IC engagement. However, a marginal correlation was found between AI level and ADHD group, such that young adults with ADHD were associated with higher levels of AI, $r = -.15$, $p = .07$.

Influence of Emotion Processing Skills on Task Engagement

Results from the first RM-MANOVA revealed significant main effects of Emotion Cue for both percent correct on Go trials [$F(2.64, 245.85) = 12.27, p < .001, \eta_p^2 = .12$] and Go RT [$F(2.54, 236.33) = 21.76, p < .001, \eta_p^2 = .19$]. Similar to measures of IC engagement, post-hoc analyses showed young adults were more engaged and accurate on Go trials with Happy Go/Fear Nogo expressions ($M = 94.79, SD = 4.72$) relative to all other Emotion Cue trials ($ps < .05$; see Figure 5). Young adults were also more engaged and accurate on Go trials with Fear Go/Happy Nogo expressions ($M = 93.47, SD = 4.79$) than on Go trials with Neutral Go/Fear Nogo expressions ($M = 91.82, SD = 5.24$), though this difference was marginally significant, $t(96) = 2.55, p = .07$. For Go RT, young adults were faster on Go trials with Happy Go/Fear Nogo expressions ($M = 427.87, SD = 57.77$) than on all other Emotion Cue trials ($ps < .001$; see Figure 5). Young adults were also marginally faster on Go trials with Fear Go/Happy Nogo expressions ($M = 447.19, SD = 58.34$) than on Go trials with Fear Go/Neutral Nogo expressions [$M = 457.06, SD = 64.53; t(96) = -2.42, p = .10$].

The interaction between Emotion Cue and Task Order was also significant for percent correct on Go trials [$F(2.64, 245.85) = 6.29, p = .001, \eta_p^2 = .06$]. Post-hoc analyses revealed only marginal differences between Task Orders such that young adults were more engaged and accurate on Go trials with Neutral Go/Fear Nogo expressions when Fear and Happy expressions were presented first ($M = 93.00, SD = 4.22$) compared to when Fear and Neutral expressions were presented first [$M = 90.56, SD = 5.92; t(95) = 2.35, p = .08$; see Figure 6]. Within Task Orders, no significant differences were observed for general task engagement when Fear and Happy expressions were presented first ($ps > .10$; see Figure 6). However, when Fear and Neutral expressions were presented first, young adults were the most engaged and accurate on Go trials with Happy

Go/Fear Nogo expressions ($M = 95.81$, $SD = 4.14$; $ps < .05$). Young adults were also more engaged and accurate on Go trials with Fear Go/Happy Nogo expressions ($M = 94.04$, $SD = 5.66$) relative to Go trials with Neutral Go/Fear Nogo expressions [$M = 90.56$, $SD = 5.92$; $t(46) = 3.18$, $p = .02$; see Figure 6].

Additionally, the interaction between Emotion Cue and Task Order was marginally significant, though underpowered, for Go RT [$F(2.54, 235.33) = 2.61$, $p = .062$, $\eta_p^2 = .03$]. No significant differences were found between Task Orders ($ps > .20$). Within Task Orders, regardless of which expressions were presented first, young adults were faster on Go trials with Happy Go/Fear Nogo expressions relative to all other Emotion cue trials ($ps < .05$).

No significant main effects of Task Order or ADHD group were found for either measure of general task engagement ($ps \geq .10$). There were also no significant interactions between Emotion Cue and ADHD group ($ps > .50$), ADHD group and Task Order ($ps > .15$), or between Emotion Cue, ADHD group, and Task Order ($ps > .60$). With the addition of AI level to the analyses, results from the second RM-MANOVA did not alter or reveal any additional significant findings for either measure of general task engagement¹.

¹ Given that prior research has documented various medications ameliorate IC impairments among ADHD adults (e.g., Aron, Dowson, Sahakian, & Robbins, 2003; Chamberlain et al., 2007), there were concerns for the current study regarding performance effects as a result of participants not being asked to go off their medication(s) prior to participating. When exploring this question in our data, no differences were found in performance between those individuals on or off any medication(s) for ADHD. Provided that we asked participants when they last took their medicine, we also explored various cutoffs from those self-reported timeframes and again, no differences emerged.

CHAPTER 4

DISCUSSION

The current study used an Emotion GNG task to examine whether affective cues influence IC in young adults with and without ADHD. The potential role of AI on IC among individuals with and without ADHD was also explored. Three key findings emerged. First, young adults were most efficient at engaging IC when presented with Fear Nogo cues. Second, Task Order mattered such that young adults exhibited enhanced IC when initially challenged with expressions that were similar in valence. Moreover, Task Order was particularly influential for IC engagement among young adults with ADHD. Third, AI and ADHD seem to be related such that young adults with ADHD were associated with higher levels of AI. Each of these findings are examined in more detail below and implications for future studies are discussed.

Partially consistent with our hypothesis, both measures of IC engagement (percent correct on Nogo trials and d') revealed Fear Nogo cues were only the most helpful to young adults when they were paired with Happy Go cues. These findings support prior research that emphasizes the freezing and withdrawal-like responses that individuals typically manifest when presented with Fearful expressions (e.g., LeDoux & Pine, 2016). Although we also predicted that the worst IC performance would be seen when Happy was a Nogo cue, d' results showed a different pattern. Namely, young adults had better IC on trials with Happy Nogo/Fear Go expressions relative to trials with Fear Nogo/Neutral Go expressions. Worse IC on Happy Nogo trials had been predicted based on prior work associating Happy expressions with reward (e.g., O'Doherty et al., 2003) and approach-based behavior (e.g., Davidson et al., 1990), however, the current results suggest that adults found it easier to engage IC when affective cues were more easily

distinguishable (i.e., when either Fear or Happy expressions were used vs. when Fear and Neutral were paired together). Indeed, Fear and Neutral expressions may be more difficult to differentiate as Neutral expressions have previously been associated with negative emotion (e.g., Fear; Lee, Kang, Park, Kim, & An, 2008).

Alternatively, instead of capturing IC engagement, our d' results may better explain young adults' sensitivity to the different affective expressions. As previously mentioned, d' assesses an individual's ability to properly distinguish between Go and Nogo cues and may thus indicate that young adults were actually more sensitive to the differences between Fear and Happy as Go and Nogo cues. Current findings for patterns of general task engagement further support this interpretation, as young adults were the most engaged (i.e., accurate Go trial responding) on Fear Nogo/Happy Go trials. Young adults also responded the fastest on Go trials when presented with Happy Go/Fear Nogo expressions. These patterns of poorer IC (Nogo trials) but higher engagement (faster RT on Go trials) to Happy cues also correspond to a study using Sad faces as the negative expression (Schulz et al., 2007).

Overall, the current findings emphasize how natural it is for young adults to inhibit responding to Fear Nogo cues when paired with Happy Go cues, perhaps due to the ability to easily distinguish between these two expressions. Uniquely, the current findings also highlight the similarity between Fear and Neutral expressions and the difficulties associated with trying to distinguish between these two expressions. For instance, Hare and colleagues (2005) found that adults exhibited better IC to both Neutral and Fear Nogo cues compared to Happy Nogo cues and were faster to respond to Happy and Neutral Go trials relative to Fear Go trials. That pattern of results suggests that it did not matter what Go cue Fear Nogo cues were paired with, whereas our results indicated

that the type of Go cue impacted how efficiently participants responded to Fear Nogo cues. This conflicting pattern was surprising as the current study adapted its task from Hare et al. (2005). One factor that may have led to the different patterns in performance was how each task was manipulated. Prior work has emphasized the importance of preceding context on behavior (Durstun, Thomas, Worden, Yang, & Casey, 2002), thus limiting the number of Go trials that precedes each Nogo trial seems to have an effect on inhibition. This manipulation could largely impact on how individuals process different affective cues.

Other studies have found better IC among adults on Neutral Nogo trials relative to what was defined as “emotional” Nogo trials (i.e., Happy or Fear), as well as better IC on positive (e.g., Happy) than on negative Nogo trials (Köchel et al., 2012; Tottenham, Hare, & Casey, 2011). However, Tottenham and colleagues (2011) limited the number of trials per block (i.e., 30) and used Neutral expressions in all of their blocks, thus with so few opportunities to inhibit to different “emotional” expressions relative to Neutral expressions, this task structure may explain why better IC was found on Neutral Nogo trials. Additionally, Köchel and colleagues (2012) used multiple expressions within each task block (i.e., 3:1 ratio of negative to positive), along with a separate Neutral block. With that setup, it is difficult to attribute better IC on Neutral Nogo trials as no blocks included both “emotional” and Neutral expressions. To properly interpret how IC varies among different combinations of positive and negative expressions, one should avoid including them all within the same block.

Another interesting finding of our study was the significant main effect of Task Order, as well as a significant interaction between Emotion Cue and Task Order. To the best of our knowledge, this is the first study to find these patterns on an Emotion GNG

task. For the main effect of Task Order, young adults exhibited better IC when first presented with combinations of Fear and Neutral faces as compared to when they received Fear and Happy stimuli first. This suggests young adults were overall better at engaging IC when they first experienced a greater challenge and had to differentiate between affective cues with similar valence. Another explanation may be that the Fear/Neutral combination was a potent negative affective condition which elicited top-down modulation of emotion and in turn primed executive attention processes (e.g., Cohen, Henik & Mor, 2011) leading to improved performance on subsequent blocks.

For the interaction between Emotion Cue and Task Order, young adults always exhibited similar IC on the different Fear and Happy cue combinations, regardless of Task Order. However, when Fear and Neutral expressions were presented first, young adults displayed better IC on Fear and Neutral cues compared to when Fear and Happy expressions were presented first. In fact, IC on Fear and Neutral cues improved so much from one Task Order to the other that IC was worse on Happy Nogo/Fear Go trials when Fear and Neutral expressions were presented first. Interestingly, these results follow our initial hypotheses more closely, as well as what Hare and colleagues (2005) found in their study: better IC on Fear Nogo trials and worse IC on Happy Nogo trials.

At the same time, we must be cautious in attributing the observed differences solely to changes in IC. The interaction between Emotion Cue and Task Order was also significant for one of our measures of general task engagement (i.e., percent correct on Go trials). This interaction did not find adults to be more engaged (i.e., accurate and faster on Go trials) when they first experienced Fear and Happy faces, but differences did emerge when Fear and Neutral faces were presented first. Specifically, young adults were the most engaged on Go trials with Happy Go/Fear Nogo expressions. Therefore, it

is possible that when Fear and Neutral expressions were presented first, we observed IC differences with the Fear and Neutral cue combinations simply because young adults were not as engaged in the task. Put another way, the influence of Task Order was specific to IC and did not equally impact task engagement. From a performance perspective, Fear and Neutral expressions may increase cognitive processing due to the challenge of distinguishing between these faces (i.e., the frequency of non-responses may have been an artifact of uncertainty rather than better IC engagement). In turn, the opportunity to experience these expressions first may have better prepared participants to perform more effectively on subsequent Nogo trials using more easily distinguishable cues.

To the best of our knowledge, this is also the first study to find a significant interaction between ADHD Group and Task Order on an Emotion GNG task. Though marginally significant, results indicate that young adults with ADHD showed better IC than TD young adults when Fear and Neutral Expressions were presented first. This finding is inconsistent with what was hypothesized for the relation between ADHD Group and IC: adults with ADHD were expected to be worse at engaging IC relative to TD young adults. This hypothesis was based off prior research that has shown impaired IC among ADHD adults (e.g., Aron & Poldrack, 2005; Neely et al., 2017). Provided this finding was for the d' measure of IC, again, it is possible that ADHD adults were simply more sensitive to the Fear and Neutral expressions. The observed significant difference was actually *within* the ADHD group, which suggests that just young adults with ADHD were more sensitive to Fear and Neutral expressions when they were presented first. Additionally, a marginal interaction between ADHD Group and Task Order for percent correct on Nogo trials was also found. This finding implies that only young adults with

ADHD may have displayed better IC when Fear and Neutral expressions were presented first. Considering all of these findings, it is interesting there were more females ($N = 15$) than males ($N = 5$) in these groups (i.e., ADHD, Fear and Neutral expressions first). Prior literature has emphasized that women perform better than men on recognizing affective expressions (e.g., Hall, 1978; Hall & Matsumoto, 2004; Tottenham et al., 2011), thus it is possible that females were driving the observed effects.

Limitations

The current sample consisted of only undergraduate students, who were also mostly recruited through an online research participation system available to Psychology majors, and the majority of whom were female. Thus, our sample was disproportionately comprised of students who were not only highly educated but were also female, limiting the population(s) we can generalize our findings to. Moreover, as expected, young adults with ADHD in our sample had higher levels of AI. Although this is consistent with prior research that found adults with ADHD reported higher levels of AI compared to TD adults (Friedman et al., 2003; Rapport et al., 2002), this relation was marginally significant, which raises the possibility that our findings may have been limited by what the current study's AI measure actually assessed. One critique of the AIM is that it assesses both AI level *and* frequency (Bachorowski & Braaten, 1994) such that in the directions of the AIM, participants are instructed to rate how they emotionally react to typical life events, but the scale they use for their responses emphasizes the frequency with which they react (e.g., "Never", "Almost Never", "Occasionally"). If young adults were focusing on how frequently they react to those events, then we may not have accurately assessed the intensity of their reactions.

Future Directions

Although we limited our sample to highly educated young adults, it will be important for future research to recruit a more diverse sample (i.e., more community-based) and to consider a developmental approach when exploring how emotion processing differences influence individuals with and without ADHD, particularly as recent research is beginning to explore these associations in children and adolescents (Köchel, Leutgeb, & Schienle, 2014; Tottenham et al., 2011). Future research should also place special emphasis on studying a sample with a more evenly split gender composition in order to more fully explore if gender differences exist and are driving any emotion processing differences among individuals with and without ADHD and whether it is a factor in the ADHD Group by Task Order interaction that emerged in this data set.

Given the range of conflicting findings in the literature, future studies using an Emotion GNG task to explore how affective cues influence IC should place special emphasis on how the task is structured (e.g., total number of affective expressions, number of expressions per block, task length) so that the task is well-balanced and most appropriate for the population under study. Moreover, future studies should also consider which expressions to use within their tasks. In the current study, we had a primary interest on Fear cues and how they would influence IC, yet the current results indicate that further understanding of processing Happy cues would also be useful. One combination of expressions that we did not explore was Happy and Neutral, which prevented any comparative assessment of how this cue combination might have influenced young adults' IC relative to other cue combinations.

In addition to behavioral measures of IC, future research should consider incorporating electrophysiological measures into their study designs. The current study's behavioral findings suggest unique emotion processing and IC differences among all

young adults, and limited evidence emerged for differences specific to young adults with and without ADHD. Through the use of electrophysiology, we may gain a better understanding of whether individuals with and without ADHD differ in underlying neural processes that may not be observable with behavioral measures only. With these methods, researchers would have the ability to track cognitive resource allocation as a way of identifying how participants are processing different affective expressions. Future studies may also want to consider using an alternative measure, like the Emotional Intensity Scale (EIS; Bachorowski & Braaten, 1994) or the Emotion Reactivity Scale (ERS; Nock, Wedig, Holmberg, & Hooley, 2008), or even multiple measures, to ensure they are comprehensively assessing AI.

Lastly, future iterations should be aware of the potential value of alternative statistical approaches when dealing with missing data and outliers. For example, the current study not only excluded participants that were missing questionnaire data (i.e., AIM data), but also participants that were too extreme on different behavioral variables. Imputation is one method that future iterations should explore when attempting to save missing questionnaire data. As for saving outliers, one method that should be explored is moving or adjusting outlier values to be less extreme (e.g., Tabachnick & Fidell, 2013).

Table 1. Emotion GNG Task Cue and Order Information

ORDER 1		
Blocks	Go Stimulus	Nogo Stimulus
1-2	Fear Expressions	Happy Expressions
3-4	Happy Expressions	Fear Expressions
5-6	Fear Expressions	Neutral Expressions
7-8	Neutral Expressions	Fear Expressions

ORDER 2		
Blocks	Go Stimulus	Nogo Stimulus
1-2	Neutral Expressions	Fear Expressions
3-4	Fear Expressions	Neutral Expressions
5-6	Happy Expressions	Fear Expressions
7-8	Fear Expressions	Happy Expressions

Table 2. Descriptive statistics for percent correct on Nogo trials, d' , percent correct on Go trials, Go RT, and AI scores.

Variable	Mean	SD	ADHD ($N = 45$)	TD ($N = 52$)	Task Order 1 ($N = 50$)	Task Order 2 ($N = 47$)
			Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Percent Correct Nogo	78.62	9.72	78.07 (9.80)	79.09 (9.72)	76.23 (10.43)	81.15 (8.28)
Fear Go/Happy Nogo	77.16	11.94	77.29 (10.71)	77.04 (13.01)	78.44 (10.13)	75.80 (13.58)
Happy Go/Fear Nogo	83.63	10.16	83.47 (11.40)	83.77 (9.07)	81.75 (11.26)	85.64 (8.51)
Fear Go/Neutral Nogo	77.32	12.35	76.53 (11.99)	78.00 (12.73)	73.19 (13.23)	81.72 (9.66)
Neutral Go/Fear Nogo	76.35	13.29	75.00 (13.67)	77.52 (12.97)	71.56 (14.12)	81.45 (10.23)
d'	2.54	0.59	2.56 (0.70)	2.53 (0.49)	2.41 (0.56)	2.69 (0.59)
Fear Go/Happy Nogo	2.54	0.83	2.57 (0.89)	2.51 (0.78)	2.42 (0.65)	2.67 (0.97)
Happy Go/Fear Nogo	2.99	0.97	3.07 (1.18)	2.91 (0.75)	2.82 (1.01)	3.16 (0.91)
Fear Go/Neutral Nogo	2.36	0.71	2.36 (0.80)	2.36 (0.63)	2.17 (0.54)	2.57 (0.81)
Neutral Go/Fear Nogo	2.28	0.59	2.23 (0.59)	2.33 (0.59)	2.21 (0.67)	2.36 (0.49)
Percent Correct Go	93.10	3.39	93.25 (3.73)	92.98 (3.09)	92.99 (3.17)	93.22 (3.63)
Fear Go/Happy Nogo	93.47	4.79	93.73 (4.99)	93.25 (4.65)	92.94 (3.78)	94.04 (5.66)
Happy Go/Fear Nogo	94.79	4.72	94.75 (4.84)	94.83 (4.65)	93.83 (5.05)	95.81 (4.14)
Fear Go/Neutral Nogo	92.33	4.13	92.57 (4.55)	92.13 (3.75)	92.19 (3.69)	92.49 (4.58)
Neutral Go/Fear Nogo	91.82	5.24	91.94 (5.69)	91.71 (4.86)	93.00 (4.22)	90.56 (5.92)
Go RT	445.91	55.22	436.32 (48.25)	454.20 (59.83)	447.69 (58.06)	444.01 (52.59)
Fear Go/Happy Nogo	447.19	58.34	435.10 (51.03)	457.66 (62.60)	450.50 (51.09)	443.67 (65.56)
Happy Go/Fear Nogo	427.87	57.77	418.65 (53.79)	435.85 (60.38)	434.58 (58.58)	420.74 (56.65)
Fear Go/Neutral Nogo	457.06	64.53	450.81 (61.60)	462.48 (67.08)	457.03 (73.11)	457.10 (54.75)
Neutral Go/Fear Nogo	453.88	60.43	443.06 (46.82)	463.23 (69.22)	450.19 (65.58)	457.79 (54.86)
AI Scores	3.77	0.49	3.86 (0.52)	3.67 (0.45)	3.64 (0.42)	3.91 (0.52)

Note. TD = typically developing; RT = reaction time; AI = affect intensity; Task Order 1 = Fear/Happy expressions first; Task Order 2 = Fear/Neutral expressions first.

Table 3. Bivariate correlations for percent correct on Nogo trials, d' , percent correct on Go trials, Go RT, and AI scores.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Percent Correct Nogo																	
1. Fear Go/Happy Nogo	--																
2. Fear Nogo/Happy Go	.60***	--															
3. Fear Go/Neutral Nogo	.39***	.63***	--														
4. Fear Nogo/Neutral Go	.45***	.57***	.68***	--													
d'																	
5. Fear Go/Happy Nogo	.62***	.50***	.28**	.30**	--												
6. Happy Go/Fear Nogo	.48***	.69***	.28**	.37***	.61***	--											
7. Fear Go/Neutral Nogo	.34**	.46***	.71***	.48***	.34**	.41***	--										
8. Neutral Go/Fear Nogo	.39***	.37***	.38***	.72***	.32**	.42***	.41***	--									
Percent Correct Go																	
9. Fear Go/Happy Nogo	.12	.13	-.06	-.03	.67***	.45***	.14	.13	--								
10. Happy Go/Fear Nogo	.18 [†]	.22*	-.02	.06	.41***	.70***	.20 [†]	.24*	.54***	--							
11. Fear Go/Neutral Nogo	.05	.04	.01	.09	.30**	.32**	.50***	.36***	.41***	.41***	--						
12. Neutral Go/Fear Nogo	.07	-.03	.08	-.11	.15	.15	.11	.48***	.19 [†]	.22*	.40***	--					
Go RT																	
13. Fear Go/Happy Nogo	.04	.07	.28**	.20 [†]	-.40***	-.38***	.02	-.03	-.76***	-.56***	-.38***	-.21*	--				
14. Happy Go/Fear Nogo	-.06	-.03	.24*	.10	-.40***	-.52***	-.03	-.11	-.64***	-.71***	-.38***	-.18 [†]	.85***	--			
15. Fear Go/Neutral Nogo	.20*	.22*	.47***	.32**	-.17	-.18 [†]	.09	.01	-.49***	-.41***	-.45***	-.26*	.79***	.74***	--		
16. Neutral Go/Fear Nogo	.18 [†]	.24*	.49***	.36***	-.17 [†]	-.19 [†]	.18 [†]	-.01	-.47***	-.44***	-.40***	-.38***	.75***	.76***	.85***	--	
AI																	
17. AI Scores	-.01	-.02	.15	.15	.09	.03	.19 [†]	.17 [†]	.05	-.02	.18 [†]	.15	-.08	-.04	.02	-.05	--

Note. RT = reaction time; AI = affect intensity; [†] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

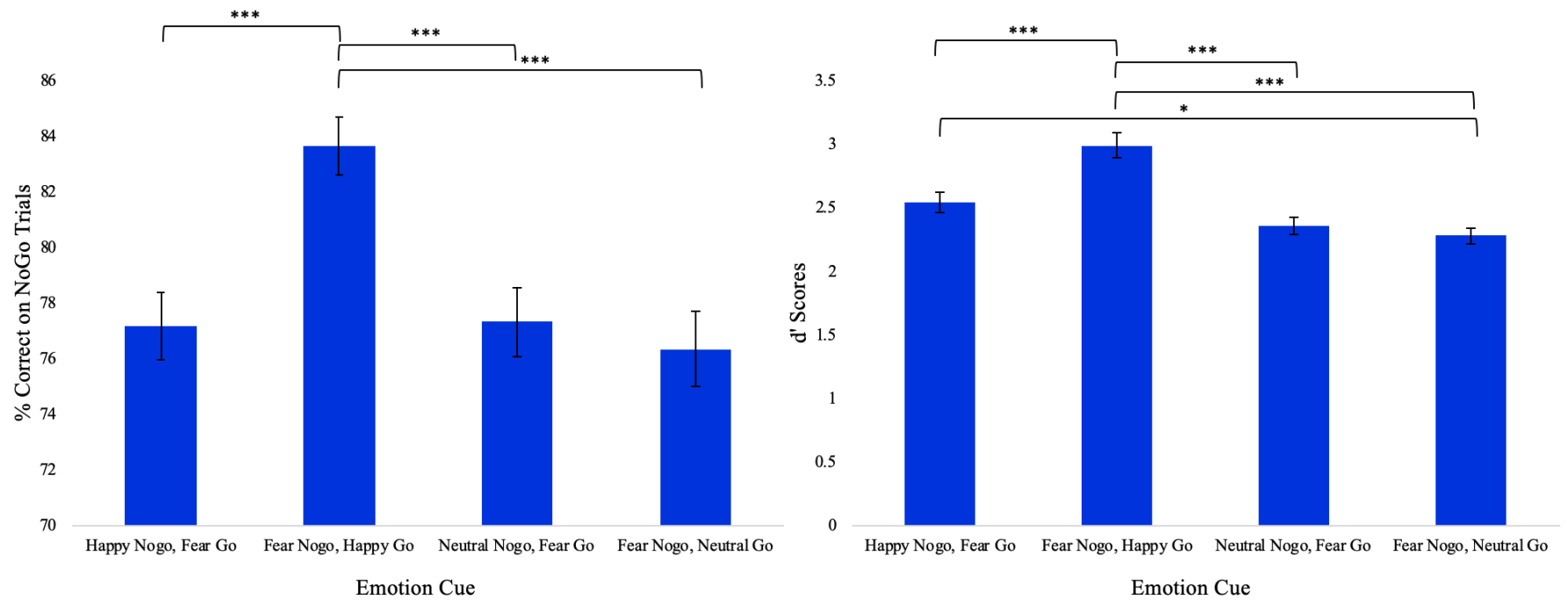


Figure 1. Breakdown of Emotion Cue combinations. Percent correct on Nogo trials (left) and d' scores (right) shows main effect of Emotion Cue. $*p < .05$, $***p < .001$.

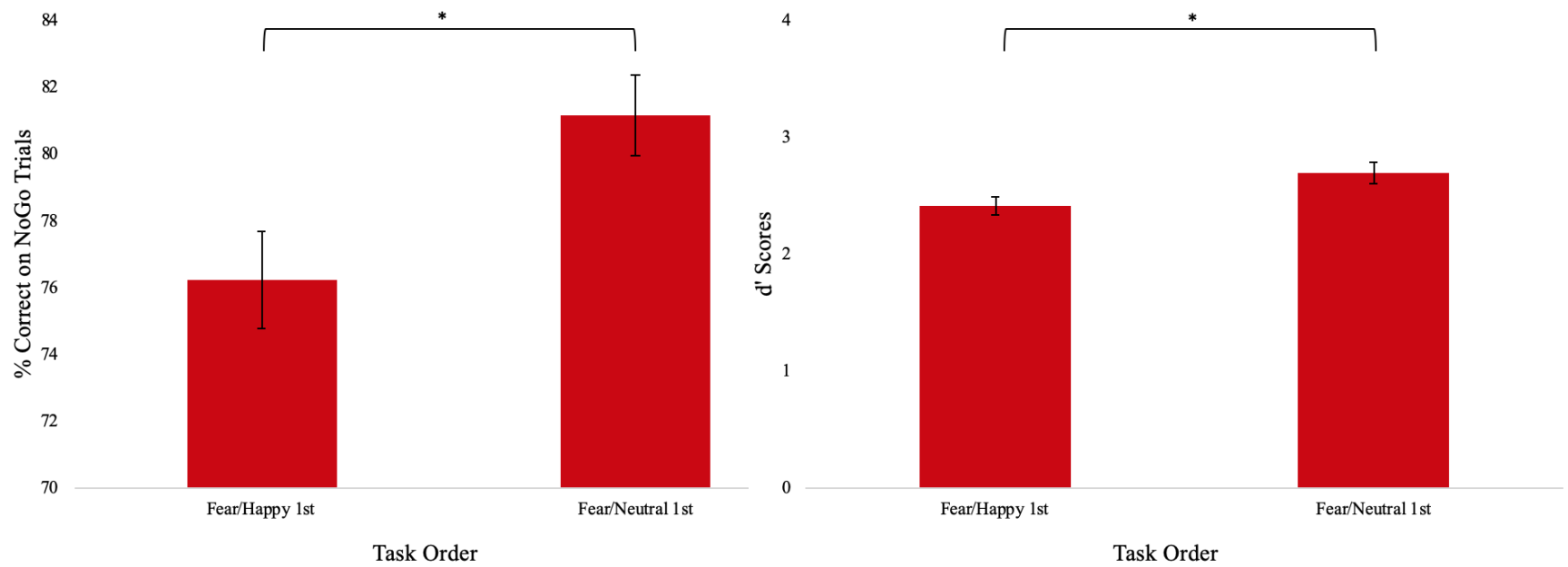


Figure 2. Breakdown of Task Order performance. Percent correct on Nogo trials (left) and d' scores (right) shows main effect of Task Order. $*p < .05$.

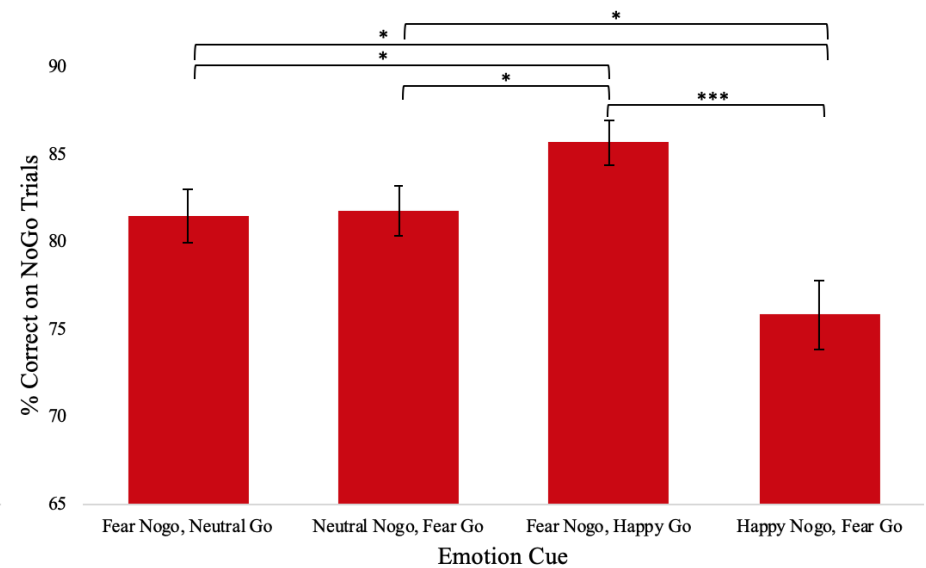
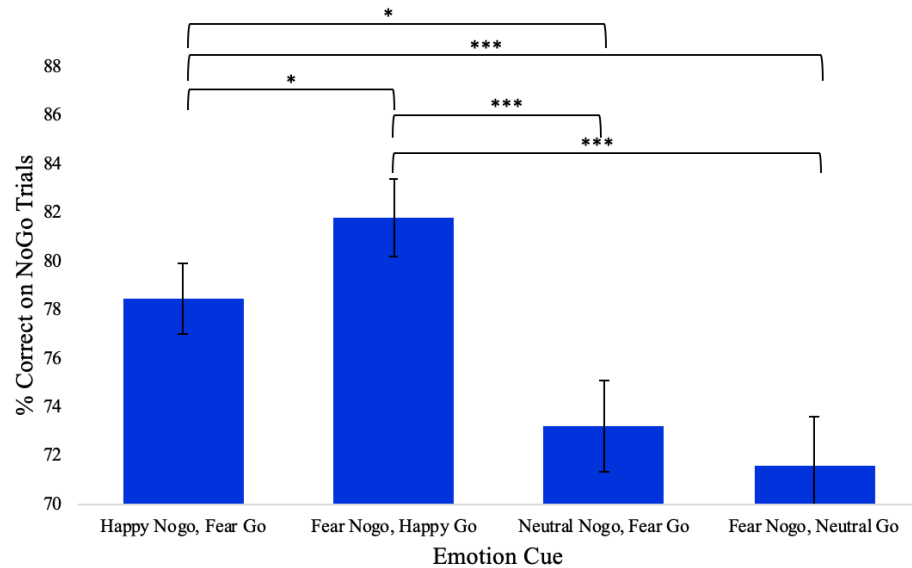
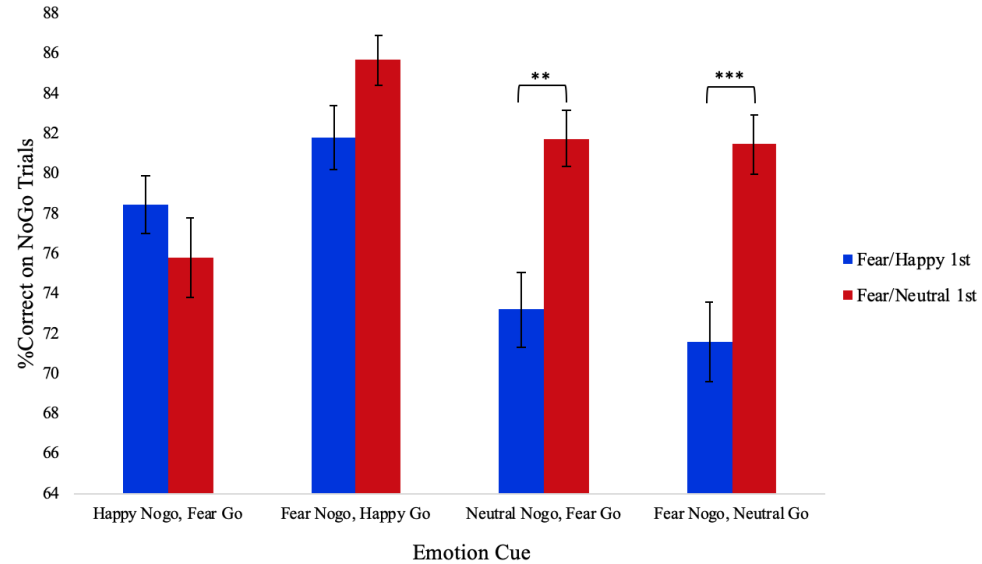


Figure 3. Breakdown of the interaction between Emotion Cue and Task Order for percent correct on Nogo trials. There were significant differences between Task Orders (top) and within Task Orders (Fear and Happy expressions presented first in bottom left; Fear and Neutral expressions presented first in bottom right). * $p < .05$, ** $p < .01$, *** $p < .001$.

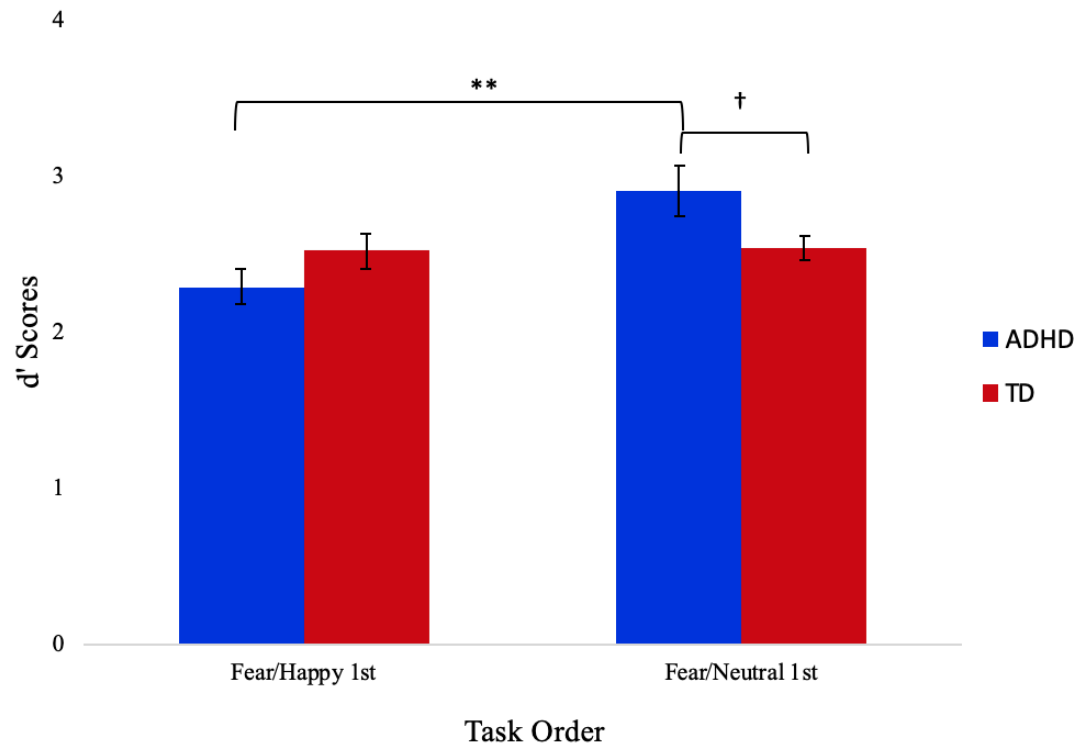


Figure 4. Breakdown of the interaction between ADHD Group and Task Order for d' . There was a marginal difference between ADHD Groups when Fear and Neutral expressions were presented first (TD = typically developing). There was a significant difference within young adults with ADHD between the two Task Orders. † $p < .10$; ** $p < .01$.

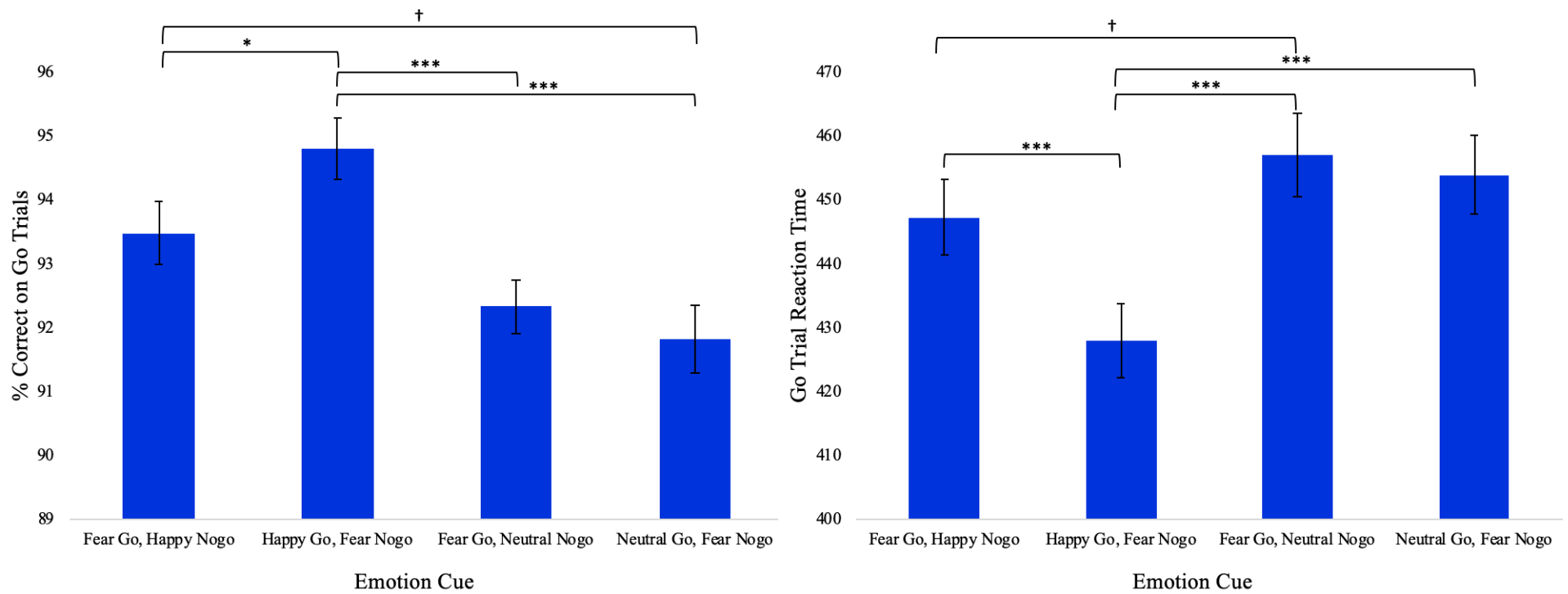


Figure 5. Additional breakdown of the Emotion Cue combinations. Percent correct on Go trials (left) and Go trial reaction time (right) shows a main effect of Emotion Cue. † $p < .10$, * $p < .05$, *** $p < .001$.

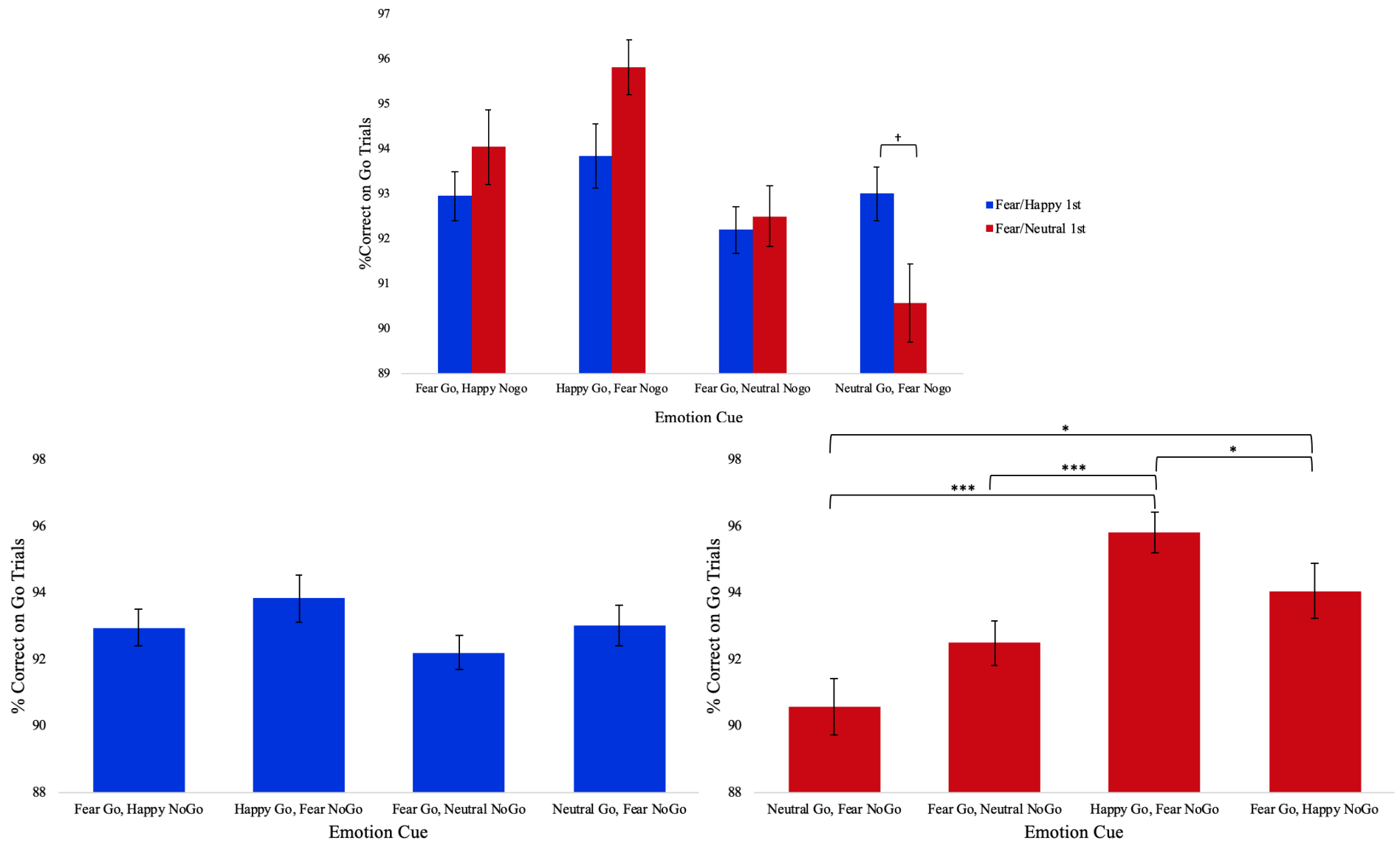


Figure 6. Breakdown of the interaction between Emotion Cue and Task Order for percent correct on Go trials. There were marginal differences between Task Orders (top). There were no significant differences when Fear and Happy expressions were presented first (bottom left), but significant differences when Fear and Neutral expressions were presented first (bottom right). † $p < .10$ * $p < .05$, *** $p < .001$.

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