2016

Irritability and Emotion Perception in Young Adults

Alexandra Roule
aroule@wellesley.edu

Irritability and Emotion Perception in Young Adults

Alexandra Roule

Submitted in Partial Fulfillment
of the
Prerequisite for Honors
in Psychology Department

April 2016

Acknowledgments

I would like to thank Professor Christen Deveney for her continued support and guidance in this project. I am very appreciative of being given the opportunity to delve into research as an undergraduate and to have the help of a wonderful teacher.

I would also like to thank my thesis committee members, Professors Margaret Keane and Jeremy Wilmer, and Professor Louise Marlow. Your expertise and insight shaped my project to be even more exciting than I imagined it could be. I would also like to thank the Psychology Department and the Provost's Office in funding this project, without which I would never have had this fantastic experience in the first place.

Thank you to those who have shared and lightened the thesis journey: Jenny Chen, Riley Abeles, and Grace Bennett-Pierre. Grace, thank you for being my first research collaborator and inspiring me towards pursing a thesis. Thank you to Caitlin Coyiuto, Lisa Jenkins, and Rie Maeda, I would be hard pressed to find better lab mates. To Ali Johnson and Mariela Hernandez Cruz thank you for your beautiful friendships. Thank you to my family for your love and support.

Lastly, thank you to my participants for your interest in my project and for giving your time to participate.

Abstract

Severe irritability is impairing to affected individuals and those around them. Literature on irritability and social functioning is growing with a focus on face emotion identification tasks. Most studies, however, have been conducted in children and adolescents, leaving a gap in the literature on adults. This study sought to determine how state irritability, induced during a frustrating computer task, and trait irritability, measured through self-report questionnaires, related to the performance of seventy-five undergraduate students on a face emotion morphing task. Responses to anger were of particular interest and explored through a hostile attribution bias. During the task participants viewed brief movies of faces morphing from a neutral to a 100% prototypical emotional facial expression and were asked to stop the movie when they detected the face emotion. Participants in the frustration condition and participants with high trait irritability were expected to require greater emotional intensity in a facial expression in order to identify non-angry emotions and less intensity in order to identify anger. Results indicated that, although the frustration manipulation was successful, participants in the frustration and non-frustration conditions identified emotions at equal intensities. Participants in the frustration condition also identified happiness – the most easily identifiable emotion, and anger at comparable intensities. Trait irritability was unrelated to overall emotion intensity but correlated with hostile attribution biases. These findings suggest that the study of irritability and emotion identification should distinguish between state and trait irritability.

Keywords: irritability, social functioning, emotion identification, aggression

Key of Abbreviations

ARI	Affective Reactivity Index
AQ	Aggression Questionnaire
BITe	Brief Irritability Test
CESD-S	The Center for Epidemiologic Studies Depression Scale
DERS	Difficulties in Emotion Regulation Scale
DMDD	Disruptive mood dysregulation disorder
MDD	Major depressive disorder
PANAS	The Positive and Negative Affect Scale
RMET	Reading the Mind in the Eyes Task
SFQ	The Social Functioning Questionnaire
SIP-AEQ	The Social Information Processing-Attribution and Emotional Response Questionnaire
SMD	Severe mood dysregulation
STAI-S/T	The State-Trait Anxiety Scale
WAIS	Wechsler Adult Intelligence Scale

Irritability and Emotion Perception in Young Adults

Irritability is common in the general population – an estimated 3.3% of children meet criteria for a disorder characterized by chronic irritability (Brotman et al., 2006). In addition, of the 19.2% of adults in a national survey who met criteria for major depressive disorder (MDD), 50% also reported irritability (Fava et al., 2010). In addition to occurring frequently in clinical diagnoses, the presence of irritability might predict future, negative clinical outcomes. In multiple studies, children with chronic irritability developed depression and anxiety in adulthood (Brotman et al., 2006; Copeland, Shanahan, Egger, Angold, & Costello, 2014; Stringaris, Cohen, Pine, & Leibenluft, 2009). Although irritability is common and confers long-term risks, it is still an underdeveloped area of study and existing treatment relies upon medicine used for other disorders (Deveney et al., 2015). Originally thought to be a form of childhood bipolar disorder, irritability in its severe and chronic form is now a defining symptom of several recently defined disorders (Copeland, Angold, Costello, & Egger, 2013; Leibenluft, 2011). Better understanding of the mechanisms of irritability will facilitate the development of effective treatments and possible prevention programs to reduce the effects of severe irritability.

The study of irritability in relation to social functioning is particularly important, since research suggests irritability is likely to impair relationships. Indeed, the diagnostic criteria for two conditions whose primary symptom is severe and chronic irritability (severe mood dysregulation (SMD); disruptive mood dysregulation disorder (DMDD)), require that children have frequent disruptions in two social spheres, including family, peer, and school relationships (American Psychiatric Association & American Psychiatric Association, 2013; Copeland et al., 2013; Leibenluft, 2011). In a longitudinal study, DMDD, as well as other childhood clinical illnesses such as depressive and anxiety disorders predicted poorer social functioning in adulthood compared to individuals without childhood psychiatric illnesses (Copeland et al., 2014). Still, this pattern implies that the association between social functioning deficits and severe irritability extends beyond childhood. The present study will explore two potential mechanisms by which irritability may directly impair social functioning: poorer ability to identify non-angry face emotions and enhanced ability to detect expression of anger.

Emotion Recognition Ability of Individuals with Irritability

One possibility is that individuals with irritability cannot read emotions in facial expressions, and this deficit causes them to react in ways that compromise interpersonal relationships. If a neutral facial expression is seen as angry, an individual may act in an aggressive manner that seems unprovoked (Crick & Dodge, 1996; Wilkowski & Meier, 2010; Wilkowski, Robinson, Gordon, & Troop-Gordon, 2007). Or, if a sad facial expression is mistaken as happy, then the individual's behavior may seem insensitive if he approaches without addressing the sadness. Behavioral data from children with SMD support a link between irritability and face emotion identification deficits. For instance, children with SMD correctly identify fewer emotions than healthy controls in still images of prototypical angry, happy, sad, and afraid facial expressions (Guyer et al., 2007; Kim et al., 2013). Their accuracy is also poorer in comparison to that of children with other psychiatric disorders, such as major depressive disorder and attention deficit hyperactivity disorder (Guyer et al., 2007). Furthermore, expressions of disgust, surprise, fear, and happiness must be closer to their 100% prototypical depictions for children with SMD to correctly identify the emotions, than for healthy controls (Rich et al., 2008), suggesting that children with chronic irritability need clearer facial cues to identify emotions in the expressions of others. The majority of these studies do not include a measure of social functioning, however, one study observed a link between poorer emotion recognition deficits on a task and poorer family relationships (Rich et al., 2008).

A second possibility is that, rather than being impaired at recognizing face emotions, individuals with severe irritability might attend to hostile faces more quickly than to non-hostile faces, like those expressing happiness. In this case, irritability might prime children to notice hostile, potentially threatening faces more quickly, but otherwise not interfere with face emotion recognition. Since angry faces prompt responses related to approach rather than avoidance behavior (Ford et al., 2010; Wilkowski & Meier, 2010), a tendency to see hostility may prompt sudden aggressive behavior. As an example, one study suggests that youths with SMD have an attention bias to angry faces but not to happy faces. Participants viewed two images next to one another: a neutral and an angry, or happy, face. Then, the images were replaced with a target stimulus. Relative to the healthy comparison children, those with severe irritability detected target stimuli faster when they appeared behind an angry face than a neutral one. Yet participants with irritability did not show an attention bias towards the happy faces. Therefore, children with SMD attend more closely to angry faces that could be interpreted as hostile (Hommer et al., 2014). A similar bias towards angry faces occurred in a study that morphed angry and happy faces together (e.g., 90% angry; 10% happy; 50% angry, 50% happy – percentages are approximate) and then asked participants to identify whether an expression was happy or angry. Relative to healthy controls, youths with DMDD identified expressions as angry when the faces contained lower levels of anger intensity. Furthermore, an intervention designed to increase the amount of anger intensity required to identify the expression as angry rather than happy increased the amount of anger required for youths with DMDD to interpret the stimuli as angry. Other than illustrating a bias towards reading expressions as angry, this study also demonstrates that this bias can be avoided so that the identification of non-angry emotions is not impaired (Stoddard et al., 2016). Moreover, a similar treatment was successful for youths with high levels of aggression (Penton-Voak et al., 2013), suggesting similar emotion identification mechanisms between individuals with high irritability and high aggression.

Expanding the Literature on Irritability and Incorporating Aggression

The study of irritability has typically focused on children with severe, clinical irritability (Copeland et al., 2013, 2014; Guyer et al., 2007; Hommer et al., 2014; Leibenluft, 2011; Rich et al., 2008). Yet, because children with irritability are later diagnosed with depression and anxiety (Brotman et al., 2006; Copeland et al., 2014; Stringaris et al., 2009), a comprehensive understanding of irritability across the lifespan requires studies with children and adults. Studying young adulthood in particular, provides insight into the developmental period when depression and anxiety typically begin (Brotman et al., 2006; Copeland et al., 2014; Stringaris et al., 2009); a national survey reported the average distribution of anxiety and mood disorders' age-of-onset to be between 18- to 21-years-old and 18 to 43-years-old, respectively (Kessler, Berglund, Demler, Jin, & Walters, 2005). To the best of the author's knowledge, no studies have examined face emotion deficits in adults with high levels of irritability. However, studies of related populations, such as individuals with high levels of aggression, may offer insight into the performance of adults with irritability – an emotional state that can involve, but is not limited to, anger and/or aggressive behavior (Barata, Holtzman, Cunningham, O'Connor, & Stewart, 2015)- on face emotion identification tasks. These studies suggest that adults with high levels of aggression do not have an overall deficit recognizing face emotions, but rather, they tend to judge faces as angry more readily (Hall, 2006; Larkin, Martin, & McClain, 2002; Schönenberg & Jusyte, 2013) and identify anger more quickly (Wilkowski & Robinson, 2012) than other emotions, suggesting a unique response to anger. Therefore, similar to the bias that youths with severe irritability have when identifying anger in ambiguous faces (Hommer et al., 2014; Stoddard et al., 2016), adults with irritability might also have a unique response to anger.

The ability of adults with high levels of aggression to read anger in ambiguous facial expressions is explained by two separate mechanisms: 1) a hostility bias, meaning they are more likely to perceive anger in ambiguous or non-angry expressions , and 2) a lower threshold for recognizing anger when it is displayed; i.e., that they can perceive anger at a lower threshold of intensity (Mellentin, Dervisevic, Stenager, Pilegaard, & Kirk, 2015; Schönenberg & Jusyte, 2013; Wilkowski & Robinson, 2010, 2012). The first theory of the hostile attribution bias developed from research on children with high levels of aggression. In these studies, participants are presented with ambiguous scenarios involving a character whose actions may or may not have been intentionally malicious. Participants are then asked to determine the character's intent. Responses attributing hostile intent to the character reflect participants' hostile attribution bias (Crick & Dodge, 1996; Dodge, 1980). Researchers have attempted to distinguish between children who have reactive aggression (aggression triggered by a stimulus) and proactive aggression (aggression implemented for gain). Children with high levels of reactive aggression perceive hostile intent more often than children with high levels of proactive aggression (Crick & Dodge, 1996). This distinction is relevant to the present study, because reactive aggression is often related to irritability (Leibenluft & Stoddard, 2013).

Aggression is also related to a hostile attribution bias in adults with high levels of anger and aggression. For instance, when presented with an image of a character completing an act that could be perceived as either accidental or hostile, participants (young adult males) focused longer on the novel, benign intent indicators (e.g. a man's unfocused gaze, implying he did not break a window on purpose) in the scenario rather than the hostile intent indicators (e.g. a man's gaze towards a window, implying he purposefully broke it). This focus was likely because these indicators did not fit into their previously-formed interpretation of the characters' intent (Wilkowski et al., 2007). Individuals with high levels of aggression are also more likely to identify other emotions as anger (Hall, 2006; Larkin et al., 2002) or mistake ambiguous expressions for aggressive expressions (Schönenberg & Jusyte, 2013). Indeed, individuals with high levels of hostility are more likely than individuals with low hostility to interpret expressions of disgust as anger, although this tendency appears to be pronounced in males (Larkin et al., 2002). A study on undergraduates also found that individuals with high aggression were more likely than individuals with low aggression to misidentify non-angry emotions as angry, which would support a bias to assume anger when reading facial expressions (Hall, 2006).

The second theory suggests that individuals with high aggression notice subtle anger cues that exist but are not detected by non-aggressive individuals (Wilkowski & Robinson, 2012). That is, individuals with high levels of anger and aggression do not perceive anger where it does not exist, rather they are better able to detect subtle anger cues compared to individuals with lower levels of anger and aggression. In turn, this ability could lead to aggressive outbursts because of the acuity and speed of their anger perception. Wilkowski and Robinson (2012) proposed this theory in a study of three experiments that ask undergraduate participants to identify the emotion of ambiguous faces consisting of: an equal combination of two emotions (anger, sadness, fear, happiness, and neutral), a combination of neutral and angry expressions, or a combination of angry and happy expressions. If aggression is associated with a better ability to detect anger, then individuals with high aggression would perceive anger in ambiguously angry faces at lower intensities and not generally mistake ambiguous faces as angry. Individuals with high levels of aggression identified anger in facial expressions at lower thresholds more frequently than individuals with low aggression, but did not identify ambiguous faces as angry when anger was not part of the expression composition (Wilkowski & Robinson, 2012). Another study compared male antisocial violent offenders, who had high aggression, to healthy controls of similar age but no antisocial, violent, or aggressive classification on a face emotion identification task. During the task, participants viewed morphed faces expressing both: happy and afraid, happy and angry, and afraid and angry. Individuals with high aggression were more likely to identify the emotion as angry, rather than happy or afraid, when the face contained some degree of anger, but were not more likely to identify the face as angry for composite expressions of happy and afraid. This study suggests better anger acuity in such individuals, rather than a bias to assume anger, since only faces that included anger were labeled as such (Schönenberg & Jusyte, 2013). Although these studies were conducted with adults with trait aggression and anger (Schönenberg & Jusyte, 2013; Wilkowski & Robinson, 2012), their proposal for a relationship between heightened attention to anger cues and irritability is supported by a recent study documenting the identification of anger in angry-happy morphed faces at lower intensities of anger among children with DMDD as compared to healthy controls (Stoddard et al., 2016). Together, the research suggests that irritability may be associated with general face emotion recognition deficits or a bias to identify anger.

Predicting the Interaction of Comorbid Diagnoses and Irritability

Irritability, anger, and aggression are not the only mood states associated with differential performance on face emotion recognition tasks. A number of studies have examined the differential recognition of face emotion in populations with anxiety and depression. These two populations are particularly relevant to this study, because anxiety and depression are common comorbid diagnoses in children with chronic irritability. One longitudinal study observed 23.1% prevalence rates of both anxiety and depression in children first diagnosed with severe irritability (Deveney et al., 2015). Children with chronic irritability are also often diagnosed with anxiety or depression in adulthood (Brotman et al., 2006; Copeland et al., 2014; Stringaris et al., 2009). Moreover, a recent meta-analysis has suggested that general emotion recognition deficits are prevalent in adult, but not childhood populations with anxiety (Demenescu, Kortekaas, den Boer, & Aleman, 2010). Therefore, studies of face emotion recognition in adult populations with anxiety and depression may provide clues as to how adults with irritability may perform on a face emotion task.

Similar emotion recognition tasks given to individuals with irritability and aggression have been given to individuals with anxiety (Mogg, Garner, & Bradley, 2007; Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006). Individuals with high levels of anxiety are more likely to attend to a 100% prototypical angry face, compared to more ambiguous versions of the angry faces than individuals with low anxiety. Yet, this bias is mirrored in their responses to fearful facial expressions as well (Mogg et al., 2007). Therefore, the singularity of the attention bias towards angry faces in individuals with aggression might not extend to individuals with high anxiety. Indeed, in a study comparing the emotion recognition accuracy of individuals with high and low anxiety, only responses to fearful expressions were significantly different. Individuals with high anxiety were more accurate in their perception of fear compared to other emotions, including anger, than individuals with low anxiety (Surcinelli et al., 2006).

Emotion identification tasks on individuals with depression indicate that these individuals have unique responses to identifying happy expressions (Joormann & Gotlib, 2006; LeMoult, Joormann, Sherdell, Wright, & Gotlib, 2009; Surguladze et al., 2004). Indeed individuals with depression are less accurate when identifying happy expressions (Surguladze et al., 2004). Moreover, studies on the minimum intensity of emotion required for individuals to correctly identify expressions suggest that compared to healthy controls, individuals with depression require greater happiness intensity. This distinction was not found for sad or angry emotions (Joormann & Gotlib, 2006; LeMoult et al., 2009).

Although the focus of the present study is the relationship between irritability and the perception of anger, it is possible that adults with high levels of irritability would show similar emotion identification impairments to individuals with anxiety and depression. Better perception of fear and poorer perception of anger might suggest a shared mechanism between irritability and anxiety and depression. In this study, the performance of individuals with irritability is expected to reflect that of individuals with aggression rather than anxiety and depression, because previous literature on irritability in youths only provides evidence of greater attention and faster recognition of angry facial expressions (Hommer et al., 2014; Stoddard et al., 2016) and overall emotion recognition deficits (Kim et al., 2013; Rich et al., 2008).

The Present Study

The proposed study represents a preliminary effort to examine the relationship between irritability and face emotion recognition by using a non-clinical undergraduate population. Participants completed either a frustration or a non-frustration condition, followed by a face morph task. Because irritability has been defined as a low tolerance for frustration (Barata et al., 2015), frustration manipulations are used frequently to elicit irritability in a laboratory setting (Brown, 2015; Deveney et al., 2013; Leibenluft & Stoddard, 2013; Yu, Mobbs, Seymour, Rowe, & Calder, 2014). Irritable mood states induced by the frustration manipulation, as well as self-reported trait irritability were expected to be associated with emotion identification impairments, except for anger, which was expected to be recognized more quickly. Emotion recognition ability was also expected to be negatively associated with measures of social functioning. The results of this study will help guide future clinical research on irritability. Moreover, clarifying the relationship between irritability and emotion recognition might inform the use of emotion recognition training tasks to help bolster social functioning skills in individuals with severe irritability.

Method

The study was advertised as an experiment on basic attention and emotion. Advertisements for the study were posted on online listservs. Eligible participants met the following criteria: (1) were at least 18 years of age or had a parent consent form on file with the Psychology Department; and (2) had not completed a study in our lab involving a similar frustration manipulation. The latter criterion was included to increase the chance that participants would be deceived by the frustration manipulation.

Participants

Eighty-six Wellesley College undergraduates consented to this study, however, data from eleven participants were excluded because they did not meet one or more of the *a priori* inclusion criteria (did not complete the frustration manipulation (n = 1); did not complete at least half of the face morph task (n = 3); and/or were not deceived by the frustration manipulation (n = 8)). Therefore, the remaining analyses were conducted with data from 75 participants (M age = 20.05 yrs, SD = 1.22). Of the participants with usable data, 74 (98.67%) identified as female and one identified as neither male nor female (1.33%). Thirty-six (48%) participants identified as Caucasian, 23 (30.67%) as Asian/Asian-American, 9 (12%) as Hispanic/Latino, 5 (6.67%) as biracial/multiethnic, and 2 (2.66%) as African/Caribbean/African-American.

Procedure

Over the course of approximately 60 minutes, participants completed questionnaires, the Reading the Mind in the Eyes Task (RMET), a randomly-assigned frustrating or non-frustrating condition of a frustration manipulation task, a novel face morph task, and a test of processing speed (the digit symbol coding subset of the Wechsler Adult Intelligence Scale (WAIS)) (see Figure 1). Participants were compensated $10 for every hour of participation and received a $5 bonus as part of the frustration manipulation task. Immediately after study completion or termination, if the study ended early, participants were debriefed and given a $5 bonus. Participants were offered the chance to withdraw their data upon being informed of the deception involved in this study. No participants chose to withdraw their data. Based on the effect size calculated from a previous study on children with SMD ($d = .40$, Rich et al., 2008), a sample size of at least 100 individuals was needed for a power of 0.8 to detect significant differences between conditions at traditional significance levels ($p < .05$). Due to time constraints, we were unable to run the full participant sample.

Self-Report Data

Participants completed six categories of self-report questionnaires: 1) background information, 2) state and trait affect, 3) trait irritability, 4) trait aggression, 5) hostile attribution bias, and 6) social aptitude.

Background information. Participants were first asked to complete a three-item Background Questionnaire, which asked them to state their date of birth, gender, and ethnicity. The questionnaire was used to determine whether background information affected the study results.

State and trait affect.

The Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). Participants rated their current mood using the PANAS at three time points during the study: during the initial questionnaires (baseline), after the frustration manipulation (post-manipulation), and after the face morph task. The original PANAS consists of 20 items and asked participants to rate the relevance of an emotion (e.g. irritable, excited) to how they felt on a Likert scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). The questionnaire allows experimenters to specify the time frame that participants should contextualize how they feel (e.g. in general; this week). This study asked participants to make ratings of their current emotional state (i.e., how they felt at that moment). Test-retest reliability for positive affect emotions (PA) and negative affect emotions (NA) for state ratings in the moment are moderate (α = .54 and α =.45, respectively). PA and NA internal consistency reliability estimates are high (α = .89 and α = .85, respectively) (Watson et al., 1988). After the frustration manipulation and face morph tasks, participants rated how strongly they felt on only ten affective states, which were thought to relate most directly to this study: proud, excited, attentive, interested, determined, upset, irritable, hostile, frustrated, and ashamed.

The State-Trait Anxiety Scale (STAI-S/T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). As mentioned earlier, children diagnosed with chronic irritability often display anxiety and depression as adults (Brotman et al., 2006; Copeland et al., 2014; Stringaris et al., 2009). Anxiety has been linked to abnormal emotion identification – such as more accurate recognition of fear (Surcinelli et al., 2006). To determine whether anxiety influences performance on the face morph task, participants were given the STAI-S/T, which asks about participants' current feelings (state; 20 items) and general feelings (trait; 20 items) of anxiety. Items included statements such as "I feel calm" or "I feel nervous." Participants rated how strongly they identified with the statements (*not at all*, *somewhat*, *moderately so*, *very much* so) (Spielberger et al., 1983). A meta-analysis of studies using the STAI-S/T finds that the internal consistency and test-retest reliability for state items is on average, $\alpha = .91$ and .70, respectively. Internal consistency and test-retest reliability for trait items is on average, $\alpha = .89$ and .88, respectively (Barnes, Harp, & Jung, 2002).

The Center for Epidemiologic Studies Depression Scale (CESD-S; Radloff, 1977). The 20-item CESD-S assessed participants' feelings of depression (e.g. "I was bothered by things that usually don't bother me" or "People were unfriendly"). The scale asked participants to rate how often they identified with given statements (*Rarely/none of the time: less than 1 day, Some or a little of the time: 1-2 days, Occasionally or a moderate amount of time: 3-4 days, Most or all of the time: 5-7 days*). Internal consistency reliability is $\alpha = .85$ and for clinical samples has been found to be $\alpha = .90$. Test-retest correlation is $r = .59$ over eight weeks (Radloff, 1977). The CES-D also correlates with measures of self-esteem (.58) and trait anxiety (.71) (Orme, Reis, & Herz, 1986).

The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The DERS was used to determine whether irritability and emotion identification performance were related to participants' mood regulation difficulties. The scale has 36 items that are grouped into six categories: 1) *Nonacceptance of emotional responses* (e.g. "When I'm upset, I feel guilty for feeling that way"), 2) *Difficulties engaging in goal-directed behavior* (e.g. "When I'm upset, I have difficulty concentrating"), 3) *Impulse control difficulties* (e.g. "When I'm upset, I lose control over my behaviors"), 4) *Lack of emotional awareness* (e.g. "I am attentive to my feelings" which is reverse-scored), 5) *Limited access to emotion regulation strategies* (e.g. "When I'm upset, I believe that I'll end up feeling very depressed"), and 6) *Lack of emotional* *clarity* (e.g. "I have difficulty making sense out of my feelings"). Participants rated how often they experienced these statements on a scale of 1 (*almost never*) to 5 (*almost always*). Internal consistency for DERS is $\alpha = .93$. For each of the six categories: Nonacceptance, Goals, Impulse, Awareness, Strategies, and Clarity, internal consistency is $\alpha = .85, .89, .86, .80, .88$, and $.84$, respectively. Test-retest reliability is $\rho_I = .88$, $p < .01$. For each of the six categories: Nonacceptance, Goals, Impulse, Awareness, Strategies, and Clarity, test-retest reliability is ρ_Is = .69, .69, .57, .68, .89, .80, respectively) (Gratz & Roemer, 2004).

Trait irritability.

The Brief Irritability Test (BITe; Holtzman, O'Connor, Barata, & Stewart, 2015). Self-reported trait irritability was assessed using the BITe, which consists of five items (e.g. "I have been feeling irritable" or "I have been feeling like I might snap") rated on a Likert scale ranging from 1 (*never*) to 6 (*always*). Overall reliability and validity are high for the BITe, with internal reliability being $\alpha = .88$. Convergent validity with the Irritability Questionnaire (IRQ) and the Bron-Steiner Irritability Scale (BSIS) is high (r = .80 and .86, respectively) (Holtzman et al., 2015).

The Affective Reactivity Index (ARI; Stringaris et al., 2012). The ARI questionnaire also measured trait irritability, but has primarily been used to assess children in clinical settings where children and their parents report irritability over a specified period of time. In order to compare the irritability in the population of this study with that of prior studies, we collected ARI scores, which were the sum of the first six responses to seven items on a 0-3 scale (0 - *not true, 1 - somewhat true,* or 2 - *certainly true*). The first six items measured irritability symptoms (e.g. "I am easily annoyed by others"), while the seventh item measured impairment caused by irritability ("Overall, irritability causes me problems"). Participants were asked to base their responses on how they felt over the last six months. Internal reliability is high for reported scores from a sample of American children ($\alpha = .88$) and their parents ($\alpha = .92$) and from a sample of UK children ($\alpha = .90$) and their parents ($\alpha = .89$) (Stringaris et al., 2012).

Trait aggression.

The Aggression Questionnaire (Buss & Perry, 1992). The Aggression Questionnaire determined whether trait aggression rather than irritability might be associated with performance on the face morph task. This 29-item questionnaire contains four categories: 1) *physical aggression* (e.g. "Once in a while I can't control the urge to strike another person"), 2) *verbal aggression* (e.g. "I tell my friends openly when I disagree with them"), 3) *anger* (e.g. "I flare up quickly but get over it quickly"), and 4) *hostility* (e.g. "I am sometimes eaten up with jealousy"). Participants chose their responses from 1 (*extremely uncharacteristic of me*) to 5 (*extremely characteristic of me*) on a Likert scale. Internal consistency for physical aggression, verbal aggression, anger, and hostility are: $\alpha = .85, .72, .83, .77$, respectively. Test-retest reliability for physical aggression, verbal aggression, anger, and hostility are $r = .80, .76, .72, .72$, respectively (Buss & Perry, 1992).

Hostile attribution bias.

***The Social Information Processing-Attribution and Emotional Response Questionnaire (SIP-AEQ; Coccaro, Noblett, & McCloskey, 2009)*.** The SIP-AEQ assessed hostile attribution bias in participants' interpretations of social interactions. The items in the questionnaire combine into four categories: 1) *hostile attribution*, 2) *benign attribution*, 3) *instrumental attribution*, and 4) *negative emotional response*. Participants imagined themselves as the subject in eight short scenarios involving a potentially negative social situation (e.g. someone cuts in front of you in line). Participants were asked to explain the reason for the other characters' actions, to identify the other characters' intentions, and to rate how angry or upset/embarrassed they would feel in that scenario on a scale of 0 (*not at all likely*) to 3 (*very likely*) (Coccaro et al., 2009).

The SIP-AEQ has been used to compare healthy controls with anger-prone individuals with diagnoses from the DSM-IV, primarily related to impulsive aggression. In one particular study, internal consistency of items relating to hostile attribution, benign attribution, instrumental attribution, and negative emotional response are: α = .90, .80, .76, and .91. Test-retest stability for hostile attribution, benign attribution, instrumental attribution, and negative emotional response are r = .74, .98, .82, and .94, respectively. Internal hostile attribution is positively correlated with the Hostile Automatic Thought questionnaire (r = -.59, p = .001), and negatively with the Positive Automatic Thought questionnaire (r = -.29, p = .003) (Coccaro et al., 2009).

Social functioning.

The Social Functioning Questionnaire (SFQ; Tyrer et al., 2005). Participants completed the SFQ to determine whether trait irritability relates to overall social functioning and the face morph task. This questionnaire consists of eight items (e.g. "I complete my tasks at work and home satisfactorily" and "I have difficulties in getting and keeping close relationships"). Participants rated how true these statements were on a point scale specific to each question (e.g. in response to "I complete my tasks at work and home satisfactorily" participants could respond: *0 – most of the time, 1 – quite often, 2 – sometimes,* or *3 – not at all*). The validity of this questionnaire has been supported although specific statistics are not available (Tyrer et al., 2005).

Frustration Manipulation

Task. A modified version of the Stop Signal task was used to elicit state frustration, because of its previous success in a laboratory setting (Brown, 2015, see Figure 2). The task (consisting of 80 trials) was programmed using *E-Prime 2.0* ® (Sharpsburg, PA). Participants were randomly assigned to a frustration or a non-frustration condition. In both conditions, a fixation cross appeared on a computer screen for 2,000 ms at the start of each trial and was replaced by either an "X" or an "O." During *Go* trials (75% of trials), participants were instructed to press the left arrow key for an "X" and the right arrow key for an "O." During *Stop* trials (25% of trials), a red box, or *stop signal*, appeared around the letter and participants were instructed to refrain from pressing any key. The stop signal, however, appeared after one of three delays. In the frustration condition, the stop signal appeared after: 300 ms (n = 4 trials), 550 ms (n = 8 trials), or 650 ms (n = 8 trials) delays. Longer stop signal delays increased the difficulty of response inhibition, which elicited frustration in a prior study (Brown, 2015). In the non-frustration condition, the stop signal appeared after shorter delays: 300 ms (n = 4 trials), 325 ms (n = 8 trials), or 400 ms (n = 8 trials) delays. In addition, participants were told that they could earn a $5 bonus if their performance reached a target set by the experimenter. However, in order to induce frustration, this goal was not attainable in the frustration condition and periodic feedback slides informed participants that their performance did not meet the criteria for the bonus. In the non-frustration condition, participants were given positive feedback on their performance.

Face Morph Task

Stimuli. Twelve models from the NimStim set of facial expressions (Models: 3, 7, 9, 13, 14, 19, 27, 36, 37, 39, 40, 45) were used during the face morph task (Tottenham et al., 2009). Expressions of six prototypical emotions were used from each model: sad, happy, fearful, angry, disgusted, and neutral. The ethnicities of these models included: European-American (2 female, 2 male), African-American (2 female, 2 male), Asian-American (1 female, 1 male), and Latino-American (1 female, 1 male). The order of the set of stimuli was randomized for each participant, with a short rest period in the middle of the set.

The stimuli were transformed into brief, individual sequences of images, which will be referred to as movies. Seventy-two movies were made using *Abrosoft FantaMorph Professional* software (12 movies were created for each emotion category). The design of the stimuli was based upon that of In-Albon and colleagues (2015). Movies were meant to match the complexity of human's facial expressions more closely than still images of a 100% prototypical emotion. Each movie lasted 5,000 ms and depicted a neutral facial expression changing gradually into an emotional expression (sad, happy, fearful, angry, disgusted, or neutral) over the course of 50 frames. Emotion intensity increased by 2% every frame except in two frames (depicting 27% and 76% of the prototypical emotion) that increased by 3% (Figure 3). Movies ending in neutral were a compilation of open and closed-mouth neutral and calm expressions, which ensured participants' responses to a neutral expression were not based on a lack of movement in the expression (In-Albon et al., 2015).

Task procedure. The face morph task was similar to ones used in prior research (Blair, Colledge, Murray, & Mitchell, 2001; In-Albon, Ruf, & Schmid, 2015; Rich et al., 2008). The task was programmed using *E-Prime 2.0* ® (Sharpsburg, PA) and presented on a computer screen in front of the participants. The task included 72 trials. Each trial consisted of a fixation cross (500 ms) followed by a 5 s movie. Participants were instructed to press the stop bar when they could first identify the emotion in the model's expression. Doing so stopped the movie and allowed participants to identify the model's expression by choosing one of six emotions presented on the screen. Participants pressed a button to indicate their choice and then watched the same movie replay uninterrupted to the end, when the 100% prototypical emotion was displayed and participants were given the opportunity to confirm or change their response before proceeding to the next trial.

Three variables were calculated from the Face Morph Task: *overall task performance* (accuracy on the task, regardless of face emotion), *emotion intensity* (the average movie frame at which participants correctly identified each emotion), and *percent emotion misattributed* (the proportion of times a particular emotion was misattributed to an emotion).

Face Morph Task Validity

Because this study used a novel face morph task, we wished to ascertain the concurrent and divergent validity of the task.[1] The revised Reading the Mind in the Eyes Task (RMET) was used to measure concurrent validity (Baron-Cohen & Wheelwright, 2001). The RMET is a face emotion identification task that has been used to investigate face emotion recognition ability in a number of different populations (Baron-Cohen & Wheelwright, 2001; Bos et al., 2016). During the task, participants viewed 36 photographs of eyes (male = 18, female = 18). Participants described the eyes using four possible emotion choices for each item (e.g. *jealous, panicked, arrogant,* or *hateful*; see Figure 4). Participants were provided a list of definitions of the emotions (Baron-Cohen & Wheelwright, 2001). If participants performed well on the RMET, it was expected that they would also perform well on the face morph task. Therefore, the more emotions that participants correctly identified on the RMET, the more accurately they would identify emotions on the face morph task.

[1] We appreciate Professor Wilmer's suggestion to compare RMET and WAIS scores with face morph task performance.

The Digit Symbol Coding Task from the Wechsler Adult Intelligence Scale (WAIS) IV was used to measure divergent validity. During this task, participants viewed a key linking a unique symbol with nine separate numbers. Below the key was a list of numbers with blank boxes beneath them. Participants had 120 s to fill as many of the blank boxes with the symbol that corresponded to each number as possible (Wechsler, 2008a). Higher scores on this task reflect faster processing speeds. Therefore, if participants' performance on the developed face morph task was faster due to faster processing speed, the face morph task and digit symbol coding performance would be highly correlated. The main dependent variable for this task was the number of symbols participants wrote that correctly corresponded with the numbers in the key.

Hypotheses and Planned Analyses

To ensure randomization in the face morph task was successful and that the results were not due to demographic, clinical, or overall task performance differences between conditions, univariate ANOVAs and chi-square analyses compared the frustration and non-frustration groups on the following variables: age, gender, ethnicity, positive and negative affect scores, state and trait anxiety, depression, irritability, aggression, hostility bias, social functioning, overall face morph accuracy, RMET performance, and digit symbol coding performance. Neutral trials (faces composed of open and closed mouth neutral and calm faces) were excluded from this analysis and all proceeding analyses. They were originally included in the study to control for any effect the movement of faces may have had on participants' responses. However, the movement of the neutral stimuli was minimal, less than that of other emotions, and inconsistent across neutral trials.

Hypothesis 1. Self-reported feelings of irritability will increase during the frustration condition. Participants' total negative affect and specifically, the ratings for how irritable they felt, were expected to increase after the frustration condition, which would indicate the manipulation successfully induced irritability. A mixed factorial ANOVA with *condition* (frustration, non-frustration) as the between subject factor and *time* (baseline, post-manipulation) as the within subject factor compared self-reported feelings of irritability. A *time* x *condition* interaction was expected such that, relative to the non-frustration group, individuals in the frustration condition demonstrated equal irritability at baseline, but higher frustration following the frustration manipulation. After the frustration manipulation, a main effect of *condition* was expected to show irritability levels were higher, with individuals in the frustration condition demonstrating a significant increase between baseline and post-manipulation irritability that was not expected to be present in the non-frustration group.

Hypothesis 2. Frustration will increase the intensity required for participants to correctly identify non-angry emotions, and reduce the intensity required to identify anger. Participants in the frustration condition were expected to require greater emotion intensity to correctly identify non-angry emotions than participants in the non-frustration condition, indicating that when irritated, participants required greater expressiveness in the stimuli to recognize emotions. The induced irritability, however, would result in the accurate identification of anger at lower emotion intensity. A repeated measures ANOVA with *condition* (frustration, non-frustration) as the between subject factor and *emotion* (sad, happy, fearful, angry, disgusted) as the within subject factor compared participants' intensity requirements. A *condition* x *emotion* interaction was expected, such that the required emotion intensity for participants in the frustration condition was expected to be longer for sad, happy, fearful, and disgusted faces, yet less for angry faces, compared to participants in the non-frustration condition. To reduce the number of statistical tests conducted, we collapsed across all non-angry emotions (sad, happy, fearful, angry, and disgusted) before comparing emotion intensity for non-angry faces between the frustration and non-frustration conditions.

Hypothesis 3. High self-reported trait irritability scores will correspond with greater emotion intensity needed to correctly identify non-angry emotions. High BITe scores were expected to predict higher emotion intensity in the frustration condition, implying that trait irritability delayed participants' perception of non-angry face emotions following an emotion provocation. A multivariate regression analysis predicting average emotion intensity at correct identification of non-angry emotions was computed with BITe scores and condition (frustration, non-frustration) as indicator variables entered simultaneously. This multivariate regression analysis was repeated using self-reported ARI scores, since this measure is commonly used in literature on irritability (e.g. Stoddard et al., 2016; Stringaris et al., 2012).

Hypothesis 4. High self-reported trait irritability scores will correspond with recognizing anger at lower intensities. High BITe scores were expected to be associated with participants requiring lower emotion intensity given the frustration condition compared to non-angry face emotions. Support for this hypothesis comes from adults with high trait aggression who perceive anger more quickly than other emotions (Wilkowski & Robinson, 2012) and children with high trait irritability who attend more quickly to hostile rather than non-hostile expressions (Hommer et al., 2014). A regression analysis predicting response time to anger was computed with BITe scores and condition (frustration, non-frustration) as indicator variables. A second regression analysis substituted ARI scores for BITe scores.

Hypothesis 5a. Frustration will not be associated with a hostile attribution bias during the face morph task. If supported, the preceding hypotheses about the relationship between irritability and anger-identification would give evidence to the theory that these individuals are more perceptive of anger. However, in order to test whether irritability was associated with a hostile attribution bias (i.e., the tendency to consistently misinterpret emotions as angry (Hall, 2006; Schönenberg & Jusyte, 2013)), we calculated the percentage of error trials that were misperceived as sad, happy, angry, fearful, or disgusted. These values were then compared using a mixed factorial ANOVA with *condition* (frustration, non-frustration) as the between subjects factor and *emotion* (anger, fear, disgust, sadness, happiness) as the within subject factor. No effect of emotion was expected, meaning that the proportion of errors in each emotion category would not differ significantly across emotions and supporting the theory that irritability is not associated with a hostile attribution bias.

Hypothesis 5b. Self-reported irritability scores will be associated with hostile attribution bias in the SIP-AEQ scenarios. The SIP-AEQ asks participants how they would interpret and respond to a social interaction, which may or may not be interpreted as hostile. Negative interpretations of such interactions imply a hostile attribution bias and are associated with high levels of aggression (Coccaro et al., 2009; Dodge, Price, Bachorowski, & Newman, 1990). In the present study, participants with high levels of irritability were expected to be more perceptive of ambiguous angry faces. This perception bias might extend to ambiguous social situations that are potentially hostile – like those in the SIP-AEQ. Unlike the face morph task, the SIP-AEQ cannot distinguish between faster perception of hostile cues and a hostile attribution bias to interpret ambiguous cues as hostile. Moreover, participants were given an unlimited amount of time to complete the SIP-AEQ and would be able to ruminate on the hostile aspects of the ambiguous scenario descriptions, which may in turn have led them to determine the intent of the character was hostile (Wilkowski & Robinson, 2010; Wilkowski et al., 2007). Therefore, SIP-AEQ hostile attribution subscores were specifically expected to relate to irritability. A simple linear regression analysis predicting SIP-AEQ scores from BITe scores was computed for each subscore of the SIP-AEQ: 1) hostile attribution, 2) benign attribution, 3) instrumental attribution, and 4) negative emotional response.

Hypothesis 6. Poorer self-reported social functioning scores will relate to participants requiring greater emotion intensities to recognize face emotions after the frustration condition. Children with chronic irritability who exhibit emotion recognition deficits are more likely to have poorer familial relationships (Rich et al., 2008). Therefore, low self-reported social functioning was expected to correspond with participants requiring greater emotion intensity to correctly identify emotion given the frustration condition. This pattern would suggest poor emotion recognition is related to overall social functioning deficits. A multiple linear regression analysis predicted emotion intensity for sad, happy, afraid, angry, and disgusted faces with self-reported SFQ scores and condition (frustration, non-frustration) as indicator variables.

Other analyses. In order to determine whether any significant findings that emerged from the preceding analyses were due to irritability rather than related variables such as: demographic variables, feelings of depression and anxiety, and trait aggression, significant findings were initially intended to be re-tested using hierarchical regression models that included the related variables described above. For example, to evaluate the unique contribution of self-reported irritability on response time, we would conduct a hierarchical regression analysis predicting average response time to face emotions with the related variables entered first and BITe scores entered second.

Results

Participants in the frustration (*n* = 36) and non-frustration (*n* = 39) conditions did not differ on demographic variables, self-reported positive and negative affect, anxiety, depression, aggression, hostile attribution bias, social functioning scores, or on RMET and digit symbol coding performance (see Table 1). Overall accuracy on the face morph task did not differ between the frustration (87.41%, *SD* = 6.79) and non-frustration groups (88.53%, *SD* = 4.77), $F(1, 74) = .69$, $p < .41$.

Hypothesis 1: Self-Reported Irritability Increased During the Frustration Condition

Main effects of *time* (baseline, post-manipulation), $F(1, 73) = 12.88$, $p < .001$, $\eta_p^2 = .15$ and *condition* (frustration, non-frustration), $F(1, 73) = 23.00$, $p < .001$, $\eta_p^2 = .24$ were observed. However, these effects were qualified by an interaction between *time* and *condition*, $F(1, 73) = 16.48$, $p < .001$, $\eta_p^2 = .18$. Follow-up ANOVAs revealed that the frustration group reported a significant increase in frustration between time points, $F(1, 35) = 16.51$, $p < .001$, $\eta_p^2 = .32$ that was not seen in the non-frustration group, $F(1, 38) = .33$, $p > .50$, $\eta_p^2 = .01$ (Figure 5). As expected, the frustration group's post-manipulation frustration ratings were higher than those of the non-frustration group, $F(1, 73) = 39.25$, $p < .001$, $\eta_p^2 = .35$. Unexpectedly, the frustration group also reported higher levels of frustration at baseline than the non-frustration group, $F(1, 73) = 4.52$, $p < .04$, $\eta_p^2 = .06$. Therefore, we conducted a univariate ANCOVA to test group differences in post-manipulation frustration ratings after accounting for baseline frustration. This analysis revealed that frustration ratings remained significantly higher in the frustration group compared to the non-frustration group post-manipulation, $F(1, 72) = 33.67$, $p < .001$, $\eta_p^2 = .32$, even after accounting for baseline frustration levels. Together, these findings indicate that the manipulation successfully induced frustration, and therefore, higher state irritability.

Hypothesis 2: Emotion Intensity Varied Between Emotions

The main effect of *condition* (frustration, non-frustration) was not significant, $F(1, 73) = .99$, $p > .30$, $\eta_p^2 = .01$), however, an effect of *emotion* (sad, happy, fearful, angry, disgusted) was significant, $F(3.549, 259.092) = 43.14$, $p < .001$, $\eta_p^2 = .37$. Pairwise comparisons revealed that happiness was identified at a lower intensity ($M = 30.61$, $SD = 9.69$) than all other emotions ($p < .001$) for all participants (Figure 6). The main effect of *emotion* was qualified by an *emotion* and *condition* interaction, $F(3.549, 259.092) = 2.03$, $p < .10$, $\eta_p^2 = .03$, at the level of a trend.

Of particular interest to our original hypothesis, was whether emotion intensity differed between groups on non-angry versus angry faces. When all non-angry emotions were combined, no significant difference emerged between groups for emotion intensity, $F(1, 73) = .72$, $p = .40$, $\eta_p^2 = .01$. However, a slight trend was observed for individuals in the frustration group to recognize anger at lower intensities than those in the non-frustration group, $F(1, 73) = 1.90$, $p = .17$, $\eta_p^2 = .03$.

Although our main hypothesis pertained to non-angry and angry emotions, the *condition* x *time* interaction was explored to consider all of the emotions separately and explore whether emotion perception patterns within each group differed. We computed post hoc exploratory ANOVAs testing group differences for each emotion, followed by ANOVAs testing differences across emotions within the frustration and non-frustration groups. The emotion intensity required to detect each emotion did not differ between groups. However, main effects of *emotion* on emotion intensity emerged within the frustration, $F(4, 140) = 15.63$, $p < .001$, $\eta_p^2 = .31$ and non-frustration groups, $F(4, 152) = 30.22$, $p < .001$, $\eta_p^2 = .44$.

The main effect of *emotion* revealed similarities and differences in emotion perception patterns within each group (Table 2). Consistent with the overall analysis, happiness was recognized at a significantly lower emotion intensity than sadness [Frustration: $p < .001$, Non-Frustration: $p < .001$], disgust [Frustration: $p < .001$, Non-Frustration: $p < .001$], and fear [Frustration: $p < .05$, Non-Frustration: $p < .001$]. However a discrepancy between groups emerged for emotion intensity of anger. Whereas participants in the non-frustration group required greater emotion intensity to perceive anger than happiness ($p < .001$), participants in the frustration group required equal emotion intensity to perceive anger and happiness ($p = 1.00$).

Hypotheses 3 & 4: Trait Irritability Differed on Non-Anger and Anger Perception

Self-reported irritability (BITe scores) and condition did not explain non-angry emotion intensity ($R^2 = .06$, $F(2, 72) = 2.16$, $p > .10$). Neither BITe scores ($\beta = .33$, $p > .06$) nor condition ($\beta = -1.66$, $p > .39$) predicted non-angry emotion intensity. Self-reported irritability and condition did explain anger emotion intensity, but only at the level of a trend ($R^2 = .07$, $F(2, 72) = 2.56$, $p > .08$). BITe scores appeared to predict this trend ($\beta = .34$, $p = .08$), slightly more than condition ($\beta = -2.91$, $p > .10$). The correlation between self-reported irritability and angry emotion intensity was significant, $r = .20$, $p > .04$, suggesting that higher irritability scores were associated with greater emotion intensity required to identify angry faces accurately.

We performed exploratory analyses using the ARI, another irritability measure, in order to compare our findings with studies in the literature (Stringaris et al., 2012). A post hoc analysis revealed ARI self-reported irritability scores and condition did not explain non-angry emotion intensity ($R^2 = .04$, $F(2, 72) = 1.44$, $p > .20$) but did predict angry emotion intensity ($R^2 = .08$, $F(2, 72) = 3.22$, $p < .05$). ARI scores predicted ($\beta = 1.11$, $p < .04$) higher irritability scores would be associated with greater emotion intensity to identify anger (Figure 7). Condition did not predict the intensity required to identify angry faces (β = -2.50, $p > .20$).

In the initial design of this study, significant findings related to trait irritability were intended to be replicated using hierarchical regression analyses. Since ARI scores rather than BITe scores were significantly related to anger perception, three hierarchical regression analyses were conducted with relevant covariates: demographic variables (i.e. age and gender), anxiety and depression, and aggression, added first and ARI scores entered second. A hierarchical regression including aggression explained anger emotion identification, ($R^2 = .12$, $F(4, 70) = 2.26$, $p > .07$), at the level of a trend. This model did not significantly improve upon adding ARI scores, ($R^2 = .13$, $F(5, 69) = 2.13$, $p > .07$). Self-reported depression and anxiety did not explain anger identification ($R^2 = .07$, $F(3, 71) = 1.78$, $p < .16$) unless ARI scores were included in the model ($R^2 = .13$, $F(4, 70) = 2.51$, $p = .05$). ARI scores significantly predicted anger intensity (β = 1.13, $p < .04$). Age and gender did not explain anger identification ($R^2 = .17$, $F(2, 72) = 1.12$, $p > .30$), although the model improved to the level of a trend with the addition of ARI scores ($R^2 = .09$, $F(3, 71) = 2.31$, $p = .08$). Indeed, ARI scores significantly predicted anger emotion intensity (β = 1.13, $p < .04$).

Hypothesis 5a: State Irritability Unrelated to Face Morph Hostile Attribution Bias

A main effect of *percent emotion misattributed* (sad, happy, fearful, angry, disgusted) or the proportion of errors that a particular emotion was misattributed, was observed on a repeated measures ANOVA ($F(3.060, 223.349) = 39.00$, $p < .001$, $\eta_p^2 = .35$). When participants made an error, they were least likely to choose happy as the answer compared to sad ($p < .001$), fearful ($p < .001$), angry ($p < .001$), and disgusted ($p < .001$). Sad was given as the incorrect response more frequently than happy ($p < .001$), fearful ($p < .001$), angry ($p < .01$), and disgusted ($p < .001$).

The number of times fearful, angry, and disgusted were given as incorrect responses did not differ significantly from one another. A follow-up post hoc regression analysis using ARI and BITe scores entered simultaneously to explain the percent of errors that misattributed anger was not significant ($R^2 = .03$, $F(2, 72) = 1.12$, $p > .30$).

Hypothesis 5b: Trait Irritability Predicted Self-Report Hostile Attribution

One participant was excluded from data analyses, because the SIP-AEQ was not completed. A simple linear regression found self-reported irritability (BITe scores) significantly explained by hostile attribution (HA) scores ($R^2 = .28$, $F(1, 73) = 28.73$, $p < .001$). Self-reported irritability significantly predicted HA scores ($\beta = .70$, $p < .001$) (Figure 8).

A follow-up regression analysis comparing ARI scores and SIP-AEQ HA scores found ARI scores explained significant HA scores at the level of a trend ($R^2 = .05$, $F(1, 73) = 3.86$, $p > .05$). ARI self-reported irritability scores also predicted HA scores at the level of a trend ($\beta = .815$, $p > .05$)

Hypothesis 6: Emotion Intensity Unrelated to Overall Social Functioning

Self-reported SFQ scores and condition did not explain emotion intensity (sad, happy, fearful, angry, or disgusted) ($R^2 = .02$, $F(2, 72) = .72$, $p > .50$).

Internal Reliability and Construct Validity

The internal reliability of the subset of the NimStim set of facial expressions used in the face morph task ($n = 60$) was high ($\alpha = .98$).

To determine the construct validity of the face morph task, separate regression analyses were conducted predicting emotion intensity using total score on the RMET and digit symbol coding subtest. Only participants who completed the RMET ($n = 71$) and digit symbol coding subtest ($n = 71$) were included in their respective analyses. RMET score explained emotion intensity at the level of a trend (R^2 = .04, F(1, 69) = 2.97, *p* < .09), with RMET predicting emotion intensity at a trend (β = -.58, *p* < .09). Since emotion intensity and RMET score are not direct comparisons, with one involving response time and the other accuracy, RMET score was also compared to face morph task accuracy. RMET score did not explain initial response accuracy on the face morph task (R^2 = .03, *F*(1, 69) = 2.44, *p* > .10) but did explain final response accuracy (R^2 = .06, *F*(1, 69) = 4.03, *p* < .05). RMET scores significantly predicted final response accuracy (β = .23, p < .05). WAIS score did not explain emotion intensity (R^2 = .02, *F*(1, 69) = 1.36, *p* > .20).

Discussion

The purpose of this study was to demonstrate the relationship between irritability and face emotion identification ability, with a particular focus on the identification of anger. No association between state and trait irritability and overall emotion identification deficits was observed, however, some evidence suggests that the perception of anger and the mechanisms that explain anger perception were differentially related to state and trait irritability. State irritability elicited by a frustration manipulation was associated with slightly enhanced anger identification on the novel face morph task. High trait irritability was related to needing greater emotion intensity in order to identify anger. Furthermore, high trait irritability, but not state irritability, was related to a self-reported hostile attribution bias.

Perception of Non-Angry Emotions with High State and Trait Irritability

Neither state nor trait measures of irritability were related to the amount of emotion intensity required to recognize non-angry faces. Therefore, contrary to our hypotheses, irritability did not impair participants' ability to identify non-angry emotions. Rather, for all participants, happy expressions were the easiest to perceive, meaning they required less emotion intensity to recognize than the other emotions. This finding is consistent with those of a recent article, in which authors argued that happiness was perceived at lower intensities, because the upward curvature of the lips allowed individuals to recognize happiness more easily than negative emotions (e.g. anger, sadness) (Maher, Ekstrom, & Chen, 2014).

Our findings contrast with prior research with children, in which severe and persistent irritability was related to impaired emotion recognition (Kim et al., 2013; Rich et al., 2008). For instance, youths with SMD required greater emotion intensity to recognize disgust, surprise, fearful, and happy expressions (Rich et al., 2008). A study measuring emotion identification and eye gaze found that youths with SMD identified happiness and sadness in morphed facial expressions less accurately than healthy controls. When presented with face morphs depicting greater emotional intensity (e.g. 80% sad and 10% neutral vs. 60% sad and 40% neutral), youths with SMD gazed at eyes less frequently than controls -- suggesting that they gained less information looking at faces and potentially explaining their poorer recognition of face emotions (Kim et al., 2013).

The discrepancy between the findings of this study and prior literature may be explained by the different participant samples used in each study. Evidence for impaired emotion identification in children with severe irritability stems from studies of children with clinical levels of irritability participating in a longitudinal study at the National Institute of Health (Kim et al., 2013; Rich et al., 2008). In contrast, this study's participants were young adults drawn from a general, college-aged sample of convenience, who are more likely to have lower overall levels of irritability and be higher functioning than the pediatric samples. An example of this discrepancy can be found by comparing the scores from children and adolescents with DMDD involved in a recent NIH pilot study with those of the present study's sample. The average ARI scores for youths with DMDD self- and parent-reported irritability ratings were 4.2 (*SD* = 3.1) and 7.5 (*SD* = 2.8) (Stoddard et al., 2016). In contrast, the average ARI score in the present sample was 1.44 for the frustration group and 1.79 for the non-frustration group.

Age and gender are two other factors that may have influenced the result of no emotion recognition impairment. Emotion recognition can vary across an individual's lifespan (Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; Mill, Allik, Realo, & Valk, 2009; Sullivan, Ruffman, & Hutton, 2007). Adults are more perceptive of some emotions than young children (Durand et al., 2007), which would predict that the young adult population in this study perform well on emotion identification tasks. Consequently, their high performance might impede the detection of subtle differences in emotion identification ability between conditions. Moreover, gender differences might also have influenced this study's results. Previous findings suggest females are more perceptive of emotions in ambiguous faces than males (Hoffmann, Kessler, Eppel, Rukavina, & Traue, 2010), meaning that the present study's majority female population might positively skew their average emotion recognition ability. Conversely, severe irritability in youths with SMD is most prevalent in males (77.6%), which might negatively skew the average emotion identification ability reported for this group (Brotman et al., 2006).

State versus Trait Irritability: Two Perceptions of Anger

The perception of anger was of particular interest to this study. Several studies suggest that severe irritability in children relates to biased attention towards hostile faces or heightened sensitivity to identifying anger in ambiguous facial expressions (Hommer et al., 2014; Stoddard et al., 2016). While no studies of irritability in adults have been conducted, the related populations of individuals with high trait anger and aggression demonstrated biases towards perceiving anger in ambiguous faces and situations, however, the mechanisms behind this enhanced perception of anger are not clear. The most prominent argument is the hostile attribution bias, which implies that individuals with high aggression and trait anger attribute hostility and anger to ambiguous situations, even if none exists (Crick & Dodge, 1996; Hall, 2006; Wilkowski et al., 2007). The second argument suggests that high aggression and trait anger lead to better perception of subtle anger and hostility (Schönenberg & Jusyte, 2013; Wilkowski & Robinson, 2012). Under the hostile attribution theory, irritability would be related to misidentifying emotions as angry more often than other emotions; under the theory of better anger acuity, irritability would not be related to consistently misidentifying emotions as angry and for correct responses identifying anger in face emotions, detection would occur at lower emotion intensities.

The results of this study do not clearly support one theory of anger perception over another. Instead, they suggested that the relationship between irritability and anger perception differed between state and trait irritability and by the mechanism used to measure anger and/or hostility perception. State irritability was related to an enhanced perception of anger relative to other emotions on the face morph task. While happy faces required the least intensity to be recognized across both conditions, only in the frustration condition were the emotional intensities for angry and happy faces comparable. Therefore, the frustration group may have more easily recognized subtle clues of anger. Our data did not support a relationship between state irritability and hostile attribution bias, because irritability was not associated with a greater tendency to mistake faces as angry rather than other emotions. The findings of this study suggest that within a young adult, non-clinical population, state irritability is related to better perception of anger when anger is present.

In contrast to state irritability, high trait irritability was associated with a need for greater emotional intensity in order to perceive anger on the face morph task. Therefore, trait irritability may be associated with impairments in detecting anger in the facial expressions of others, although this relationship may also be explained by aggression, since aggression was related to anger emotion intensity at the level of a trend. This finding is surprising, given the existing literature on biased or increased perception of anger in populations with related symptoms of anger and aggression. Future studies should investigate whether the relationship between trait irritability and emotion identification is distinct from state irritability. A possible explanation for this finding is that individuals with high irritability might look at non-emotional cues in facial expressions first, thereby delaying their detection of anger. For instance, like children with SMD, participants with high trait anger might be less likely to look towards the eyes of the facial expression presented in front of them than individuals with low trait anger (Kim et al., 2013).

In addition, when the perception of anger and hostility was measured using a self-report questionnaire, an association between trait, but not state irritability, and hostile attribution bias emerged. Specifically, high trait irritability was related to a greater likelihood that participants would perceive the intentions of a character in an ambiguous scenario as hostile. The existence of a hostile attribution bias is supported by the fact that trait irritability is described in relation to reactive aggression (Leibenluft & Stoddard, 2013), which is also associated with hostile attribution biases (Crick & Dodge, 1996). An alternative explanation for the dissociation between trait and state irritability might be the context or measure of the hostile attribution bias. Hostile attribution biases with state irritability were assessed using a behavioral measure (i.e. whether or not incorrect responses primarily misidentified emotions as angry) while hostile attribution biases with trait irritability were assessed using a self-report measure (SIP-AEQ). One key difference between the two measures is the passive role participants play in the face morph task and the active role they play in the SIP-AEQ; the SIP-AEQ describes different scenarios for the participants to imagine themselves to be a part of (Coccaro et al., 2009). In these scenarios, hostile attribution biases may be a reflection of the approach–motivate behavior associated with anger (Adams, Ambady, Macrae, & Kleck, 2006; Ford et al., 2010).

From Seeing Emotion to General Social Functioning

Studies of face emotion identification and irritability seldom include measures of social functioning (Rich et al., 2008). Yet being able to identify facial expressions is essential for navigating social interactions (Crick & Dodge, 1996; Lemerise & Arsenio, 2000; Wilkowski et al., 2007). Poorer emotion recognition may result in miscommunication or translate into inappropriate responses during social interactions, thereby creating a cycle of poor social functioning. To date, only one study has linked poorer emotion recognition ability and impaired social functioning (i.e., disrupted family relationships) in a population of children with severe irritability (Rich et al., 2008).

The present study failed to detect a relationship between emotion intensity and self-reported social functioning. This lack of a relationship may be due to the same gender and age effects mentioned earlier, or it may be due to the measure of social functioning used in the present study. The SFQ was designed to assess social functioning among psychiatric patients and includes items such as, “I feel lonely and isolated from other people” and “I find my tasks at work and at home very stressful.” Scores range from 0 to 24, with scores lower than 10 reflecting better social functioning and initial validation of the SFQ reporting an average score of 4.6 for a non-psychiatric population. The average score reported for individuals receiving outpatient psychiatric treatment was 7.7 (Tyrer et al., 2005). In comparison, participants in this study reported an average SFQ score of 7.02 (*SD* = 3.3), which is closer to scores observed in individuals seeking treatment for psychiatric conditions such as depression and anxiety (Tyrer et al., 2005).

While the results of participants' SFQ scores may indicate that participants have poorer social functioning, it may also reflect a tendency among the participants to rate their functioning as lower due to the stress and demanding schedules that they experience attending a rigorous undergraduate institution, or isolation stemmed from having to form new relationships in college. Future studies should continue to directly compare emotion recognition with measures of social functioning, however, researchers should ensure that their measures accurately assess social functioning in the population being investigated.

Reliability and Validity

The internal reliability of the face models in this task was high (Tottenham et al., 2009). In addition, the face morph task also appears to have had concurrent validity. This task was not related to the WAIS digit symbol coding scale, meaning that processing speed did not drive how fast participants recognized face emotions. Initial responses on the face morph task were not predicted by RMET scores, although final responses were. Since the RMET allows participants an unlimited amount of time to complete the task, responses on the RMET are more comparable to final rather than initial responses on the face morph task. These preliminary findings suggest that our novel task successfully assessed face emotion recognition ability. Future studies are necessary to replicate this effect as task validity was only completed on a subsample of participants who completed all of the tasks (to include the RMET).

Limitations

This study contains several methodological limitations. First, nearly all participants identified as female, which could have related to better average emotion identification ability. Therefore this study should be replicated with a co-ed sample to determine whether the lack of overall emotion identification impairment related to state and trait irritability was a result of testing a primarily female participant group. Second, this study should be replicated with a larger sample pool so as to obtain the full power intended when this study was planned. Third, the software used to generate the 50 morphed images, or movies, required each image to contain 2 or 3% greater emotional intensity than the prior image. This slight variation between intensities should be eliminated in future replications such that each frame is an equal difference of intensity (e.g. 2%). Fourth, hostile attribution bias is discussed in terms of ambiguous faces or situations (Dodge, 1980; Schönenberg & Jusyte, 2013; Wilkowski & Robinson, 2012). In this study, faces were assumed to be ambiguous if emotion intensity was greater than 0% and less than 100%. However, one might argue that the recognition of a face composed of 95% anger and 5% neutral facial expressions does not constitute the recognition of an ambiguous face and should not be analyzed in an assessment of hostile attribution bias. Future studies should define emotion intensities considered ambiguous and incorporate those limits into their analyses. Lastly, analyses using ARI scores were preliminary. Future studies should explore the relationship between BITe and ARI scores to determine which measurement would be best fit, as a follow-up bivariate correlation test revealed a significant correlation between participants' total scores on the ARI and BITe questionnaires.

Conclusions

Thus far, irritability has been studied in the context of clinical research on children with severe irritability that impairs functioning and disrupts relationships with others (Brotman et al., 2006; Copeland et al., 2013, 2014; Leibenluft, 2011). The findings of the present study suggest that irritability might influence individuals' perception of the emotions of others and that high trait irritability is related to assumptions of hostility in ambiguous social interactions. This study also supports the idea that high irritability in a non-clinical population of young-adults is involved in distinct mechanisms for processing anger. Future studies of irritability in young adults must discern how the perception of anger varies dependent upon level of state versus trait irritability and dissociate between measures of the perception of anger involving behavioral tasks versus descriptions of ambiguous social scenarios.

References

Adams, J., Reginald B., Ambady, N., Macrae, C. N., & Kleck, R. E. (2006). Emotional expressions forecast approach-avoidance behavior. *Motivation & Emotion*, *30*(2), 179–188. http://doi.org/10.1007/s11031-006-9020-2

American Psychiatric Association, & American Psychiatric Association (Eds.). (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed). Washington, D.C: American Psychiatric Association.

Barata, P. C., Holtzman, S., Cunningham, S., O'Connor, B. P., & Stewart, D. E. (2015). Building a definition of irritability from academic definitions and lay descriptions. *Emotion Review*, 1–9. http://doi.org/10.1177/1754073915576228

Barnes, L. L. B., Harp, D., & Jung, W. S. (2002). Reliability generalization of scores on the Spielberger State-Trait Anxiety Inventory. *Educational and Psychological Measurement*, *62*(4), 603–618. http://doi.org/10.1177/0013164402062004005

Baron-Cohen, S., & Wheelwright, S. (2001). The "Reading the Mind in the Eyes" Test revised version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology & Psychiatry & Allied Disciplines*, *42*(2), 241–251.

Blair, R. J. R., Colledge, E., Murray, L., & Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of Abnormal Child Psychology*, *29*(6), 491–498. http://doi.org/10.1023/A:1012225108281

Bos, P. A., Hofman, D., Hermans, E. J., Montoya, E. R., Baron-Cohen, S., & van Honk, J. (2016). Testosterone reduces functional connectivity during the "Reading the Mind in the

Eyes” Test. *Psychoneuroendocrinology*, *68*, 194–201. http://doi.org/10.1016/j.psyneuen.2016.03.006

Brotman, M. A., Schmajuk, M., Rich, B. A., Dickstein, D. P., Guyer, A. E., Costello, E. J., … Leibenluft, E. (2006). Prevalence, clinical correlates, and longitudinal course of Severe Mood Dysregulation in children. *Biological Psychiatry*, *60*(9), 991–997. http://doi.org/10.1016/j.biopsych.2006.08.042

Brown, K. (2015). *Frustration & motivation: How frustration impacts persistence, self-reported ratings of motivation and enjoyability, and students’ willingness to do it all over again.* Wellesley College, Wellesley, MA.

Buss, A. H., & Perry, M. (1992). The Aggression Questionnaire. *Journal of Personality and Social Psychology*, *63*(3), 452–459. http://doi.org/10.1037/0022-3514.63.3.452

Coccaro, E. F., Noblett, K. L., & McCloskey, M. S. (2009). Attributional and emotional responses to socially ambiguous cues: Validation of a new assessment of social/emotional information processing in healthy adults and impulsive aggressive patients. *Journal of Psychiatric Research*, *43*(10), 915–925. http://doi.org/10.1016/j.jpsychires.2009.01.012

Copeland, W. E., Angold, A., Costello, E. J., & Egger, H. (2013). Prevalence, comorbidity, and correlates of DSM-5 proposed Disruptive Mood Dysregulation disorder. *American Journal of Psychiatry*, *170*(2), 173–179. http://doi.org/10.1176/appi.ajp.2012.12010132

Copeland, W. E., Shanahan, L., Egger, H., Angold, A., & Costello, E. J. (2014). Adult diagnostic and functional outcomes of DSM-5 disruptive mood dysregulation disorder. *American Journal of Psychiatry*, *171*(6), 668–674. http://doi.org/10.1176/appi.ajp.2014.13091213

Crick, N. R., & Dodge, K. A. (1996). Social information-processing mechanisms in reactive and proactive aggression. *Child Development*, *67*(3), 993–1002. http://doi.org/10.2307/1131875

Demenescu, L. R., Kortekaas, R., den Boer, J. A., & Aleman, A. (2010). Impaired attribution of emotion to facial expressions in anxiety and major depression. *PLoS ONE*, *5*(12), 1–5. http://doi.org/10.1371/journal.pone.0015058

Deveney, C. M., Connolly, M. E., Haring, C. T., Bones, B. L., Reynolds, R. C., Kim, P., … Leibenluft, E. (2013). Neural mechanisms of frustration in chronically irritable children. *The American Journal of Psychiatry*, *170*(10), 1186–1194. http://doi.org/10.1176/appi.ajp.2013.12070917

Deveney, C. M., Hommer, R. E., Reeves, E., Stringaris, A., Hinton, K. E., Haring, C. T., … Leibenluft, E. (2015). A prospective study of severe irritability in youths: 2- and 4-year follow-up. *Depression and Anxiety*, *32*(5), 364–372. http://doi.org/10.1002/da.22336

Dodge, K. A. (1980). Social cognition and children's aggressive behavior. *Child Development*, *51*(1), 162–170. http://doi.org/10.2307/1129603

Dodge, K. A., Price, J. M., Bachorowski, J.-A., & Newman, J. P. (1990). Hostile attributional biases in severely aggressive adolescents. *Journal of Abnormal Psychology*, *99*(4), 385–392. http://doi.org/10.1037/0021-843X.99.4.385

Durand, K., Gallay, M., Seigneuric, A., Robichon, F., & Baudouin, J.-Y. (2007). The development of facial emotion recognition: The role of configural information. *Journal of Experimental Child Psychology*, *97*(1), 14–27. http://doi.org/10.1016/j.jecp.2006.12.001

Fava, M., Hwang, I., Kessler, R. C., Rush, A. J., Sampson, N., & Walters, E. E. (2010). The importance of irritability as a symptom of major depressive disorder: results from the National Comorbidity Survey Replication. *Molecular Psychiatry*, *15*(8), 856–867.

Ford, B. Q., Tamir, M., Brunyé, T. T., Shirer, W. R., Mahoney, C. R., & Taylor, H. A. (2010). Keeping your eyes on the prize anger and visual attention to threats and rewards. *Psychological Science*, *21*(8), 1098–1105. http://doi.org/10.1177/0956797610375450

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology & Behavioral Assessment*, *26*(1), 41–54.

Guyer, A. E., McClure, E. B., Adler, A. D., Brotman, M. A., Rich, B. A., Kimes, A. S., … Leibenluft, E. (2007). Specificity of facial expression labeling deficits in childhood psychopathology. *Journal of Child Psychology and Psychiatry*, *48*(9), 863–871. http://doi.org/10.1111/j.1469-7610.2007.01758.x

Hall, C. W. (2006). Self-reported aggression and the perception of anger in facial expression photos. *The Journal of Psychology*, *140*(3), 255–267. http://doi.org/10.3200/JRLP.140.3.255-267

Hoffmann, H., Kessler, H., Eppel, T., Rukavina, S., & Traue, H. C. (2010). Expression intensity, gender and facial emotion recognition: Women recognize only subtle facial emotions better than men. *Acta Psychologica*, *135*(3), 278–283. http://doi.org/10.1016/j.actpsy.2010.07.012

Holtzman, S., O'Connor, B. P., Barata, P. C., & Stewart, D. E. (2015). The Brief Irritability Test (BITe); A measure of irritability for use among men and women. *Assessment*, *22*(1), 101–115. http://doi.org/10.1177/1073191114533814

Hommer, R. E., Meyer, A., Stoddard, J., Connolly, M. E., Mogg, K., Bradley, B. P., … Brotman, M. A. (2014). Attention bias to threat faces in severe mood dysregulation. *Depression and Anxiety*, *31*(7), 559–565. http://doi.org/10.1002/da.22145

In-Albon, T., Ruf, C., & Schmid, M. (2015). Facial emotion recognition in adolescents with nonsuicidal self-injury. *Psychiatry Research*, *228*(3), 332–339. http://doi.org/doi:10.1016/j.psychres.2015.05.089

Joormann, J., & Gotlib, I. H. (2006). Is this happiness I see? Biases in the identification of emotional facial expressions in depression and social phobia. *Journal of Abnormal Psychology*, *115*(4), 705–714. http://doi.org/10.1037/0021-843X.115.4.705

Kessler, R. C., Berglund, P., Demler, O., Jin, R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions' of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry*, *62*(6), 593 – 602.

Kim, P., Arizpe, J., Rosen, B. H., Razdan, V., Haring, C. T., Jenkins, S. E., … Leibenluft, E. (2013). Impaired fixation to eyes during facial emotion labelling in children with bipolar disorder or severe mood dysregulation. *Journal of Psychiatry & Neuroscience: JPN*, *38*(6), 407–416. http://doi.org/10.1503/jpn.120232

Larkin, K., T., Martin, R., R., & McClain, S., E. (2002). Cynical hostility and the accuracy of decoding facial expressions of emotions. *Journal of Behavioral Medicine*, *25*(3), 285–292.

Leibenluft, E. (2011). Severe mood dysregulation, irritability, and the diagnostic boundaries of bipolar disorder in youths. *American Journal of Psychiatry*, *168*(2), 129–142. http://doi.org/10.1176/appi.ajp.2010.10050766

Leibenluft, E., & Stoddard, J. (2013). The developmental psychopathology of irritability. *Development and Psychopathology*, *25*(25th Anniversary Special Issue 4pt2), 1473–1487. http://doi.org/10.1017/S0954579413000722

Lemerise, E. A., & Arsenio, W. F. (2000). An integrated model of emotion processes and cognition in social information processing. *Child Development*, *71*(1), 107–118. http://doi.org/10.1111/1467-8624.00124

LeMoult, J., Joormann, J., Sherdell, L., Wright, Y., & Gotlib, I. H. (2009). Identification of emotional facial expressions following recovery from depression. *Journal of Abnormal Psychology*, *118*(4), 828–833. http://doi.org/10.1037/a0016944

Maher, S., Ekstrom, T., & Chen, Y. (2014). Greater perceptual sensitivity to happy facial expression. *Perception*, *43*(12), 1353–1364. http://doi.org/10.1068/p7806

Mellentin, A. I., Dervisevic, A., Stenager, E., Pilegaard, M., & Kirk, U. (2015). Seeing enemies? A systematic review of anger bias in the perception of facial expressions among anger-prone and aggressive populations. *Aggression and Violent Behavior, 25, Part B*, 373–383. http://doi.org/10.1016/j.avb.2015.09.001

Mill, A., Allik, J., Realo, A., & Valk, R. (2009). Age-related differences in emotion recognition ability: A cross-sectional study. *Emotion*, *9*(5), 619–630. http://doi.org/10.1037/a0016562

Mogg, K., Garner, M., & Bradley, B. P. (2007). Anxiety and orienting of gaze to angry and fearful faces. *Biological Psychology*, *76*(3), 163–169. http://doi.org/10.1016/j.biopsycho.2007.07.005

Orme, J. G., Reis, J., & Herz, E. J. (1986). Factorial and discriminant validity of the Center for Epidemiological Studies Depression (CES-D) Scale. *Journal of Clinical Psychology*, *42*(1), 28–33.

Penton-Voak, I. S., Thomas, J., Gage, S. H., McMurran, M., McDonald, S., & Munafò, M. R. (2013). Increasing recognition of happiness in ambiguous facial expressions reduces anger and aggressive behavior. *Psychological Science*, *24*(5), 688–697. http://doi.org/10.1177/0956797612459657

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurements*, *1*, 385–401.

Rich, B. A., Grimley, M. E., Schmajuk, M., Blair, K. S., Blair, R. J. R., & Leibenluft, E. (2008). Face emotion labeling deficits in children with bipolar disorder and severe mood dysregulation. *Development and Psychopathology*, *20*(2), 529–546. http://doi.org/10.1017/S0954579408000266

Schönenberg, M., & Jusyte, A. (2013). Investigation of the hostile attribution bias toward ambiguous facial cues in antisocial violent offenders. *European Archives of Psychiatry and Clinical Neuroscience*, *264*(1), 61–69. http://doi.org/10.1007/s00406-013-0440-1

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Stoddard, J., Sharif-Askary, B., Harkins, E. A., Frank, H. R., Brotman, M. A., Penton-Voak, I. S., … Leibenluft, E. (2016). An open pilot study of training hostile interpretation bias to treat disruptive mood dysregulation disorder. *Journal of Child and Adolescent Psychopharmacology*, *26*(1), 49–57. http://doi.org/10.1089/cap.2015.0100

Stringaris, A., Cohen, P., Pine, D. S., & Leibenluft, E. (2009). Adult outcomes of youth irritability: A 20-year prospective community-based study. *The American Journal of Psychiatry*, *166*(9), 1048–1054. http://doi.org/10.1176/appi.ajp.2009.08121849

Stringaris, A., Goodman, R., Ferdinando, S., Razdan, V., Muhrer, E., Leibenluft, E., & Brotman, M. A. (2012). The Affective Reactivity Index: a concise irritability scale for clinical and research settings. *Journal of Child Psychology and Psychiatry*, *53*(11), 1109–1117. http://doi.org/10.1111/j.1469-7610.2012.02561.x

Sullivan, S., Ruffman, T., & Hutton, S. B. (2007). Age differences in emotion recognition skills and the visual scanning of emotion faces. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *62*(1), P53–P60.

Surcinelli, P., Codispoti, M., Montebarocci, O., Rossi, N., & Baldaro, B. (2006). Facial emotion recognition in trait anxiety. *Journal of Anxiety Disorders*, *20*(1), 110–117. http://doi.org/10.1016/j.janxdis.2004.11.010

Surguladze, S. A., Young, A. W., Senior, C., Brébion, G., Travis, M. J., & Phillips, M. L. (2004). Recognition accuracy and response bias to happy and sad facial expressions in patients with major depression. *Neuropsychology*, *18*(2), 212–218. http://doi.org/10.1037/0894-4105.18.2.212

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., … Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. http://doi.org/10.1016/j.psychres.2008.05.006

Tyrer, P., Nur, U., Crawford, M., Karlsen, S., MacLean, C., Rao, B., & Johnson, T. (2005). The Social Functioning Questionnaire: A rapid and robust measure of perceived functioning.

International Journal of Social Psychiatry, *51*(3), 265–275. http://doi.org/10.1177/0020764005057391

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. http://doi.org/10.1037/0022-3514.54.6.1063

Wechsler, D. (2008a). *Wechsler Adult Intelligence Scale—Fourth Edition*. San Antonio, TX: Pearson.

Wilkowski, B. M., & Meier, B. P. (2010). Bring it on: Angry facial expressions potentiate approach-motivated motor behavior. *Journal of Personality and Social Psychology*, *98*(2), 201–210. http://doi.org/10.1037/a0017992

Wilkowski, B. M., & Robinson, M. D. (2010). The anatomy of anger: An integrative cognitive model of trait anger and reactive aggression. *Journal of Personality*, *78*(1), 9–38. http://doi.org/10.1111/j.1467-6494.2009.00607.x

Wilkowski, B. M., & Robinson, M. D. (2012). When aggressive individuals see the world more accurately the case of perceptual sensitivity to subtle facial expressions of anger. *Personality and Social Psychology Bulletin*, *38*(4), 540–553. http://doi.org/10.1177/0146167211430233

Wilkowski, B. M., Robinson, M. D., Gordon, R. D., & Troop-Gordon, W. (2007). Tracking the evil eye: Trait anger and selective attention within ambiguously hostile scenes. *Journal of Research in Personality*, *41*(3), 650–666. http://doi.org/10.1016/j.jrp.2006.07.003

Yu, R., Mobbs, D., Seymour, B., Rowe, J. B., & Calder, A. J. (2014). The neural signature of escalating frustration in humans. *Cortex*, *54*, 165–178. http://doi.org/doi:10.1016/j.cortex.2014.02.013

Table 1

Questionnaire and Task Characteristics by Frustration Manipulation Group

Questionnaires and Tasks	Frustration Group		Non-Frustration Group	
	M	*SD*	*M*	*SD*
RMET*	28.78	2.44	29.71	3.13
Digit Symbol Coding *	13.49	3.23	13.37	2.65
CESD	16.19	13.75	13.46	8.16
PANAS				
PA	16.30	7.59	29.02	8.16
NA	16.30	8.29	13.76	5.50
STAIS	37.19	13.81	33.84	11.06
STAIT	42.88	13.80	40.56	12.31
DERS				
Nonacceptance	12.80	6.22	13.43	5.86
Goals	15.22	5.00	15.56	6.03
Impulse	10.25	4.90	10.82	5.25
Awareness	13.80	4.56	12.53	5.14
Strategies	17.30	8.05	17.02	7.33
Clarity	11.47	4.15	10.53	4.10
BITe	12.83	5.48	12.76	5.43
ARI	1.44	1.78	1.79	2.12
AQ				
Physical Aggression	13.33	3.23	12.92	3.78
Verbal Aggression	11.25	4.69	10.84	4.04
Anger	11.61	3.31	12.82	4.97
Hostility	17.08	7.26	16.20	7.04
SIP-AEQ				
HA	11.77	8.26	11.02	6.03
SFQ	7.16	3.65	6.89	3.02

Note. *Due to time constraints, only 71 participants completed the RMET (32 in the frustration group and 39 in the non-frustration group) and only 71 participants completed the digit symbol coding task (33 in the frustration group and 38 in the non-frustration group). RMET = Reading the Mind in the Eyes Test (Baron-Cohen & Wheelwright, 2001); Digit Symbol Coding subset of the Wechsler Adult Intelligence Scale (WAIS) IV (Wechsler, 2008a); CESD = Center for Epidemiologic Studies Depression Scale (Radloff, 1977); PANAS = Positive and Negative

Affect Scale (Watson et al., 1988); STAI-S/T = State-Trait Anxiety Scale (Spielberger et al., 1983); DERS = Difficulties in Emotion Regulation Scale (Gratz & Roemer, 2004); BITe = Brief Irritability Test (Holtzman et al., 2015); ARI = Affective Reactivity Index (Stringaris et al., 2012); AQ = Aggression Questionnaire (Buss & Perry, 1992); SIP-AEQ = Social Information Processing-Attribution and Emotional Response Questionnaire (Coccaro et al., 2009); SFQ = Social Functioning Questionnaire (Tyrer et al., 2005).

Table 2

Emotion Intensity Required to Identify Emotions within the Frustration Manipulation Groups

	Frustration Group		Statistics	Non-Frustration Group		Statistics
	M	*SD*	*P*	*M*	*SD*	*p*
1. Sad	35.64	8.70	2**, 4**	37.77	8.56	2**, 4**
2. Happy	30.56	9.13	1**, 3*, 5**	30.65	10.29	1**, 3**, 4**, 5**
3. Afraid	34.11	8.41	2*, 4*	36.17	8.77	2**
4. Angry	31.58	8.83	1**, 3*, 5*	34.47	9.27	1**, 3**, 5*
5. Disgust	34.69	7.51	2**, 4*	37.14	8.55	2**, 4*

Note. Each emotion type is given a number: 1) sad, 2) happy, 3) afraid, 4) angry, and 5) disgust. Significant differences are notated using these numbers followed by asterisks indicating p-value: *$p < .05$; **$p < .001$.

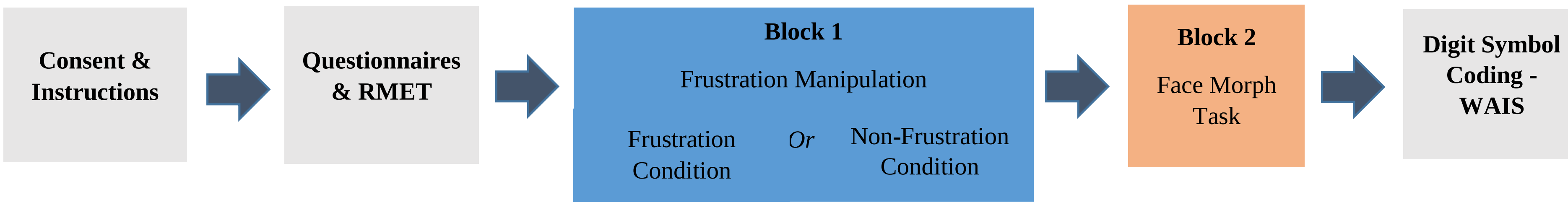

Figure 1. Schematic of study procedure. Participants completed a battery of questionnaires and the RMET followed by two blocks: a frustration manipulation task and a face morph task. During the frustration manipulation, participants were randomly assigned to complete a non-frustration or a frustration condition. Participants completed PANAS mood ratings during the questionnaires and after each block. Before leaving, participants also completed the digit symbol coding task of the WAIS.

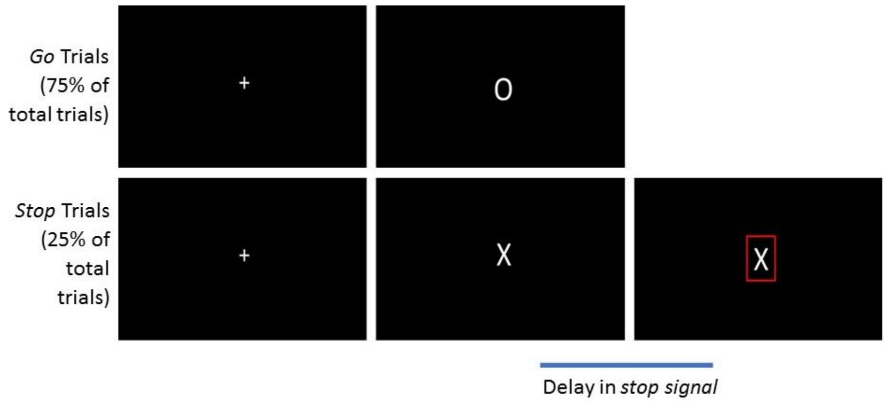

Figure 2. Modified Stop Signal task. All participants saw either an “X” or an “O” and were asked to press a button in response, except when a red box, or stop signal, appeared around the letter. On stop trials, the time between the initial letter presentation and the appearance of the stop signal varied. During the non-frustration condition, the delay was brief to facilitate the successful withholding of a motor response on the stop trials. During the frustration condition, the delay was longer, making it more difficult to withhold a response leading to errors and the intended frustration emotion.

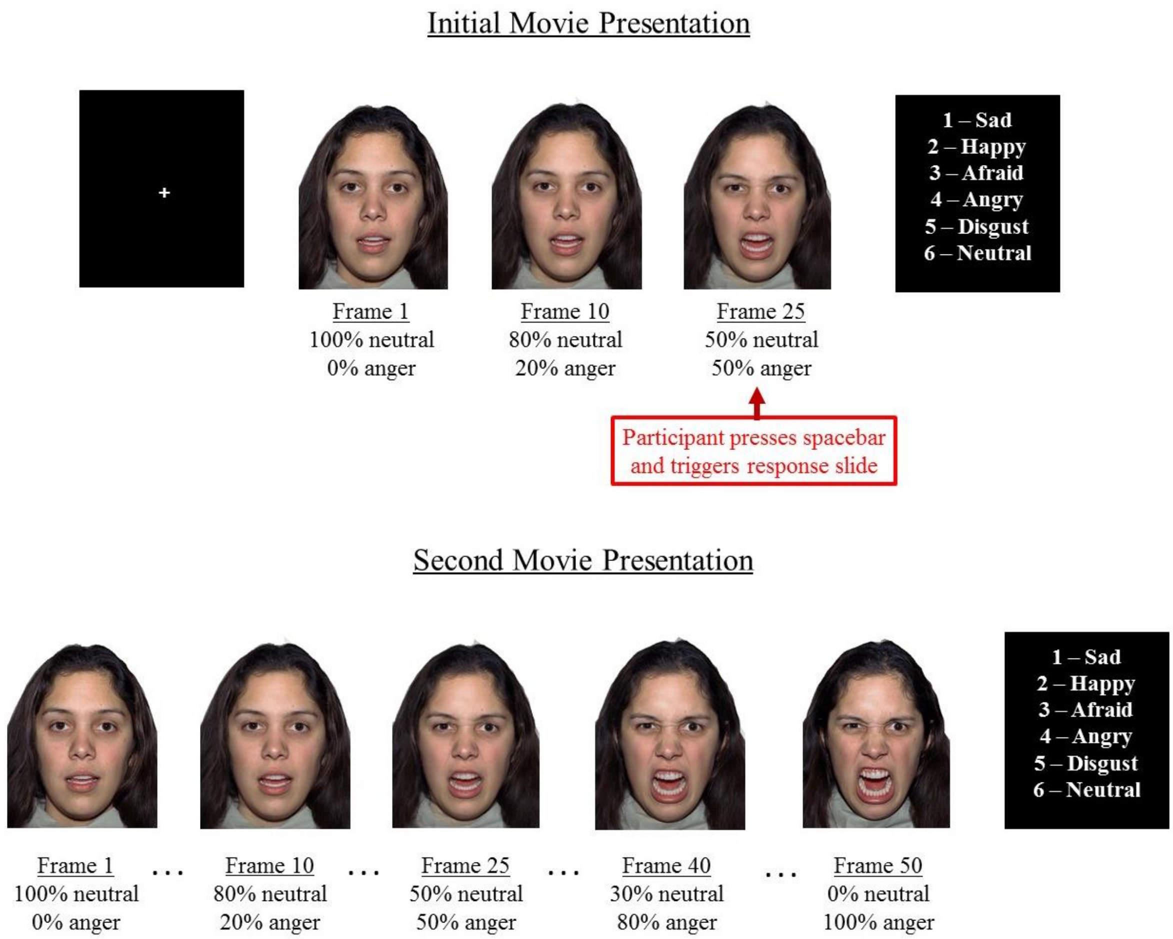

Figure 3. Schematic of face morph task. All participants watched movies depicting a facial expression morph from neutral to one of six emotions: sad, happy, afraid, angry, disgust, or neutral. Participants first saw the initial movie presentation and pressed the spacebar when they recognized the face emotion. Then, the movie played all the way through for the second movie presentation (5 s) and participants re-identified the emotion. Movies were created using neutral and 100% prototypical emotions from the NimStim set of facial expressions (Tottenham et al., 2009) and morphed together to create 50 individual frames. Only five are shown for illustrative purposes.

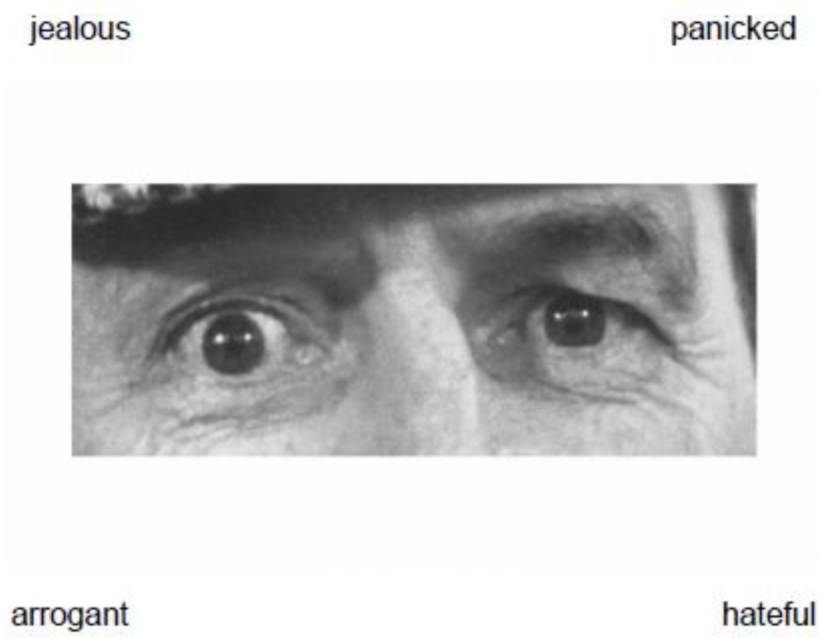

Figure 4. Practice question for the revised Reading the Mind in the Eyes Task (RMET) (Baron-Cohen & Wheelwright, 2001). Participants were presented with images of eyes and four possible words with which to describe the expression in the eyes. Participants were given an unlimited amount of time to complete the RMET and a list of definitions for the word choices.

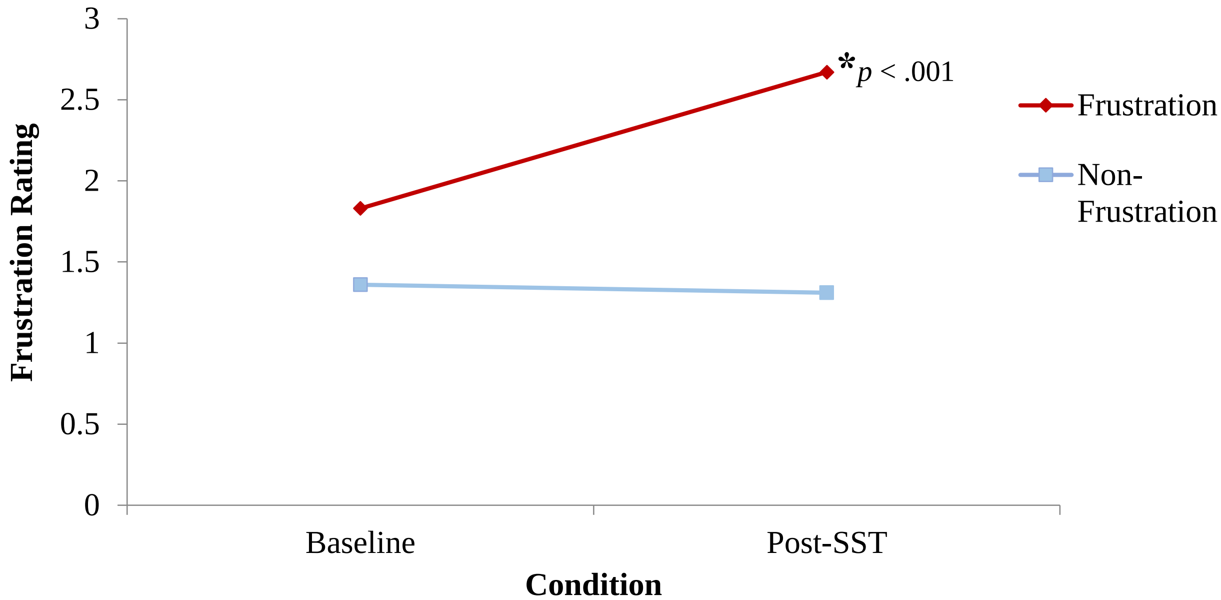

Figure 5. Group ratings of self-reported irritability before (Baseline) and after (Post-SST) the frustration manipulation. Relative to the non-frustration group, those in the frustration group reported higher levels of frustration after the manipulation and a significant increase in frustration between baseline and after the Stop Signal task (SST).

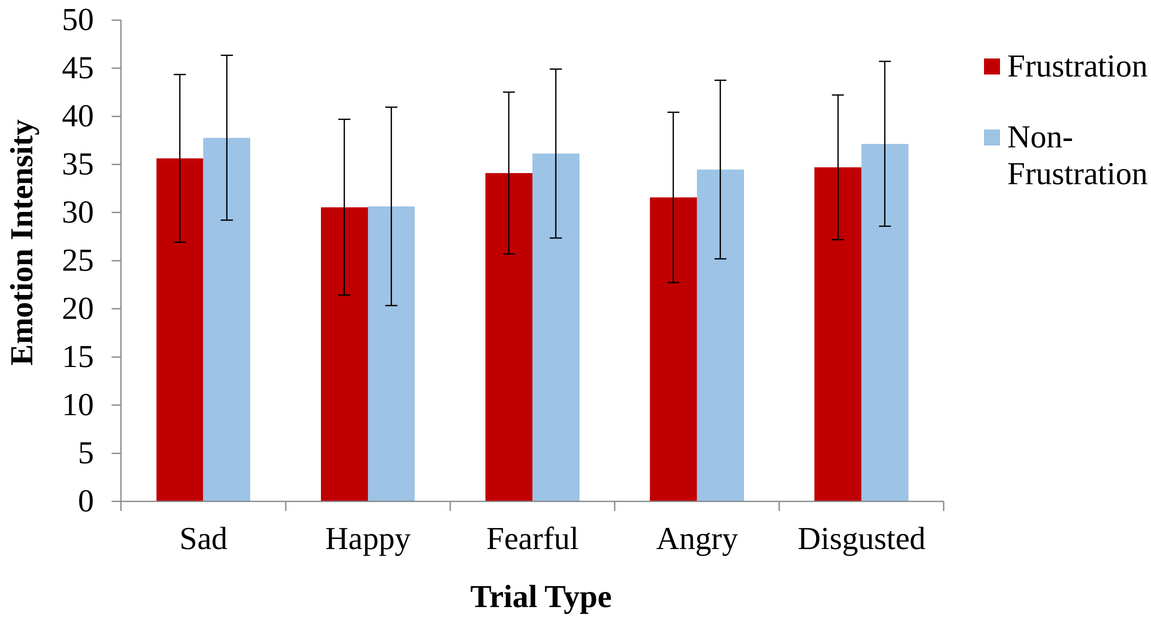

Figure 6. Emotion intensity required to correctly identify an emotion by frustration and non-frustration groups. Emotion intensity required to correctly identify emotions did not differ between conditions, but did vary between emotion types. Maximum emotion intensity was notated as 50, meaning 100% prototypical emotion. Happy intensity was lower than all other emotions (ps < .001). Sad intensity was greater than happy (*p* < .001), afraid (*p* < .01), angry (*p* < .001) and equal to disgust (*p* > .90). Afraid intensity was lower than sad (*p* < .01) and angry (*p* < .01), greater than happy (*p* < .001), and equal to disgust (*p* = 1.00). Angry intensity was lower than sad (*p* < .001), afraid (*p* < .01), and disgust (*p* < .001), and greater than happy (*p* < .001). Disgust intensity was greater than happy (*p* < .001) and angry (*p* < .001) and equal to sad (*p* > .90) and afraid (*p* = 1.00).

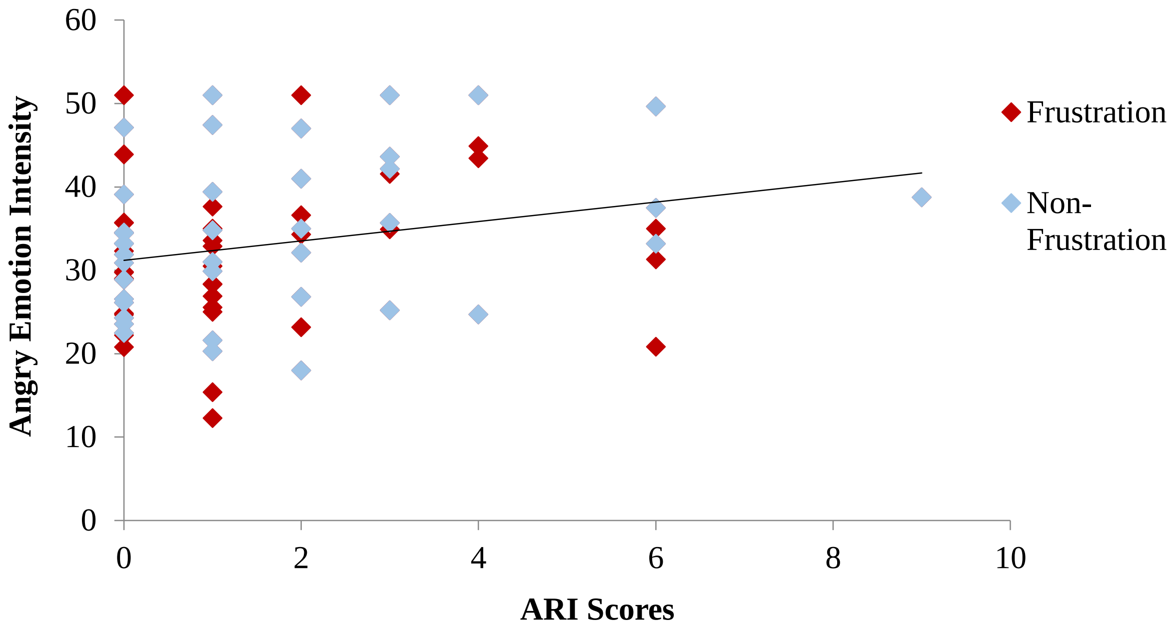

Figure 7. Self-reported irritability scores from the Affective Reactivity Index (ARI) matched to averaged angry emotion intensity (Stringaris et al., 2012). Higher self-reported trait irritability predicted greater emotion intensity required to correctly identify anger.

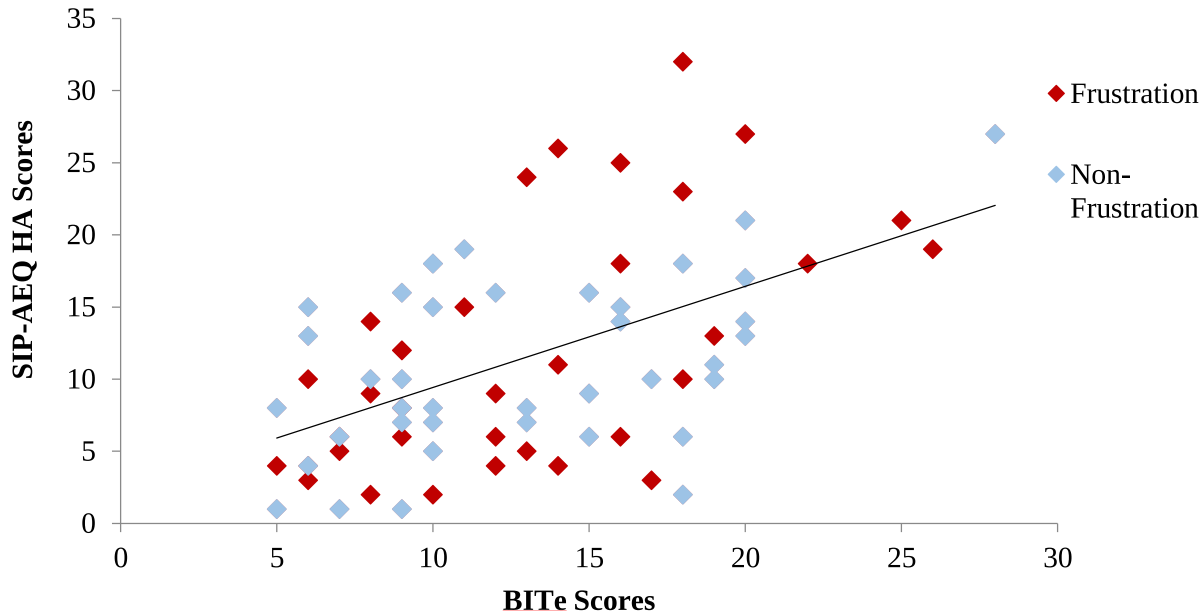

Figure 8. Self-reported irritability scores from the Brief Irritability Test (BITe) matched to hostile attribution (HA) scores on the Social Information Processing-Attribution and Emotional Response Questionnaire (SIP-AEQ) (Coccaro et al., 2009; Holtzman et al., 2015). BITe scores positively predicted participants' hostile attribution scores. Only participants who completed the SIP-AEQ were included in this analysis (*n* = 75).