

6-3-2016

Attention Deficits And Perception Of Emotion In Groups

Agnes Renee Strojewska
Illinois State University, astroje@ilstu.edu

Follow this and additional works at: <http://ir.library.illinoisstate.edu/etd>

 Part of the [Clinical Psychology Commons](#), and the [Cognitive Psychology Commons](#)

Recommended Citation

Strojewska, Agnes Renee, "Attention Deficits And Perception Of Emotion In Groups" (2016). *Theses and Dissertations*. Paper 603.

This Thesis and Dissertation is brought to you for free and open access by ISU ReD: Research and eData. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of ISU ReD: Research and eData. For more information, please contact ISUReD@ilstu.edu.

ATTENTION DEFICITS AND PERCEPTION OF EMOTION IN GROUPS

Agnes R. Strojewska

47 Pages

The present study investigated the relationship between attention deficits and the recognition of emotions of either individuals or groups (ensembles). Previous research has suggested that individuals with ADHD may have deficits in social cognition, specifically in recognizing the internal (emotional) states of others, though it remains unclear whether these deficits are a discrete component of ADHD or merely the byproduct of the inattention characteristic of the disorder. Perception of ensemble characteristics, or *ensemble coding*, has recently been the target of increased interest in perception research, and appears to represent a powerful mechanism for processing sensory information, particularly in situations when attentional resources are limited. Ensemble coding is an ideal avenue for investigating deficits in emotion recognition among those with ADHD because it may allow researchers to disentangle attentional deficits from specific deficits in social cognition. Fifty participants were evaluated for ADHD symptoms using the Barkley Adult ADHD Rating Scale (BAARS-IV), the University of California's Greater Good Emotional Intelligence Quiz, and the Sensory Gating Inventory (SGI), and subsequently asked to perform an ensemble-coding task

involving images of emotional faces. A correlation analysis was conducted using scores on the BAARS-IV and the SGI, as well as performance on the ensemble-coding task, to evaluate the relationship between ADHD symptoms and the ability to recognize emotion in others. Performance on the ensemble emotion recognition task did not differ as a function of severity of ADHD symptoms, suggesting that the emotion recognition deficits associated with ADHD are attentional in nature, rather than reflecting a deficit in downstream processing of higher order information related to emotion.

KEYWORDS: Attention Deficit, Ensemble Coding, Emotion, Visual Cognition, ADHD

ATTENTION DEFICITS AND PERCEPTION OF EMOTION IN GROUPS

AGNES R. STROJEWSKA

A Thesis Submitted in Partial
Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Psychology

ILLINOIS STATE UNIVERSITY

2016

© 2016 Agnes R. Strojewska

ATTENTION DEFICITS AND PERCEPTION OF EMOTION IN GROUPS

AGNES R. STROJEWSKA

COMMITTEE MEMBERS:

Amrita Puri, Chair

William J. Schneider

ACKNOWLEDGMENTS

The writer wishes to thank Dr. Amrita Puri, Dr. Joel Schneider, Dr. John Binning, and Brenna Knott.

A. R. S.

CONTENTS

	Page
ACKNOWLEDGMENTS	i
CONTENTS	ii
TABLES	iv
FIGURES	v
CHAPTER	
I. OVERVIEW OF ATTENTION-DEFICIT HYPERACTIVITY DISORDER	1
Barkley’s Theory of ADHD	2
ADHD and Social Deficits	4
II. ENSEMBLE CODING	8
Implications for ADHD Research	12
III. THE PRESENT STUDY	14
IV. METHODS	19
Participants	19
Stimuli	20
Diagnostic Measures	22
Greater Good Science Center Body Language Quiz (BLQ; Greater Good Science Center at the University of California, Berkeley [GGSC-UCB], 2016)	22
Barkley’s Adult Attention-Deficit/Hyperactivity Rating Scale, Fourth Edition (BAARS-IV; Barkley, 2011).	22
Sensory Gating Inventory (SGI; Hetrick, Erickson, & Smith, 2012)	22

Procedure	23
Data Analysis	25
V. OUTCOMES	27
Results	27
Discussion	30
Limitations	33
Directions for Future Research	34
Conclusions	35
REFERENCES	37
APPENDIX A: SURVEY QUESTIONNAIRES	43

TABLES

Table	Page
1. Correlation Between Attention Deficit Symptoms and Performance on Ensemble Coding Task	28
2. Correlation Between ADHD Symptoms and Performance on the BLQ	29
3. Fisher's z Transformations for Attention Deficits \times Task Correlations	30

FIGURES

Figure	Page
1. Range of possible emotional expressions displayed to participants during the ensemble coding task.	21
2. Types of ensemble configurations displayed to participants during the ensemble-coding task.	24

CHAPTER I

OVERVIEW OF ATTENTION-DEFICIT HYPERACTIVITY DISORDER

Attention-Deficit Hyperactivity Disorder (ADHD) impacts between 4% and 12% of US children aged 6 – 12, with annual cost of impairment reaching \$42 billion (Cahill et al. 2012; APA 2013). Though ADHD is most often associated with children, approximately 30 – 65% of individuals with ADHD experience persistent symptoms well into, or even throughout adulthood (Cahill et al., 2012; Bush, 2010). These individuals are susceptible to a number of problems including academic failure, difficult interpersonal relationships, deficits in recognizing others' emotions, difficulty regulating emotions, and legal trouble (Bush, 2010; Da Fonseca, Segui, Santos, Poinso, & Deruelle, 2009; Lollar 2008; Yuill & Lyon, 2007).

The root of dysfunction in ADHD is most often attributed to inattention, impulsivity, and hyperactivity, where 'inattention' refers to difficulties in maintaining selective attention and 'impulsivity' refers to rash or abrupt actions performed without prior consideration of consequences (Bush, 2010). 'Hyperactivity' refers specifically to an excess of physical movement (Bush, 2010). While ADHD most commonly presents as a combined type featuring both inattention and hyperactivity, a significant number of cases present as the purely inattentive subtype. Further complicating ADHD research is the great fluctuation seen in the level of focus of individuals with ADHD, which may vary with an individual's current state or present task (Bush 2010). Some individual with

ADHD who suffer from inattention may also appear hyper-focused on certain tasks (Bush, 2010).

In his 2010 review, Bush argues that while there is a substantial body of research on ADHD, the field must explore a greater variety of tasks and foci. Tasks such as the stroop, flanker, and go/no-go tasks, which primarily measure executive function and response inhibition, have been productive areas of study; however, many important processes still remain unstudied (Bush, 2010). Areas in need of further research range widely, from error detection to vigilance to spatial working memory to the intersection of emotion and attention (Bush, 2010). One such area in need of study is in spatial working memory tasks, as related regions of the parietal cortex have been implicated in attention and cognition, but have not been thoroughly explored with regards to ADHD (Bush, 2010). What is clear from Bush's (2010) review is that the search for a comprehensive model of ADHD continues, in part due to its complex, heterogeneous presentation.

Barkley's Theory of ADHD

While many researchers have continued to characterize ADHD as primarily a disorder of distractibility and inattention (Forster, Robertson, Jennings, Asherson, & Lavie, 2014; Aboitiz, Ossandon, Zamorano, Palma, & Carrasco, 2014), others have turned to different models of ADHD. Barkley (1997) conceptualizes ADHD primarily as a deficit in behavioral inhibition; individuals with ADHD, he theorizes, lack the behavioral inhibition necessary to fully employ four major executive functions: working memory, regulation of affect/motivation, internalization of speech, and reconstitution, ultimately making it more difficult to bring motor control, fluency, and syntax under the

control of internal information. More precisely, Barkley (1997) argues that ADHD is primarily characterized by deficits in three main inhibitory processes: inhibition of learned responses, inhibition of a current task for the purpose of task switching, and maintaining attention on a current task. It is only through these inhibitory processes that the other four executive functions are able to operate properly.

By inhibiting competing responses and ending ongoing responses, behavioral inhibition processes give working memory the opportunity to internally hold and manipulate information without distraction; these processes likewise give individuals greater control over their level of arousal, and as well as control over regulating their emotional state (Barkley, 1997). Behavioral inhibition also makes possible the internalization of speech, most important as a means of defining rules and plans prior to action (Barkley, 1997). The final executive function made possible by inhibitory processes, according to Barkley's (1997) theory, is *reconstitution*. Reconstitution is a twofold process of analysis and synthesis, or the decomposition of events or messages into component parts and the manipulation of these component parts to create new messages (Barkley 1997). The messages synthesized through reconstitution may further represent or initiate behavior, facilitating increasingly complex hierarchies of behavior and language (Barkley 1997).

Through the four executive functions and behavioral inhibition, according to Barkley (1997), individuals achieve what Barkley refers to as fluency, syntax, and motor control. Most importantly, this fluency-syntax-motor control triad represents a shift in control from external forces to primarily control by internal information (Barkley 1997). The fluency-syntax-motor control triad encompasses the inhibition of task-irrelevant

responses, re-engagement following disruptions, attention to feedback, sensitivity to errors, and the execution of complex behaviors (Barkley 1997). Inattention and distractibility, therefore, are secondary symptoms, arising as the results of an inability to self-regulate (Barkley 1997).

ADHD and Social Deficits

One advantage of Barkley's (1997) model of ADHD is that it comprehensively addresses the various behavioral effects of ADHD, including the 52–82% of individuals with ADHD that have reported social or interpersonal difficulties (Landau, Milich & Diener 1998). Surprisingly few questions have been answered with respect to social deficits in ADHD, but there are some indications that children with ADHD demonstrate reduced empathy (Uekermann et al., 2010). Likewise, neuroimaging studies have suggested that regions responsible for Theory of Mind (the ability to reason about the mental states of others) may show dysfunction in individuals with ADHD, though behavioral research in this area has yielded mixed results (Uekermann et al., 2010). Youths with ADHD have sometimes demonstrated more severe oppositional behaviors, with high levels of comorbidity between ADHD as well as Oppositional Defiant Disorder and Conduct Disorder (Nijmeijer et al. 2008). More generally, these social deficits often lead to poor outcomes, including social rejection and isolation in children, and frequent job loss and elevated divorce rates amongst adults (Friedman et al. 2003).

While Barkley (2010) explicitly acknowledges the interpersonal difficulties facing individuals with ADHD, he primarily attributes interpersonal difficulties to emotional reactivity, denying that inattention directly impacts interpersonal competency. While

increased emotional reactivity almost certainly accounts for some interpersonal difficulties, there are some who suggest that individuals with ADHD further experience difficulties recognizing the emotions of others (Da Fonseca et al., 2009; Yuill & Lyon, 2007; Cadesky, Mota, & Schachar, 2000; Petersen and Grahe, 2012; Fine, Semrud-Clikeman, Butcher & Walkowiak, 2008). This deficit in emotional understanding may be quite severe, with some evidence suggesting that individuals with ADHD demonstrate levels of emotional understanding comparable to those with Autism Spectrum Disorder (Fine, Semrud-Clikeman, Butcher & Walkowiak, 2008). This is in stark contrast to Barkley's (1997) original assumptions that perception of others' emotions should not be affected in individuals with ADHD, because such understanding is non-executive. As Barkley (1997) notes, however, these assumptions were made with little research available to confirm or dispute this claim. Interest in this area of research has grown substantially since Barkley's (1997) theory was developed, much of it suggesting significant deficits in the perception of others' emotions.

While evidence seems to suggest that those with ADHD have difficulty recognizing others' emotions, the precise nature of this deficit is not fully understood. Some researchers have concluded that individuals with ADHD experience difficulty recognizing emotions simply because they do not attend to the appropriate visual cues (Cadesky, Mota & Schachar, 2000), while others have argued that inattention cannot fully account for this deficit and that a wider deficit in social cognition must be implicated (Yuill & Lyon, 2007; Da Fonseca, Segquier, Santos, Poinso, & Deruelle, 2009; Raz & Dan, 2015). When asked to discern trustworthiness from videotaped interactions, individuals with ADHD have been shown to be more likely to attend to invalid cues (e.g.,

background color, camera angle, formality of clothing, target race) than appropriate social cues (Petersen & Grahe, 2012). Likewise, Da Fonseca et al. (2009) found that although individuals with ADHD had difficulty identifying emotion from facial images and context cues, they had no difficulty identifying hidden objects using context cues. These findings are in line with those of Raz and Dan (2015), who found that individuals with ADHD had longer reaction times and were less accurate when identifying emotional faces than when identifying geometric shapes. Together this research suggests a wider pattern of deficits in social intelligence or perception of social cues amongst individuals with ADHD.

The pattern of social deficits demonstrated by individuals with ADHD is distinct from that of many other disorders with social deficits. For example, while ADHD has commonly been associated with defiant and hostile behavior in children, the social deficits underlying these behaviors are dissimilar to those of children with Conduct Disorder (Cadesky, Mota & Schachar, 2000). Cadesky and colleagues, Mota and Schachar (2000) found that while children with Conduct Disorder regularly misinterpreted emotional faces as angry, the mistakes made by children with ADHD tended to be randomly distributed across emotion categories, despite comparable levels of overall accuracy between the groups. Despite Barkley's (1997) insistence that ADHD was not associated with deficits in perceiving others' emotions, his theory accurately predicts this pattern of response, arguing that individuals with ADHD are more likely to demonstrate high levels of variance on laboratory tasks due to a lack of internally motivated, rule-based behaviors. Moreover, because faces are higher-order stimuli, benefiting from top-down processing, it is possible that they are particularly susceptible

to the lack of controlled attention that characterizes individuals with ADHD.

Nevertheless, Barkley's theory fails to explain the specificity of deficits surrounding the perception of others' internal states.

CHAPTER II

ENSEMBLE CODING

Ensemble coding is an area of study that has potential to yield new insights for research on deficits in social perception and has been rarely examined in conjunction with ADHD. An ensemble refers to a representation of multiple images or features, which could be obtained by averaging or some other form of statistical summarization (Alvarez & Oliva, 2009). Ensemble coding, or the summary representation of an array of similar visual stimuli, occurs extremely quickly (i.e., less than 500 ms) for a variety of images and features, including number, size, and orientation, but also including high order details such as gender and facial emotion (Ariely, 2001; Chong & Treisman, 2003; Haberman & Whitney, 2007; Alvarez & Oliva, 2009; Haberman & Whitney, 2009). Besides occurring quickly, ensemble coding may also occur without the need for careful attention to detail, as even with diffuse attention, the averaging process yields considerable accuracy (Alvarez, 2011). Processing of ensembles often results in greater accuracy than would be realizable by evaluating individual objects; this is possible because the averaging of multiple stimuli cancels out “noise” or minor variations in individual iterations (Alvarez & Oliva, 2009). Moreover, the ensemble coding process is implicit, occurring despite unrelated task instructions (Haberman & Whitney, 2009). Ensemble coding is so efficient, in fact, that in one study, even individuals who suffer from prosopagnosia and, and are thus unable to discriminate between faces perform at the

same level as controls on ensemble face recognition tasks (Leib, Puri, Fischer, Bentin, Whitney, & Robertson, 2012).

Despite the blossoming in ensemble coding research, little is known about the neural correlates of ensemble coding. Recent studies have implicated the parietal cortex in the ensemble coding of numbers or quantities, though it is unknown which brain regions might be involved in ensemble coding of other data, such as size, orientation, or facial expression (Alvarez, 2011; Piazza & Izard, 2009). Even with this modicum of information, however, it is interesting to note the research demonstrating reduced activation of the parietal cortex's right and left polymodal sensory integration areas in individuals with ADHD (Schneider et al., 2010; Silk, Vance, Rinehart, Bradshaw & Cunnington, 2008).

Interestingly, ensemble coding operates not only for images shown simultaneously or in parallel, but also for stimuli perceived in sequence (Alvarez, 2011). This is evidenced in research indicating that individuals are capable of accurately identifying the mean size of dynamically changing shapes over time, as well as the mean emotion of a dynamically changing face (Alvarez, 2011). Ensemble coding's role in temporally averaging a changing image, such as an emotional face, may be a promising, albeit unexplored, direction for improving our understanding of social perception, as the ability to track the emotion of a companion's face as it moves is by definition a process of social perception.

Recent research has further implicated ensemble coding in processes beyond the realm of visual processing. Piazza, Sweeney, Wessel, Silver & Whitney (2013) investigated individuals' ability to identify the mean frequency of a set of sequential

tones. Not only were participants successful at identifying the mean frequency, but performance also declined as the number of tones decreased the benefit of representing the mean frequency (Piazza et al., 2013). Likewise, participants fared poorly when asked to identify individual tones that they had heard, and were unable to place them in sequence (Piazza et al., 2013). These findings provide strong evidence suggesting that ensemble coding is not strictly a function of visual processing, but rather a mode of processing sets of stimuli from the environment. Additionally, it must be noted that auditory information such as pitch can be an important source of social information, conveying emotion and influencing perceptions of gender (Piazza et al., 2013; Curtis & Bharucha, 2010; Smith, Grabowecky, & Suzuki, 2007). Such evidence, alongside evidence that mean emotion can be accurately discerned from face ensembles, demands further research into the role of ensemble coding in processing critical, nonverbal social information.

Ensemble coding takes advantage of the redundancy often found in nature, as one might see in a field of grass or crowd of faces, to very quickly identify the mean properties of a set of similar stimuli (Alvarez, 2011). In practical terms, ensemble coding provides a number of critical benefits including providing a sense of the “gist” of information outside of the focus of attention and quickly identifying outliers and non-group members (Alvarez, 2011; Haberman et al., 2015). One use for ensemble coding which may be of particular importance to individuals with ADHD is the role of ensemble coding in allocating attention; rather than beginning a visual search “blind,” ensemble coding can help to guide visual attention to the appropriate or distinct regions within a scene (Alvarez, 2011). Recent research has also implicated ensemble coding in

individuals' ability to evaluate group behavior; Sweeney, Haroz, and Whitney (2013) found that individuals pooled information from multiple group members to evaluate the mean direction of a crowd's travel. Moreover, in comparisons between evaluations of crowd travel and judgments about individuals' bearing within a crowd, Sweeney and colleagues (2013) found that judgments about crowd travel were more accurate than judgments about individuals.

It must also be noted that ensemble coding is not a singular process, but a complex set of processes with little connection between encoding of high-level and low-level representations (Haberman, Brady & Alvarez, 2015). High-level representations include such things as facial expression and individual identity, whereas low-level representations include stimulus color and orientation of edges within an image (Haberman et al., 2015). Moreover, encoding of high-level ensembles, particularly faces, are especially vulnerable to manipulations of the image, such as inversion (McKone 2004; McKone, Martini & Nakayama, 2001). This vulnerability is believed to be the result of facial processing's reliance on configural processing, or the integration of information perceived across the entire face, which is matched to an expected representation (McKone et al., 2001). Encoding of low-level representations, in contrast, is more likely to rely on feature-based identification utilizing discrete local regions of an image (McKone et al., 2001).

Despite involving highly sophisticated processes and high-level representations, children as young as four have been shown to use ensemble coding for evaluating the environment around them (Sweeney, Wurnitsch, Gopnik, & Whitney, 2015). So innate is ensemble coding that it occurs even under conditions of reduced attention; when tasked

with tracking several erratically-moving figures, individuals maintained the ability to identify ensemble characteristics from outside the foci of attention (Alvarez & Oliva, 2009). That ensemble processing may continue to function despite diminished attentional resources raises interesting questions for individuals who suffer generalized processing deficits.

Implications for ADHD Research

Several attributes of ensemble coding make it potentially fruitful, albeit uncharted, territory for ADHD research. Ensemble coding's role in directing attention and assessing dynamically changing stimuli, such as faces, as well as its effectiveness among populations with deficits in facial recognition, invites the question of whether the ability to generate ensemble representations is affected in individuals with ADHD. The low attentional demands of ensemble coding may prove invaluable for a population largely defined by a restricted attentional capacity. It is possible that those with ADHD will demonstrate deficits in individual facial recognition, but will exhibit normal functioning in ensemble coding tasks, as was the case within the sample of individuals with prosopagnosia (Leib et al., 2012). Alternatively, the executive function deficits implicit in ADHD may hinder the processing of higher-order ensembles that require top-down processing, such as faces. Additionally, early neuroimaging research suggests that the area of the brain responsible for ensemble coding of numbers (the parietal cortex) is dysfunctional in individuals with ADHD (Schneider et al., 2010). If ensemble coding processes are impaired in individuals with ADHD, this would partially explain the

difficulty that many with ADHD have in allocating attention, and would be a previously unidentified deficit characteristic of ADHD.

Previous research on anxiety has demonstrated implicit perceptual differences in anxious individuals, revealing a tendency to perceive the mean face of a crowd as more fearful than do non-anxious controls (Yang, Yoon, Chong & Oh, 2013). The processes underlying these differences have been a matter of some debate, with Yang et al., (2013) proposing that anxious individuals lack positive perceptual biases present in most people, while recent research by Puri, Halladay, Romager, Lee, and Caselman (2015) provides evidence suggesting that trait-anxious individuals may lack these biases, but that socially anxious individuals are more likely to additionally demonstrate a bias towards perceiving stimuli as threatening. This pattern of responses is not altogether different from the pattern identified by Cadesky, Mota and Schachar (2000) among populations with Conduct Disorder, characteristic of an interpretive dysfunction. Comparable research has not yet been performed using populations with ADHD.

CHAPTER III

THE PRESENT STUDY

Previous ADHD research has regularly demonstrated domain-specific deficits in processing, including a specific impact on the recognition of others' emotional states (Yuill & Lyon, 2007; Da Fonseca et al., 2009; Raz & Dan, 2015). Such findings suggest a specific dysfunction in social cognition and run counter to mainstream conceptions of ADHD as primarily a disorder of inattention, as well as Barkley's (1997) theory. While some have argued that these deficits are merely an extension of ADHD's impact on attentional control, research in this area has been limited (Cadesky et al., 2000). The question of whether deficits in emotion recognition are an extension of inattention or if this is a discrete deficit in social cognition can be conceptualized as a question of whether ADHD merely impacts perception of stimuli or whether it differentially impacts the processing of received emotional stimuli. Given ensemble coding's distinct role in perception, particularly with regard to stimuli such as emotional faces, it may be an invaluable avenue for investigating whether ADHD impacts stimulus perception at the level of basic visual processing or if it differentially impacts social cognition.

Given the success of Leib et al., (2012) in demonstrating that populations with prosopagnosia are able to recognize faces with accuracy similar to that of participants with typical face recognition abilities when the faces are displayed as an ensemble, it may be that individuals with ADHD will similarly show no perceptual deficits, or perhaps

only attenuated deficits, when viewing ensembles versus individual faces. Any improvement over the individual face recognition task would suggest that deficits in emotion recognition in ADHD are indeed an extension of the inattention already associated with ADHD, rather than a downstream deficit in emotion interpretation. However, if individuals scoring higher on ADHD measures are found to perform poorly on the ensemble coding task, it may suggest one of two things. One possible explanation for such a result may be that individuals with ADHD do, in fact, experience deficits in social cognition and processing of received social stimuli. Alternatively, such results might indicate that ADHD is uniquely associated with previously undiscovered deficits in ensemble coding. Unique deficits in ensemble coding are not inconceivable, in light of evidence that ADHD adversely impacts functioning in the parietal cortex – a region of the brain also implicated in ensemble coding (Alvarez, 2011; Schneider et al., 2010; Silk, Vance, Rinehart, Bradshaw & Cunnington, 2008 Piazza & Izard, 2009). Any deficits unique to ensemble coding would likely be associated with impaired performance relative to controls not only on upright ensembles of faces, but also inverted ensembles, which are not perceived holistically and therefore would not be subject to subsequent downstream dysfunctions in social cognition (McKone et al., 2001). If deficits are only evident in upright oriented ensembles but not inverted ensembles, this may provide insight and guide questions for future studies as to whether the deficits lie in ensemble coding processes or in downstream processing and interpretation of emotional data.

In light of research implicating ensemble coding not only in the perception of static ensembles, but also in perception of dynamically moving faces, human movement, and sequential tones, identifying unique deficiencies in ensemble coding in individuals

exhibiting some attentional deficits may serve to initiate productive new directions for research. Most important of these questions is to what extent might unique deficits in ensemble coding contribute to otherwise unexplained deficits in the perception of social information. Given the array of multimodal information available through ensemble coding, including information relevant to emotional processing such as facial expression, deficits in ensemble coding would almost certainly influence perception of social information.

The present study utilized an ensemble task, which includes displays of multiple faces with two levels of variance in emotional expression (high and low variance) as well as two orientations (upright and inverted), rather than traditional methods of studying facial emotion recognition in populations with attentional deficits. By testing how performance on this perceptual process relates to ADHD measures, it is possible to begin disentangling upstream perceptual deficits from downstream deficits in social cognition. This study set out primarily to answer three questions:

- 1) Do individuals with higher scores on ADHD measures exhibit greater deficits in ensemble coding of emotional faces?
- 2) Are individual facial emotion tasks, as measured by performance on the Body Language Quiz (BLQ), also adversely affected by greater ADHD symptoms, and to a greater or lesser extent than ensemble tasks?

3) Is there a significant difference between attention deficit-upright ensemble correlations and attention deficit-inverted ensemble correlations?

In the present study, we first tested the hypothesis that individuals with higher scores on ADHD measures exhibit equivalent performance on ensemble coding of facial emotion as compared to individuals with lower scores. More precisely, we predicted that greater scores on ADHD measures will not correspond to lower performance on ensemble coding tasks. Our second hypothesis was that performance on the individual facial emotion task, the BLQ, would be negatively related to scores on ADHD measures to a greater extent than it is related to performance on the ensemble coding tasks. The Body Language Quiz, developed by the University of California, Berkeley's Greater Good Science center, was used to test the hypothesis that individuals with greater attentional deficits perform poorly on single stimulus emotion-recognition tasks. By including a measure of emotion recognition of individual faces, it is possible to discern any performance advantages or disadvantages unique to ensemble coding, as was the case among participants with prosopagnosia (Leib et al., 2012). Finally, our third hypothesis was that all participants would perform better on upright-oriented trials, but that scores on the ADHD measures would not differentially relate to performance in the upright, as compared to inverted, condition.

Studying the ensemble coding ability of individuals with relatively greater attentional deficits may additionally shed light on the process of ensemble coding itself. Given that individuals with ADHD are less proficient at attending to individual faces, a finding that scores on the ADHD scale are unrelated to performance on the ensemble

coding task may lend further support to the idea that generating statistical average representations does not require detailed representations of individual faces, particularly if there is a negative relationship between performance on the BLQ (individual faces) and scores on the ADHD scale.

CHAPTER IV

METHODS

Participants

Puri et al. (2015) found a significant relationship ($r(19) = .66, p < .01$) between trait-anxiety and accuracy on the facial ensemble coding task. A power analysis ($Power = .80$) revealed that a bivariate correlational analysis with a somewhat more conservative expected correlation ($r = .40, \alpha = .05$) would require forty-six undergraduate student participants. Fifty-two participants were recruited from large public university in the Midwestern U.S. through the SONA online recruitment system. All participants received course credit in exchange for their participation. Data from five participants were excluded from analyses due to repeated disruptions during the session. Participants were required to have normal or corrected-to-normal vision in order to be eligible for the study. Participants with ADHD were not specifically recruited, as the current study aimed to explore correlations between emotion processing and levels of ADHD-like symptoms within a typical sample, rather than to compare clinical and control groups. Because correlations were based on current reported symptoms as reflected in the selected measures, participants were not asked about their medication status. All participants provided written informed consent, in accordance with a protocol approved by the Institutional Review Board at Illinois State University.

Stimuli

Images of fearful, happy, and sad faces from the Ekman Face-Emotion Database were morphed together in 50-step increments to create a set of 147 faces (see Figure 1). In separate blocks of 600 trials, participants were shown either upright or inverted ensembles of 18 faces expressing either the same or varying emotions within a display. Each set of faces was presented for 1000 ms. Stimuli were presented against a gray background, on a 19-inch monitor (1024 × 768 pixels resolution, 75 Hz refresh rate).

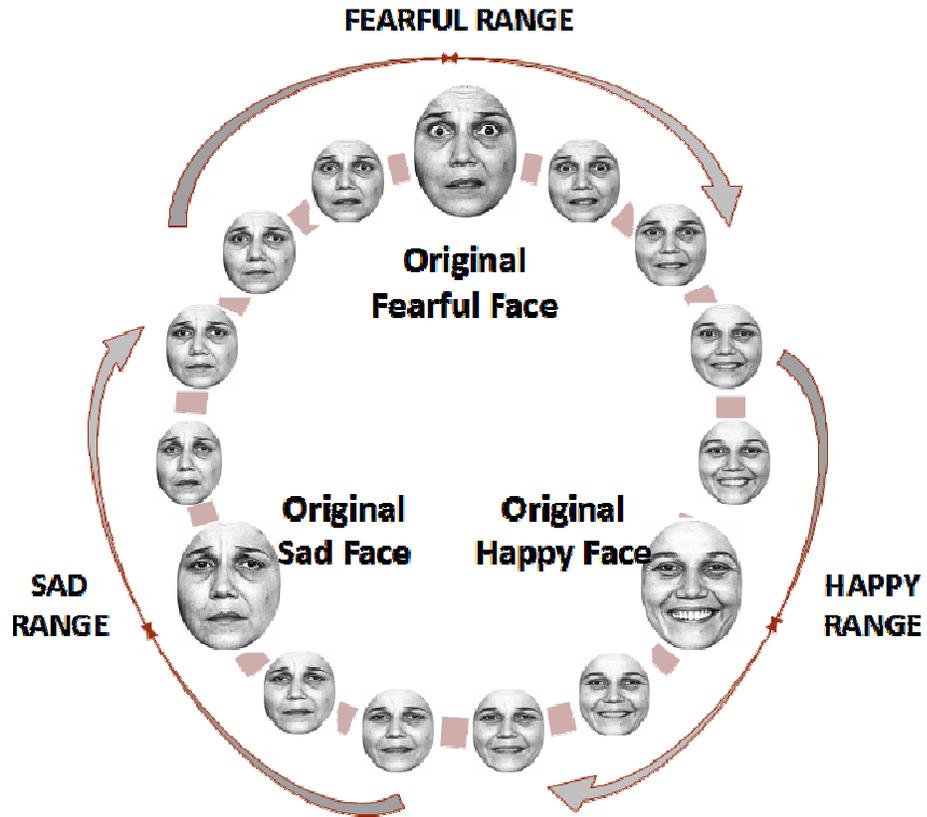


Figure 1. Range of possible emotional expressions displayed to participants during the ensemble coding task. Stimuli were created by morphing images depicting the same individual with a fearful, happy and sad expression in 50-step increments.

Diagnostic Measures

Greater Good Science Center Body Language Quiz (BLQ; Greater Good Science Center at the University of California, Berkeley [GGSC-UCB], 2016)

The BLQ is a 20-item, online, multiple-choice assessment that evaluates individuals' ability to infer emotion from color photographs of human body language (GGSC-UCB, 2016). Each item consists of one image, and four multiple-choice answers per item (Appendix A). Questionnaires were printed and answers were hand-graded following the completion of all tasks.

Barkley's Adult Attention-Deficit/Hyperactivity Rating Scale, Fourth Edition (BAARS-IV; Barkley, 2011)

The BAARS-IV consists of 30 self-report items designed to evaluate participants' current levels of several key ADHD symptoms (Appendix A; Barkley, 2011). The self-report items are subdivided into the following subsections: inattention, hyperactivity, sluggish cognitive tempo, and impulsivity (Barkley, 2011). Each subsection is hand-scored by the experimenter at the conclusion of the experiment, from which a total score is calculated (Barkley, 2011). Total scores are then grouped by numerical range into non-clinical, subclinical, and clinical groups.

Sensory Gating Inventory (SGI; Hetrick, Erickson, & Smith, 2012)

The SGI is a 36-item self-report scale occasionally used as an efficient, preliminary evaluation of a variety of clinical disorders that evaluates participants' perceptual modulation, distractibility, and over-inclusion (Sable et al., 2012). The distractibility subscale of the SGI, in particular, has been found to be highly correlated with ADHD (Sable et al., 2012; Hetrick et al., 2012). Thus, the eight questions from this

subscale have been parceled out and administered to participants (Appendix A). The scale was hand-scored by the experimenter following the experiment.

Procedure

Participants were seated individually in a quiet room and asked to complete a series of ensemble coding trials. The monitor was adjusted to an appropriate height for each participant, and participants were positioned approximately 60 cm away from the monitor. The ensemble coding task was presented using Presentation version 12.1 (Neurobehavioral Systems). Participants were presented with a total of 640 trials, of which 50% involve displays of high-variance ensembles (HV), and 50% involve low-variance ensembles (LV). In the low variance condition, displays consisted of 18 faces exhibiting identical emotional expressions, which were randomly selected from the stimulus wheel of emotions. Displays in the high-variance condition contained three instances of each of six different emotions centered on a randomly selected mean emotion. The trials were interleaved in terms of the emotional variance of displays. In one block of trials, the face displays were upright (U), while in another block, faces were inverted (I). The order of presentation of the upright and inverted blocks was counterbalanced. After the presentation of each display (1000 ms), a single face appeared in the center of the screen. Participants used a mouse to scroll through the 147 expression morphs and select the face that most closely matched the average expression of the ensemble. Each response prompted the next trial to begin. After participants had completed all trials, they were asked to complete the BLQ, BAARS-IV, and the SGI. The order of the questionnaires was counterbalanced across participants.

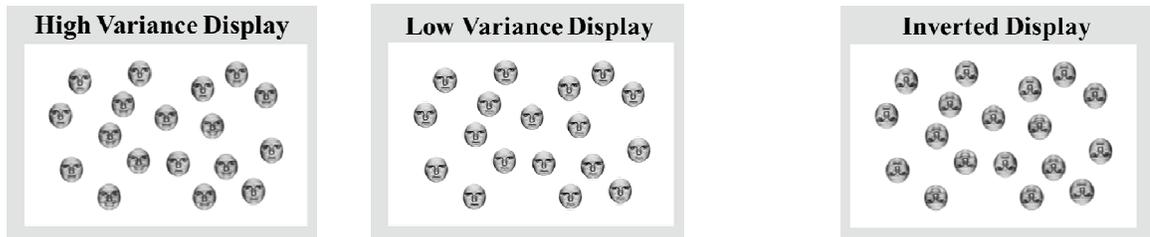


Figure 2. Types of ensemble configurations displayed to participants during the ensemble-coding task. Displays were composed of 18 faces, with the high variance (HV) condition comprised of three repetitions each of six unique faces around a randomly selected mean, and the low variance (LV) condition comprised of 18 identical faces. In separate blocks, displays were presented either in the upright or inverted (i.e., rotated by 180 degrees) orientation.

Data Analysis

By including both high- and low-variance conditions, it is possible to correct for individual differences in working memory ability, which would arguably contribute to performance on the matching component of the task. Rather than relying solely on the raw error magnitude on high-variance trials to evaluate performance, low-variance trials were used to establish a baseline performance level for matching facial expressions using the standard method of adjustment for ensemble coding tasks. Measuring the difference between performance on high- versus low-variance trials allowed us to account for the ability to perform the matching task, independent of the ability to perceive the ensemble emotion. Therefore, we were able to more accurately examine participants' ability to evaluate the average emotion of the group containing faces with varying expressions than would be possible using performance on the high variance trials alone (Puri et al., 2015). The difference between performance on the high-variance trials and the low-variance trials, calculated as HV-LV, is considered the level of performance on the ensemble-coding task.

Correlation analyses with Fisher's z transformations were conducted between the BAARS-IV and both inverted and upright ensemble coding trials, as well as between the SGI and inverted and upright ensemble coding tasks. If individuals with higher scores on the ADHD measures experienced a similar processing boost during ensemble coding to that demonstrated among people with prosopagnosia, it was expected that no significant correlations would be found. Such individuals, whose condition is defined by an inability to recognize individual faces, demonstrated no differences from controls on ensemble coding tasks involving facial identity recognition, putatively due to the processing

advantages of ensemble coding (Leib et al., 2012). Correlation analyses were also conducted between the BLQ and SGI and the BAARS-IV, respectively.

CHAPTER V

OUTCOMES

Results

Responses to the SGI (Sensory Gating Inventory) ($SD = 7.76$, $M = 21.04$) had a range of 1–37. The BAARS-IV (Barkley Adult ADHD Rating Scale) ($SD = 6.67$, $M = 30.96$) had a range of 19–49, and the BLQ (Body Language Quiz) ($SD = 1.94$, $M = 13.06$) had a range of 9–16. The SGI and BAARS-IV were correlated significantly ($r(46) = .47$, $p < .001$).

As predicted, correlation analyses of scores on the SGI and BAARS-IV with inverted and upright ensemble coding tasks yielded no significant correlations for BAARS-IV \times Upright Scores ($r(45) = -.09$, $p = .27$), BAARS-IV \times Inverted Scores ($r(45) = -.12$, $p = .21$) SGI \times Upright scores ($r(45) = -.08$, $p = .29$), or SGI \times Inverted Scores ($r(45) = -.24$, $p = .052$) (see Table 1). The trend towards a modest negative correlation between the SGI scores and accuracy of average emotion estimates in the inverted condition will be considered in the discussion, although as described below, further analyses revealed that the relationship between the SGI and performance on the ensemble task did not significantly differ across the orientation conditions.

Table 1		
<i>Correlation Between Attention Deficit Symptoms and Performance on Ensemble Coding Task</i>		
	<u>BAARS-IV</u>	<u>SGI</u>
Upright Trials	-0.09	-0.08
Inverted Trials	-0.12	-0.24 [†]
<i>Note:</i> Pearson's r is presented for each instrument.		
[†] <i>p</i> = 0.052.		

Fisher's z-to-r transformations were performed to evaluate whether the correlation between SGI scores and performance on upright ensemble tasks significantly differed from the correlation between SGI scores and performance on inverted ensemble tasks. Fisher's z transformations were also performed comparing correlations between the BAARS-IV and performance on upright and inverted ensemble tasks. Attention deficit symptoms' correlation with upright ensemble tasks was not significantly different from these symptoms' correlation with inverted ensemble tasks, as measured by the SGI ($z = 0.71, p = .45$) or by the BAARS-IV ($z = 0.14, p = .89$).

Additional correlation analyses examined the relationship between performance on the BLQ and scores on measures of attention-deficit symptomatology (see table 2). Counter to our prediction, a marginally significant positive correlation was found between the BLQ and scores on the BAARS-IV, $r(45) = .23, p = .058$. Furthermore, a small, significant positive correlation was identified between performance on the BLQ and scores on the SGI, $r(45) = .27, p < .05$. Finally, a Fisher's z transformation was

conducted to evaluate the relationship between the correlation between attention deficits and BLQ performance, and the correlation between attention deficits and inverted and upright ensemble tasks, respectively (see Table 3). The BLQ/SGI correlation was significantly higher than correlations between the SGI and inverted ensemble tasks ($z = 2.45, p = .01$) and the SGI and upright ensemble tasks ($z = 1.67, p = .04$). The BLQ/BAARS-IV correlation was not significantly different from the correlation between the BAARS-IV and performance on the upright ensemble task ($z = 1.52, p = .13$) or from the correlation between the BAARS-IV and performance on the inverted ensemble task ($z = 1.66, p = .10$).

Table 2		
<i>Correlation Between ADHD Symptoms and Performance on the BLQ</i>		
BLQ	<u>BAARS-IV</u>	<u>SGI</u>
	.23	.27*
<i>Note:</i> Pearson's r is presented for each instrument.		
* $p < .05$.		

Table 3				
<i>Fisher's z Transformations for Attention deficits × Task correlations</i>				
	BAARS-IV		SGI	
	<u>Upright</u>	<u>Inverted</u>	<u>Upright</u>	<u>Inverted</u>
BAARS-IV/BLQ	1.52	1.66		
SGI/BLQ			1.67*	2.45**
<i>Note:</i> Fisher's z is presented for each set of correlations.				
* $p < .05$.				
** $p < .01$.				

Discussion

In this study, we explored the relationship between attention deficit symptomatology on recognition of emotion in individuals and ensembles. In particular, we sought to disentangle well-documented deficits in attention from theorized deficits in subsequent processing of nonverbal indicators of emotion. We did so by correlating recorded scores on ADHD-related scales with performance on an individual emotion recognition task, and also with performance on a task in which participants estimated the average emotion of groups of faces. The latter has been argued to require only minimal attentional resources (Alvarez & Oliva, 2009). Consistent with the results obtained by Leib et al. (2012), who found that individuals with prosopagnosia were capable of estimating both the average emotion and the average identity of face ensembles despite failings in individual face tasks, individuals in our study who exhibited greater attention deficit symptoms did not show relative deficits in perceiving the average emotions in

groups of faces, and no significant correlations were found between the BAARS-IV and performance on ensemble coding tasks overall. In line with our first hypothesis, it may be that attentional deficits do not impact performance on ensemble perception, which does not require significant attentional resources.

Contrary to our second hypothesis, performance on the individual emotion recognition task, the BLQ, was positively correlated with scores on the distractibility subscale of the SGI ($r(45) = .27, p < .05$). These results were significantly different ($z = 2.45, p = 0.01$) from a slight negative correlation between SGI scores and performance on the inverted ensemble task ($r(45) = -.24, p = .052$). A number of factors may have influenced these results, as evidenced by an average SGI distractibility score that is significantly higher than that found in other studies.

One possibility is that these unusually high SGI scores may indicate the presence of a confounding factor such as susceptibility to fatigue. Whereas only the distractibility subscale was used in this experiment, it should be noted that the full SGI also includes a fatigue subscale, which correlates to increases in distractibility scores in healthy adults. As such, it is possible that SGI distractibility scores were artificially inflated as a result of outside factors, such as fatigue related to upcoming final examinations, which roughly coincided with the data collection period. Given the relatively low number of participants with clinical scores on the BAARS-IV (discussed below), it is possible that those participants with unusually high SGI scores were not exhibiting attention deficits, but were healthy adults with high fatigue scores. As such, these healthy adults may have performed better than other participants with subclinical attention deficit symptoms.

However, it should also be noted that 10.6% of participants scored within the clinical range of the BAARS-IV self-report scale. Given that only roughly 3% of the general population is estimated to qualify above two standard deviations and thus within the clinical range of ADHD (Barkley, 1997), the higher-than-average mean scores on the SGI may simply corroborate the large proportion of students scoring within the clinical range on the BAARS-IV.

Despite a modest, marginally significant negative correlation between SGI scores and inverted ensemble task performance ($r(45) = -.24, p = .052$), our findings confirmed our third hypothesis; there were no significant differences between correlations of attention deficit symptoms with upright ensemble performance and correlations between attention deficits with inverted ensemble performance ($z = 0.71, p = .45$). Though no significant differences were found, the trend towards a negative correlation between SGI scores and the amount of error for the inverted task ($r(45) = -.24, p = .052$) is worth addressing. This is a somewhat anomalous result, which supports neither our hypotheses nor the hypotheses of Yuill & Lyon (2007), who claim that domain-specific deficits in emotion recognition are the cause of social difficulties in individuals with ADHD. Whereas a specific deficit in emotion recognition might be expected to negatively impact performance on upright face trials, which would otherwise take advantage of top down processing benefits, this inexplicable boost in performance on inverted trials runs counter to any conception of ADHD as being disadvantageous. Due to the unusualness of this pattern, its presence for the inverted as opposed to upright faces, and its marginal significance, we do not consider this correlation to have a meaningful impact on our overall conclusions.

One important consideration in examining the current study in relation to other emotion recognition studies is the nature of the recognition task. Because this debate remains in its early stages, the operational definition of emotion recognition has not been universalized. While the current study uses a matching component appropriate for facial ensemble coding tasks, other studies vary in their use of rote labeling tasks, and more advanced emotion-situation matching tasks (Yuill & Lyon, 2007).

Limitations

The present study was subject to a number of limitations, including a lack of power, and may have benefitted from a greater number of participants. Although a relatively large proportion of participants (10.6%) reported BAARS-IV scores within the clinical range ($x > 39$) relative to the general population, it is possible that this study may have benefited from including a greater number of such participants to examine how effect sizes would have changed among a clinical population. The lack of access to participants within the clinical range of scores is a potential limitation if domain-specific deficits are present primarily in clinical cases with more extreme presentation. The inclusion of a clinical group of participants diagnosed with ADHD may substantively improve the study's power.

As noted above, the average SGI distractibility subscale score in the current study was greater than the average score found in similar studies. This may have occurred for various reasons. It is possible that this mean corroborates the BAARS-IV results, such that a high proportion of individuals qualified in the clinical range of ADHD relative to the general population. However, it is also possible that the unexpected correlation

between SGI scores and BLQ scores is the result of a confounding factor. Given that participants were drawn from students at a college campus during mid-to-late spring, it is conceivable that fatigue related to the academic environment at the time of data collection influenced these results, as scores on the SGI fatigue subscale (not included in the current study) are often correlated with increases in distractibility scores among healthy adults.

Finally, the majority of participants included in this study were female. In a study using a similar ensemble-coding task, Bai, Leib, Puri, Whitney, & Peng (2015) found that female participants were more accurate at estimating the average identity of a crowd compared to males. Females were also more accurate at estimating the identity of single faces (Bai et al., 2015). Importantly, the majority of individuals diagnosed with ADHD are overwhelmingly male (Barkley, 1997). Given these gender discrepancies, it would be beneficial to include a greater proportion of male participants in future related studies.

Directions for Future Research

Additional research is required to investigate the etiology of emotion recognition deficits in individuals with deficits of attention. In order to begin forming a consensus, it will be necessary to construct an operational definition of emotion recognition that aligns the varying criteria currently in use (e.g., ability to label emotions, ability to match emotional faces). Given the utility of ensemble coding as a process with relatively low attentional demands (Alvarez & Oliva, 2009), it would be useful for future studies to examine clinical populations diagnosed with ADHD using ensemble coding tasks to help dissociate between well-documented, generalized inattention, and other potential effects

of attention deficits. Future research will also benefit from recognition of ADHD's heterogeneity, with regard not only for the varying subtypes of ADHD, but also varying levels of emotionality and social difficulties experienced across subtype.

Conclusions

This study provides empirical support for claims that deficits in emotion recognition among populations with ADHD are the result of generalized deficits in attention rather than specific deficits in the processing of others' emotion (Cadesky et al., 2000). While recent trends in ADHD research have suggested selective or domain-specific deficits in recognizing facial expression, these studies have yet to fit these theorized deficits into a cohesive model of ADHD (Yuill & Lyon, 2007; Da Fonseca et al., 2009; Raz & Dan, 2015). In light of traditional models of ADHD, which emphasize inhibition and attention, the more parsimonious explanation for social difficulties among those with ADHD is that these individuals do not attend to emotional cues simply as a result of more general inattentiveness, characteristic of this disorder. In demonstrating that attention deficit symptoms are not correlated to performance on an emotion recognition task that demands relatively minimal attention (i.e., an ensemble coding task), this study suggests that specific differences in emotion processing are not the cause of emotion recognition deficits among populations with low or inhibited attentional resources. If unique deficits in processing others' emotions were implicated, one would expect to observe decreased accuracy on the ensemble emotion task among participants with higher scores on ADHD measures, despite the minimal attentional resources required by the task. Thus, our findings are more in line with generalized deficits in

attention rather than being the result of unique deficits related to higher order emotion processing, given the equivalent performance on upright trials, regardless of BAARS-IV or SGI score.

REFERENCES

- Aboitz, F., Ossandon, T., Zamorano, F., Palma, B., & Carrasco, X. (2014). Irrelevant stimulus processing in ADHD: Catecholamine dynamics and attentional networks. *Frontiers in Psychology, 5*, 1–15.
- Alvarez, G. A. (2011). Representing multiple objects as an ensemble enhances visual cognition. *Trends in Cognitive Sciences, 15*(3), 122–131
- Alvarez, G. A., & Oliva, A. (2009). Spatial ensemble statistics are efficient codes that can be represented with reduced attention. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 106*(18), 7345–7350.
- Ariely, D. (2001). Seeing sets: Representation by statistical properties. *Psychological Science, 12*, 157–162.
- Bai, Y., Leib, A. Y., Puri, A. M., Whitney, D., & Peng, K. (2015). Gender differences in crowd perception. *Frontiers in Psychology, 6*, 1300.
<http://doi.org/10.3389/fpsyg.2015.01300>
- Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*(1), 65–94.
- Barkley, R. A. (2011). *Barkley adult ADHD rating scale-IV (BAARS-IV)* Guilford Press, New York, NY.

- Bunney, W. E., Jr., Hetrick, W. P., Bunney, B. G., Patterson, J. V., Jin, Y., Potkin, S. G., & Sandman, C. A. (1999). Structured interview for assessing perceptual anomalies (SIAPA). *Schizophrenia Bulletin*, *25*(3), 577–592.
- Bush, G. (2010). Attention-deficit/hyperactivity disorder and attention networks. *Neuropsychopharmacology*, *35*, 278–300.
- Cadesky, E. B., Mota, V. L., & Schachar, R. J. (2000). Beyond words: How do problem children with ADHD and/or conduct problems process nonverbal information about affect? *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(9), 1160–1167.
- Cahill, B.S., Coolidge, F.L., Segal, D.L., Klebe, K.J., Marle, P.D., & Overmann, K.A. (2012). Prevalence of ADHD and its subtypes in male and female adult prison inmates. *Behavioral Sciences and the Law*, *30*, 154–166.
- Chong, S. C., & Treisman, A. (2003). Representation of statistical properties. *Vision Research*, *43*(4), 393–404.
- Curtis, M. E., & Bharucha, J. J. (2010). The minor third communicates sadness in speech, mirroring its use in music. *Emotion*, *10*(3), 335–348.
- Da Fonseca, D., Seguíer, V., Santos, A., Poinso, F., & Deruelle, C. (2009). Emotion understanding in children with ADHD. *Child Psychiatry and Human Development*, *40*(1), 111–121.
- Fine, J. G., Semrud-Clikeman, M., Butcher, B., & Walkowiak, J. (2008). Brief report: Attention effect on a measure of social perception. *Journal of Autism and Developmental Disorders*, *38*(9), 1797–1802.

- Forster, S., Robertson, D.J., Asherson, P., Jennings, A., & Lavie, N. (2014). Plugging the attentional deficit: Perceptual load counters increased distraction in ADHD. *Neuropsychology, 28*(1) 91–97.
- Friedman, S. R., Rapport, L. J., Lumley, M., Tzelepis, A., VanVoorhis, A., Stettner, L., & Kakaati, L. (2003). Aspects of social and emotional competence in adult attention-deficit/hyperactivity disorder. *Neuropsychology, 17*(1), 50–58.
- Greater Good Science Center. (2016). Body Language Quiz. University of California, Berkeley. Retrieved from http://greatergood.berkeley.edu/ei_quiz/ with permission from copyright holder.
- Haberman, J., Brady, T. F., & Alvarez, G. A. (2015). Individual differences in ensemble perception reveal multiple, independent levels of ensemble representation. *Journal of Experimental Psychology: General, 144*(2), 432–446.
- Haberman, J., Harp, T., & Whitney, D. (2009). Averaging facial expression over time. *Journal of Vision, 9*(11), 1–13.
- Haberman, J., & Whitney, D. (2010). The visual system discounts emotional deviants when extracting average expression. *Attention, Perception, & Psychophysics, 72*(7), 1825–1838.
- Haberman, J., & Whitney, D. (2009). Seeing the mean: Ensemble coding for sets of faces. *Journal of Experimental Psychology: Human Perception and Performance, 35*(3), 718–734.
- Hetrick, W.P., Erickson, M.A., & Smith, D.A. (2012). Phenomenological dimensions of sensory gating. *Schizophrenia Bulletin, 18*(1), 178–191.

- Landau, S., Milich, R., & Diener, M. B. (1998). Peer relations of children with attention-deficit hyperactivity disorder. *Reading & Writing Quarterly: Overcoming Learning Difficulties, 14*(1), 83–105.
- Leib, A. Y., Puri, A. M., Fischer, J., Bentin, S., Whitney, D., & Robertson, L. (2012). Crowd perception in prosopagnosia. *Neuropsychologia, 50*(7), 1698–1707.
- Lollar, D.J. (2008). Function, impairment, and long-term outcomes in children with ADHD and how to measure them. *Psychiatric Annals, 38*(1), 15–33.
- McKone, E. (2004). Isolating the special component of face recognition: Peripheral identification and a mooney face. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*(1), 181–197.
- McKone, E., Martini, P., & Nakayama, K. (2001). Categorical perception of face identity in noise isolates configural processing. *Journal of Experimental Psychology: Human Perception and Performance, 27*(3), 573–599.
- Nijmeijer, J. S., Minderaa, R. B., Buitelaar, J. K., Mulligan, A., Hartman, C. A., & Hoekstra, P. J. (2008). Attention-deficit/hyperactivity disorder and social dysfunctioning. *Clinical Psychology Review, 28*(4), 692–708.
- Petersen, B. D., & Grahe, J. E. (2012). Social perception and cue utilization in adults with ADHD. *Journal of Social and Clinical Psychology, 31*(7), 663–689.
- Piazza, M., & Izard, V. (2009). How humans count: Numerosity and the parietal cortex. *The Neuroscientist, 15*(3), 261–273.
- Piazza, E. A., Sweeny, T. D., Wessel, D., Silver, M. A., & Whitney, D. (2013). Humans use summary statistics to perceive auditory sequences. *Psychological Science, 24*(8), 1389–1397.

- Puri, A., Halladay, T., Romager, J., Lee, K., & Caselman, E. (2015). Anxiety and Accuracy of Ensemble Representations of Emotion in a Crowd. *Psychonomic Society Annual Meeting*.
- Raz, S., & Dan, O. (2015). Altered event-related potentials in adults with ADHD during emotional faces processing. *Clinical Neurophysiology*, *126*(3), 514–523.
- Sable, J.J., Kyle, M.R., Knopf, K.L., Schully, L. T., Parry, K. H., Diamond, R.E., Flink, L.A., Stowe, R., Suna, E., & Thompson, I.A. (2012). The sensory gating inventory as a potential diagnostic tool for attention-deficit hyperactivity disorder. *ADHD Attention Deficit and Hyperactivity Disorders*, *4*(3), 141–144.
- Schneider, M. F., Krick, C. M., Retz, W., Hengesch, G., Retz-Junginger, P., Reith, W., & Rösler, M. (2010). Impairment of fronto-striatal and parietal cerebral networks correlates with attention deficit hyperactivity disorder (ADHD) psychopathology in adults—A functional magnetic resonance imaging (fMRI) study. *Psychiatry Research: Neuroimaging*, *183*(1), 75–84.
- Silk, T. J., Vance, A., Rinehart, N., Bradshaw, J. L., & Cunnington, R. (2008). Dysfunction in the fronto-parietal network in attention deficit hyperactivity disorder (ADHD): An fMRI study. *Brain Imaging and Behavior*, *2*(2), 123–131.
- 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
- Sweeny, T. D., Haroz, S., & Whitney, D. (2013). Perceiving group behavior: Sensitive ensemble coding mechanisms for biological motion of human crowds. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(2), 329–337

- Sweeny, T. D., Wurnitsch, N., Gopnik, A., & Whitney, D. (2015). Ensemble perception of size in 4–5-year-old children. *Developmental Science, 18*(4), 556–568.
- Uekermann, J., Kraemer, M., Abdel-Hamid, M., Schimmelmann, B. G., Hebebrand, J., Daum, I., Wiltfang, J., & Kis, B. (2010). Social cognition in attention-deficit hyperactivity disorder (ADHD). *Neuroscience and Biobehavioral Reviews, 34*(5), 734–743.
- Yang, J., Yoon, K. L., Chong, S. C., & Oh, K. J. (2013). Accurate but pathological: Social anxiety and ensemble coding of emotion. *Cognitive Therapy and Research, 37*(3), 572–578.
- Yuill, N., & Lyon, J. (2007). Selective difficulty in recognizing facial expressions of emotion in boys with ADHD: General performance impairments or specific problems in social cognition? *European Child & Adolescent Psychiatry, 16*(6), 398–404.

APPENDIX A
SURVEY QUESTIONNAIRES

GREATER GOOD SCIENCE CENTER
AT UNIVERSITY OF CALIFORNIA – BERKELEY
BODY LANGUAGE QUIZ (BLQ)

SAMPLE

Participant ID _____ Age: _____ Gender: _____

Please try to identify the emotion conveyed in each of the following photos:



1. This face is expressing...

___ **Embarrassment**

___ **Fear**

___ **Sadness**

___ **Surprise**



2. This face is expressing...

___ **Flirtatiousness**

___ **Interest**

___ **Happiness**

___ **Politeness**

BARKLEY ADULT ADHD RATING SCALE-IV (BAARS-IV)

SAMPLE

Participant ID _____ Date: _____
 Sex: (Circle one) Male Female Age: _____

Instructions

For the first 27 items, please circle the number next to each item below that best describes your behavior **DURING THE PAST 6 MONTHS**. Then answer the remaining three questions.

	Never or rarely	Sometimes	Often	Very often
Section 1				
1. Fail to give close attention to details or make careless mistakes in my work or other activities	1	2	3	4
2. Difficulty sustaining my attention in tasks or fun activities	1	2	3	4
3. Don't listen when spoken to directly	1	2	3	4
4. Don't follow through on instructions and fail to finish work or chores	1	2	3	4
5. Have difficulty organizing tasks and activities	1	2	3	4
6. Avoid, dislike, or am reluctant to engage in tasks that require sustained mental effort	1	2	3	4
7. Lose things necessary for tasks or activities	1	2	3	4
8. Easily distracted by extraneous stimuli or irrelevant thoughts	1	2	3	4
9. Forgetful in daily activities	1	2	3	4
Section 2				
10. Fidget with hands or feet or squirm in seat	1	2	3	4
11. Leave my seat in classrooms or in other situations in which remaining seated is expected	1	2	3	4
12. Shift around excessively or feel restless or hemmed in	1	2	3	4
13. Have difficulty engaging in leisure activities quietly (feel uncomfortable, or am loud or noisy)	1	2	3	4
14. I am "on the go" or act as if "driven by a motor" (or I feel like I have to be busy or always doing something)	1	2	3	4

(cont.)

SENSORY GATING INVENTORY: DISTRACTIBILITY

FACTOR STRUCTURE SAMPLE QUESTIONS

Distractibility:

- 3. I find it hard to concentrate on just one thing.
- 6. There are times when I can't concentrate with even the slightest sounds going on.
- 13. I am easily distracted.
- 16. It is hard to keep my mind on one thing when there's so much else going on.
- 17. When I am in a group of people I have trouble listening to one person.
- 22. I find it difficult to shut out background noise and that makes it difficult for me to concentrate.
- 28. At times I have trouble focusing because I am easily distracted
- 31. I have more trouble concentrating than others seem to have.

SENSORY GATING INVENTORY: DISTRACTIBILITY

SAMPLE SURVEY

SGI

**Participant
Research ID:**

Gender:

Date:

Age:

Misc:

Experimenter:

**Never
True**

**Almost
Never**

**Sometimes
True**

**Almost
Always**

**Always
True**

0

1

2

3

4

5

Please circle your response

1. I find it hard to concentrate on just one thing. 0 1 2 3 4 5

2. There are times when I can't concentrate with even the
slightest sounds going on. 0 1 2 3 4 5

3. I am easily distracted 0 1 2 3 4 5

4. It is hard to keep my mind on one thing when there's
so much else going on. 0 1 2 3 4 5