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Arielle Bowers

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RESPIRATORY SINUS ARRHYTHMIA (RSA) IN ADULTS WITH POSSIBLE
AUTISM SPECTRUM DISORDER (ASD) SYMPTOMS

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ABSTRACT

Autism Spectrum Disorders (ASD) are a group of developmental disorders, which are becoming a major health concern within the US. According to *The Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association, 2013) an ASD includes the following features: continuous impairments associated with social communicative and interactive skills, replication of specific, patterned behaviors and/or attentiveness to specific interests. Recent psychophysiological research has looked at how high and low respiratory sinus arrhythmia (RSA) activity may be related to a lack of social communicative skills relating to social cognition, which are hallmark features of individuals who have been diagnosed with an ASD (Porges et al., 2013). These missing social cognitive skills such as empathy and emotion recognition skills can have detrimental effects on an individual's life and how they interpret the social world around them. The current study looked at RSA activity in a community sample of adults. The study aimed to clarify if there was a predictive relationship between PNS indices and ASD symptoms, if there was relationship between PNS indices and social cognition, and if social cognition had a mediating effect on baseline RSA activity. The results found that within this sample there was not a predictive relationship between PNS indices and ASD symptoms, PNS indices and social cognition, and that social cognitive skills did not mediate participants' baseline RSA activity. The results might aid in improving future research on this topic. Thus allowing researchers to work with

clinicians to work on improving the empathic skills of individuals with symptoms of an ASD by using PNS indices, social cognitive measures, and diagnostic and intervention tools.

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Chapter 1

Introduction

1.1 Background

Autism Spectrum Disorders (ASD) are a group of developmental disorders that pose a major health concern in the US. According to *The Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM–5; American Psychiatric Association, 2013) an ASD includes the following features: continuous impairments associated with social communicative and interactive skills, replication of specific, patterned behaviors and/or attentiveness to specific interests. These symptoms are typically presented during the early developmental years of the individual and can significantly impact their daily life. The prevalence of ASDs has increased in recent decades, as it is has been estimated that 1 in 50 school-aged children meet criteria for an ASD (Blumberg et al., 2013).

The National Institute for Mental Health has recently identified processes that underpin the social deficits associated with ASD as one dimension that may cut across various mental illnesses (Cuthbert & Kozak, 2013). This dimension, termed the “social system,” includes an individuals’ ability to recognize other individuals’ emotional signals, and their ability to evaluate their own and others’ mental experiences and/or objectives

during social communications (Cuthbert and Kozak, 2013). This system is comprised of three main components: physiological, cognitive, and behavioral components (Cuthbert and Kozak, 2013). One example within the cognitive system includes social cognition, which pertains to the ability to infer others' intentions and motivations (Green et al., 2008). This social system includes social cognition, which is key for individuals to successfully adapt to social environments.

Social cognition is the ability to process social information, which includes but is not limited to empathy, social decision-making within social environments, and using morality when making decisions (Baron-Cohen et al., 2013). Social cognition deficits have been linked to various psychopathologies. For example individuals with an ASD have difficulties relating to others around them within social situations. If an individual has diminished social cognitive skills such as relating to another individual's emotional state during an interaction, the individual will likely experience ASD symptoms. The same individual will also struggle in successfully navigating everyday social interactions.

Deficits in social cognition have been measured in individuals with an ASD by looking at the length of eye contact and lack of interest when looking at others' faces (Lord et al., 2000). Decreased levels of eye contact, eye gaze, and emotion recognition skills have been suggested to be linked to lowered levels of social motivation during social interactions in ASD individuals (Insel & Fernald, 2004). Mazefsky et al. (2014) suggested that an empathy-eliciting situation might be indicative of interpersonal struggles. Nonetheless, social cognitive skills are key for individuals to make appropriate and productive decisions during social interactions.

One physiological substrate of the social system is the Parasympathetic Nervous System (PNS). The PNS uses organs like facial muscles, which are pertinent when conveying varying levels of communicative responses and emotional presentations. These include social interactional responses such as physiological arousal associated with stimuli presentation (Porges, 2007). The PNS is quantified by examining heart rate variability (HRV) within the frequency of respiration (respiratory) sinus arrhythmia, (RSA) when external stimuli are presented and/or resting states are measured (Porges, 2007). Deficits within this substrate can be detrimental to an individual's understanding and actions during various social situations. It has been suggested that a higher level of RSA activity may be related to positive, social cognitive actions (Bal et al., 2010). While Porges et al. (2013) has suggested that a lower RSA may encourage decreased levels of social understanding and communication associated with symptoms of ASDs. Unfortunately, these studies have only looked at children, but not adults.

Despite the ostensible link between ASD and deficits in constituent processes of the Social System; no studies to date have examined the interplay of social cognition and PNS activity among individuals with ASD symptoms. The present study aimed to bridge this gap by looking at an adult, community sample.

1.2 Social Cognition and Social Deficits

According to Baron-Cohen and colleagues (2013) social cognition is the ability to process social information, which includes but is not limited to empathy, social decision-making within various social environments, and using morality when making decisions. Green et al. (2008) defined social cognition as the ability to make inferences surrounding others' intentions and/or motives in social interactions. Martins-Junior et al. (2011)

suggested domains associated with social cognition, which include a domain associated with understanding others, (i.e. empathy), a domain that includes understandings ones self and being able to control ones self within social interactions, and finally a domain that involves interactions with others.

The concept of social cognition has also been used interchangeably in research studies associated with Theory of Mind (ToM). Premack and Woodruff (1970) suggested that an individual with an appropriate level of ToM are able to connect their own mental state with the mental states of others around them. Within their seminal article Baron-Cohen et al. (1985) suggested that a child who is diagnosed with an ASD has deficits within the domain surrounding ToM. The researchers suggested that ToM is the ability or lack of ability in understanding others within social situations and/or interactions. Frith & Corcoran (1996) completed seminal research associated with ToM, which suggested that individuals with schizophrenia struggle with understanding others around them. Tella et al. looked at whether social cognition impairments are present within individuals who have been diagnosed with fibromyalgia, and found that these impairments do exist especially in the scales surrounding, “difficulty in identifying feelings,” (pp. 9, 2015). Without the proper social cognitive skills individuals across all domains of mental illness and physical illness may not be able to effectively adapt during social interactions.

1.3 Social Deficits in Autism Spectrum Disorders.

Individuals diagnosed with an ASD have difficulties associated with the social system. A 2012 NIMH session regarding social processes suggested the importance of facial expressions associated with emotions during social situations and/or social communicative processes with others (NIMH Social Processes: Workshop Proceedings).

ASD diagnosed individuals typically struggle with social impairments such as difficulty in identifying others emotions (Bal et al., 2010). This suggests that an individual with an ASD will struggle to recognize another individual's emotion, such as recognizing that their lowering eyelids and frown are associated with sadness. Within the laboratory setting this struggle of recognizing emotions has been assessed via the Mind in the Eyes task (RMET). Participants with an ASD have been shown to score lower when compared to other typically developed participants (Lugnegard, et al., 2013).

Along with not recognizing other emotions individuals with an ASD typically struggle with communicating emotions during social communicative processes and/or understanding others mental conditions (5th ed.; *DSM-5*; American Psychiatric Association, 2013). Again this can have detrimental effects during social interactions, such as making it difficult for an individual with an ASD or ASD symptoms to relate to others and make lasting connections. For example an individual with an ASD will find it difficult to convey their feeling of sadness and understand the feeling of sadness in relation to the individual experiencing the actual emotion. Unfortunately, this lack of understanding can also result in increased levels of stress. Mazefksy et al. (2013) suggested that this increased level of stress might result in impaired emotion regulatory skills. The researchers also noted that individuals may also interpret the stressful, intensive reactions of an individual with an ASD incorrectly, forgetting that social cognitive and emotion regulatory impairments are symptoms of the individual's psychopathology (Mazefsky et al., 2013). Mazefsky and colleagues (2013) concluded that in order to properly research social cognitive and emotional regulatory deficits in individuals with an ASD or ASD symptoms numerous longitudinal studies must be

completed, which should include combining psychophysiological measurements (e.g. PNS indices) and behavioral measurements (RMET).

Losh and Capps (2006) found that within their study, children with an ASD had difficulty relating to researchers about their complex emotions. This would suggest that social cognitive skills are indeed altered within a child who has an ASD and/or ASD symptoms. If a child were unable to describe to others their complex and/or appropriate emotions this would make it difficult for them to relate to others. Furthermore it would complicate their ability to feel complex emotions like feeling proud after an accomplishment (Losh & Capps, 2006). It should be noted that the Losh & Capps study only examined children's insights and not the insights of adults.

Few studies have looked at the emotional insights of adults with an ASD and/or ASD symptoms. However, Hill et al. (2004) found that ASD adults who were considered to be higher functioning had similar issues describing their emotions when compared to the children within the Losh & Capps study. The participants described their emotions and/or feelings as being quite explicit and at times identical (Hill et al., 2004). Thus suggesting that the lack of social cognitive skills extends into adulthood.

Previous research has suggested how important the concept of eye gaze and attention is when an individual is developing social cognitive skills, such as facial recognition. Schultz et al. (2000) suggested that the participants with an ASD exhibited patterns of focusing on certain facial features and not looking at the individual's face holistically. For example an individual with an ASD or ASD symptoms may only focus on the individual's forehead and cheeks, rather than looking at the eyes, nose, and mouth collectively.

Simon Baron-Cohen created the RMET in order to test emotion recognition skills by having the participant view an image of two eyes and choosing the appropriate emotion associated with the eyes and brow in the image. Baron-Cohen and his colleagues (2000) have completed extensive research using the RMET. Individuals with an ASD and ASD symptoms struggle with emotion recognition tasks. These struggles and/or lack of social system processing skills impact daily, social communicative experiences.

1.4 Parasympathetic Nervous System (what is it, how is it measured, role in social behavior, its relationship to ASD)

The social system proposed by the NIMH includes a component that is related to the parasympathetic nervous system (PNS). The PNS uses organs such as facial muscles that are important when conveying levels of communicative responses and emotional presentations. These responses are key within social, communicatory situations and include physiological arousal associated when a stimuli is presented (Porges, 2007).

Previous research has suggested that these social abilities are influenced and supported by physiological cues from the parasympathetic nervous system (PNS). The Polyvagal Theory analyzes how the PNS helps to regulate social behaviors (Austin, Todd, & Porges, 2007). The theory also underlines the idea that an “integrated Social Engagement System,” which regulates muscles associated with facial muscles and social behaviors are related to PNS activity (Austin, Todd, & Porges, pp.70, 2007). This homogenous system has evolved so that individuals are able to adapt to quickly changing social environments. If an individual’s PNS system does not properly adapt to environmental cues they experience intense flight or fight reactions and/or improperly convey appropriate “social engagement behaviors,” (Austin, Todd, & Porges, pp.70,

2007). These maladaptive behaviors are associated with hallmark symptoms of varying psychopathological diagnoses such as ASDs and Borderline Personality Disorder (BPD). The PNS is measured by looking at respiratory sinus arrhythmia (RSA) activity and determining whether any relevant changes occurred when the individual was presented with stimuli (Porges, 2007). Porges (1986) has suggested that when baseline RSA levels are higher, the individual will be more likely to have adaptive social responses. This suggests that individuals with an ASD or ASD symptoms may have lower baseline RSA values as a hallmark of the disorder thus resulting in a lack to adapt to emotionally driven social interactions. For example an individual with an ASD or ASD symptoms will likely find it difficult to adapt and understand a situation that is driven by emotion, such as an incident surrounding an individual that is upset and crying.

1.5 Relationship between Social Cognition and PNS.

Bal and colleagues (2010) suggested that a higher level of RSA activity is related to positive, adaptive social cognitive actions. Social cognition is key in social development and an impairment of these skills or lack of can be detrimental within social situations. Peterson et al. (2007) compared typically developing preschool children and preschool children with an ASD in relation to their social cognitive skills as rated by their teachers via a social maturity scale. It was found that preschool children with an ASD were rated lower on the social maturity scale when compared to typically developing preschool children (Bal et al., 2010).

Another way to measure social cognition or ToM is by using the RMET. This measurement has the participant look at 36 images of individuals' eyes and match them to the appropriate emotion associated with the individuals' eye expressions. Individuals

with ASDs typically perform low on this task as they lack social cognitive skills that allow them to correctly identify an individual's emotion. Lugnegard et al. (2013) used the RMET to compare individuals diagnosed with either an ASD or schizophrenia to a control group with no psychopathology history. The results showed that both groups' scored lower on the RMET when compared to the control group. Previous research studies conducted by RMET creator, Dr. Simon Baron-Cohen and colleagues found similar results, as within their study individuals with ASDs scored lower on the task (2001).

Social cognition has been studied in relation to ASDs, but few studies have looked at what may cause these differences in social cognitive skills. Some researchers suggest that these social cognitive impairments may be related to respiratory sinus arrhythmia (RSA) activity within these individuals. However, it has yet to be determined if this activity is typically higher or lower when compared to a typically developed individual.

Informed by the Polyvagal Theory Porges et al. (2013) looked at whether RSA activity and auditory processing can be predictors of social engagement difficulties within children with an ASD. This theory suggests that a lower RSA may encourage decreased levels of social understanding and communication associated with symptoms of ASDs. On the other hand a higher RSA may encourage increased levels of social understanding and communication associated with typically developing individuals. Porges et al. (2013) hypothesized, that both RSA and auditory processing could determine successes or deficits concerning social interactions. EKG was used in order to measure RSA while the SCAN measure was used to measure levels of auditory

processing during an attention task. Overall, the results showed that the children with an ASD had a lower RSA value and shorter heart rate interval (HRV) when compared to children without an ASD (Porges et al., 2013). Additionally, researchers found an interesting relationship between IQ and RSA activity. Children with an ASD and who had a higher IQ were more likely to have higher baseline measurements of RSA activity (Porges et al., 2013). Generally children with an ASD had a lower baseline RSA activity, which suggested that the biological depression of myelinated vagus resulted in decreased levels of social engagement and/or social cognition (Porges et al., 2013). Porges et al. (2013) also suggested that children with an ASD had an abnormal increase in RSA during a demanding task, which may be distracting and detrimental to the task at hand.

Bal and colleague's (2010) study measured eye gaze and RSA activity in relation to PNS indices. Their review of past literature noted that negative emotions are found within the upper part of the face, and positive emotions within the lower part of the face. The study found that the children with an ASD had lower RSA activity when compared to typically developing children when measuring a baseline period (Bal et al., 2010). This lower measurement of RSA has been suggested by previous research to be associated with an inefficient vagal brake. These deregulated brakes have been associated with social, communicatory skill deficits during a child's early developmental stages (Porges, 2007). Additionally, Bal and colleagues (2010) found that children with an ASD do not always look at the face of an individual during the facial expression of fear, but rather the individual's body. The researchers suggested that looking at the eyes of an individual results in more accurate recognitions of emotions when compared to looking at the mouth.

The article suggested that children with an ASD might need more time to process facial expressions when compared to typically developing children (Bal et al., 2010).

Patriquin et al. (2011) also applied the Polyvagal Theory to their hypotheses and research processes. The study used various measures completed by both the child and the parent to determine symptom severity, social communication levels, and receptive language skills (Patriquin et al., 2011). The researchers found that higher RSA activity was associated with positive social cognitive development, thus meaning that future research focusing on measuring RSA in individual's with ASDs or ASD symptoms is needed in order create the proper social cognitive interventions (Patriquin et al., 2011).

Sheinkopf et al. (2013) looked at whether parasympathetic measures could be used in order to determine social functioning in children with an ASD. Previous research suggests that higher baseline RSA activity is associated with efficient responses to environmental changes and/or appropriate adaptations (Porges et al., 2013). Previous research has also found that children with an ASD do not typically have a decrease in HRV meaning that children with ASDs are unable to adapt quickly to environmental changes (Austin, Todd, & Porges, 2007). However, Sheinkopf and colleagues (2013) noted that previous studies had different results suggesting that children with an ASD had either an unexpected increase or decrease within HRV results, which suggests some ASD children may be hypersensitive to environmental changes. Additionally, they noted that within previous research that an ASD child's heart rate did not drop when presented with a stressful mood when compared to a typically developing child (Sheinkopf et al., 2013).

The results showed that there was no difference in mean levels of RSA activity, but rather that individual differences within ASD children may determine RSA activity

(Sheinkopf et al., 2013). For example 3 of the 14 ASD children showed a decrease in RSA when the stranger approached them from afar, and 9 of the 14 showed a decrease in RSA associated when the stranger approached from a closer distance (Sheinkopf et al., 2013). Sheinkopf and colleagues (2013) suggested that increased levels of intensity within an environmental situation are needed in order to produce normal RSA activity within an individual with an ASD.

Shahrestani et al. (2014) combined aspects of social interactions and HRV within a meta-analysis to determine if there was a difference between atypically and typically developing children. The researchers followed specific guidelines in choosing the 18 appropriate articles to include within their meta-analysis. The study found that the RSA activity did not change during engagement tasks when compared to baseline measures (Shahrestani et al. 2014). However, the results found that “child psychopathology on autonomic flexibility appears specific to dyadic social stress tasks,” or social disengagement (Shahrestani et al., pp.986, 2014). These results suggested that an irregular HRV within a child might help to determine psychopathological, diagnostic features and/or dysfunctional social functioning.

1.6 The present study.

The previously discussed studies were notable within this specific area, but they focused only on children, instead of adults with an ASD or ASD symptoms. Results may have differed if these studies looked at RSA within ASD adults and/or with ASD symptoms. The following study aimed to look at baseline RSA activity in adults with ASD symptoms. Previous research has suggested both high and low RSA activity within ASD individuals during interpersonal situations. The study aimed to clarify if there was

a predicative relationship between PNS indices and ASD symptoms, if there was relationship between PNS indices and social cognition, and if there was a mediating effect of social cognition on baseline RSA activity. Results from this study can be used to support the suggestion that individuals with ASD symptoms will likely have social cognitive difficulties. These results can be used in future research to improve the empathic skills of individuals with an ASD and/or symptoms of an ASD. Finally, results from this study can be used in future research to determine if RSA activity can be used with the DSM 5 and/or social cognitive measures such as the RMET to aid in the diagnosis of an individual with a possible ASD.

Chapter II

Method

2.1 Participants

The participants of this study were recruited via a community sample from the Cleveland metropolitan area (N=74). The participants' ages ranged from 18-63 with a mean age of 29 (SD = 12.27). Among participants, 66.2% were female (N = 49) and 33.8% were men (N = 25). Two participants' data were excluded from analyses due to RSA activity data not being collected and a missing AQ-10 score. This sample was sufficient enough to meet the power analysis suggested sample size of N=70.

2.2 Measures

Participants were given a variety of survey measures, which included the AQ-10, and the RMET. These measures are described below.

Autism Spectrum Quotient (AQ10)

This short measure used questions from the following ASD symptom related areas: the participant's attention to detail, their ability to switch attention, communicatory skills, their imaginary thinking skills, and their social skills (Allison, Auyeung, and Baron-

Cohen, 2012). A score of 6 or higher would result in a clinician to refer the individual for further diagnostic assessments.

Minds in the Eye's Task (RMET) This task asks the participant to match the appropriate emotion from the choices provided with the image provided. A list of possible emotion choices and their denoted definitions is placed next to the participant's computer.

2.3 Procedure

Participants completed a prescreening measure, were invited to the lab, and completed the protocol described below. Informed consent was attained from each participant. Participants then completed survey measures including the AQ-10 and the RMET. Participants then completed a psychophysiology protocol in which RSA was collected through ECG during a 3-minute free breathing rest period and a 3-minute paced breathing task. During the 3-minute paced breathing task participants were instructed to breath 12 times per minute, which is the average respiration rate for adults.

Respiratory Sinus Arrhythmia (RSA)

An electrocardiogram (ECG) was used to measure resting RSA levels following standard guidelines (Berntson et al., 1997; Task Force, 1996) using the MP150 Data Acquisition System and software from BIOPAC Systems, Inc. (Santa Barbara, CA). Ag/AgCl ECG electrodes were placed in a modified Lead –II configuration on the chest. The signals were acquired at a 2,000 Hz frequency and submitted through a 0.01 high-pass filter from the offline MindWare software. The interbeat intervals of the ECG were acquired and the IBI time series was transformed into a frequency spectrum and was subjected to Fast Fourier transformation as per best practices (Berntson et al., 1997; Task Force, 1996). Frequencies between .15 and .40 Hz reflect RSA activity. Both epochs

were used because variable respiration rates are known to confound the measure of PNS activity (Grossman & Kollai, 1993). The BioNomadix respiration systems and ECG modules were analyzed via the MindWare program.

2.4 Analysis

A mediation model was used to determine if the relationship between the predictor variable and outcome variable was mediated by another variable. Within this study the predictor variable was baseline RSA, the outcome variable was ASD symptoms, and the mediating variable were social cognitive skills as measured by the RMET. The study's mediation model was created by using Baron and Kenney's (1986) seminal article as an example. First a possible direct relationship was tested between baseline RSA and ASD symptoms. After this a possible relationship was tested between baseline RSA and social cognitive skills. Then the possible social cognitive skills effects on ASD symptoms were tested. Finally, the change in the relationship between baseline RSA and ASD symptoms in the presence of social cognitive skills was measured. All statistical analyses were completed using IBM SPSS Statistics 22 (IBM Inc., 2013) software. The mediation model tested can be found within Figure 1.

Power Analysis

Based on a pilot sample collected by the Thesis Chair and the extant literature, moderate effects were expected for the relationship between ASD symptoms and social cognition, and RSA and social cognition. A Monte Carlo simulation study revealed that a sample of $N = 70$ would be sufficient to maintain Power = .80 at an alpha level of .05.

Chapter III

Results

3.1 Descriptives and Correlational Analysis

Sample means, standard deviations and correlations can be found in Table 1.

Within this sample the average AQ-10 score was a 3.64 (SD=1.81), which was not above the cutoff of 6. The results found that RSA activity was unrelated to the study variables with the exception of each other, as paced breathing RSA was related to free breathing RSA, $r = .67, p < .01$. Additionally, there was a negative correlation between age and free breathing RSA, $r = -.46, p < .01$, and age and paced breathing RSA, $r = -.48, p < .01$. The older an individual is the lower their RSA activity will be. Therefore age and sex were covaried from the analysis. It also should be noted that the AQ-10 score was not significantly correlated, but rather at a trend level with an $r = -.210, p = .075$; males tended to score higher on the AQ-10 when compared to females. Males $N = 25, SD = 1.74$ and females $N = 48, SD = 1.8$.

3.2 Mediation Analyses

Two mediation analyses were conducted to test the possible mediation effects of social cognition between free and paced breathing RSA on ASD symptoms. While

correlation analyses did not support the expected association between the predictor (RSA indices), mediator (social cognition), and outcome (ASD), mediation analyses were conducted via hierarchical regression to rule out the possible confounding effects of age and sex. Following Baron and Kenney's (1986) procedures, the first model examined the relationship between RSA and the outcome variable, ASD. In the first step demographic characteristics were controlled for, and the effects of RSA were entered into the second step. Contrary to expectation, RSA failed to predict ASD. Because recent criticisms have arisen with Baron and Kenney's (1986) requirement for a significant relationship between the predictor and outcome as a request step, another model that tested the effects of the predictor on the mediator was also examined. In this model, the demographic covariates of age and sex were entered in the first step, and the effects of RSA were entered in the second step. Contrary to expectation, RSA did not predict social cognition levels. These steps were then repeated using RSA paced breathing, and the results did not differ. The results of these two mediation analyses can be found in Tables 2-4 and Tables 5-7.

Chapter IV

Discussion

4.1 Discussion of Findings

The present study aimed to clarify the relationship between the PNS, social cognition, and ASD symptoms. While previous research has shown that PNS activity is related to social and emotional processes (Porges, 2007), the interplay of social cognition and PNS activity among adults with ASD symptoms remains largely unexplored in the literature. The study examined the relationship between PNS indices and social cognition, examined if PNS indices could predict ASD symptoms, and finally determined if a change in the relationship between PNS indices and ASD symptoms could be explained with social cognitive skills.

The first aim of this study examined the association between indices of the PNS and social cognition. Contrary to expectation, PNS activity during free breathing and in response to a paced breathing task were unrelated to social cognition, as indexed by the RMET. These findings are consistent with a mixed literature showing that RSA activity

can be either high or low in relation to social cognition, as evidenced by the relationship between RSA and ASD, a disorder marked by social-cognitive deficits.

For example Sheinkopf et al. (2013) looked at ASD children and typically developed children's RSA activity when experiencing an effortless task and when experiencing a stranger procedure. Their findings showed that RSA activity during baseline and two behavioral tasks of social cognition did not differ between the children with an ASD and typically developed children (Sheinkopf et al., 2013). In a similar vein, a meta-analysis conducted by Sharestani and colleagues (2014) found no association among healthy children and those with psychopathology diagnoses, which included ASD.

Others, however, found significant associations between RSA activity and social functioning. For example, Bal and colleagues (2010) found that when looking at eye gaze patterns in children with an ASD and their RSA activity, that their RSA activity was lower than typically developed children. Patriquin et al. (2013) also found that a higher RSA is associated with positive social cognitive development when looking at ASD children's PNS indices and parental reports on social cognitive skills and language abilities. Likewise, Porges and colleagues (2013) observed that high RSA levels predicted better social skills among children with an ASD. Further, ASD children who received an intervention in their study evidenced increased RSA levels and improved social skills (Porges et al., 2013). These mixed results suggest that further research is needed in order to clarify how PNS activity and social cognition are intertwined.

Another expectation of this study was that PNS indices would predict ASD symptoms, given the purported link between PNS activity and social processes. The results suggested that contrary to expectation, PNS activity during free and paced

breathing tasks were not predictive of ASD symptoms as measured by the AQ-10. These findings are again consistent with a mixed literature. Specifically, while Sheinkopf et al. found PNS indices were unrelated among children with and without an ASD (2013), others (e.g., Porges et al., 2013) found that children with an ASD had lower RSA values and shorter heart rate intervals (HRV) when compared to children without ASD. Other researchers have noted that inaccurate adaptations of the PNS can lead to maladaptive behaviors such as ineffective social cognitive skills, which are associated with hallmark symptoms of an ASD (Austin, Todd, & Porges, 2007). Again these mixed results suggest that further research is needed in samples including children and adults when looking at PNS indices and ASD symptoms.

The final aim of this study was to determine if social cognition has a mediating effect on PNS indices. Contrary to expectation, social cognition did not have a mediating effect on PNS indices. Furthermore, social cognition did not predict ASD symptoms. However, other researchers have found significant association between social cognition measures and ASD (e.g., Baron-Cohen et al., 2001). Within the laboratory setting these social cognitive deficits such as struggling to recognize emotions have been assessed via the RME. Individuals with an ASD have been shown to score lower when compared to typically developed participants (Lugnegard, et al., 2013). Losh and Capps (2006) found that children with an ASD had difficulty relating to researchers about their complex emotions. This would suggest that social cognitive skills are deficient within an individual who has an ASD and/or ASD symptoms.

Although many studies have found robust relationships between social cognition and ASD symptoms, negative findings have been found as well. Pellicano (2013) found

when looking at thirty-seven children with an ASD that there was not a predictive relationship between ToM (social cognition) and ASD children's social communication skills. These mixed findings suggest that further research is needed in order to clarify the predictive relationship of social cognition on ASD symptoms.

Unfortunately, there has not been any research that specifically looks at social cognition's possible mediating effects on PNS indices. Although, Sheinkopf et al. (2013) found RSA activity did not differ among children with and without an ASD, they did not include other measures of social cognition such as the RMET. This suggests that it is still unclear how an individual's level of social cognitive skills impacts their PNS indices. In a similar vein, Shahrestani et al. (2014) found that RSA activity did not change during social cognitive tasks when compared to baseline RSA measures. On the other hand Porges et al. (2013) suggested that an individual's lack of social cognitive skills would notably lower PNS indices. This suggests that further research is needed when looking at the possible mediating effects social cognition has on PNS indices.

Furthermore, current and past research has not clarified possible social cognitive skills, mediating effects upon PNS activity in individuals with ASD symptoms. However, it seems that without social cognitive interventions individuals with ASDs or ASD symptoms will find it difficult to adapt to our social world. Generally, past studies have suggested that higher RSA activity is better adaptive to social environments. Unfortunately, these studies have not looked at adult populations, have not used more than one PNS indices, and have not used multiple social cognitive measures.

The results did find that when an individual's age increases their RSA activity tends to decrease, which supports past research. Although there was not a correlation

between sex and a higher AQ-10, it seemed that males were more likely to score higher on this questionnaire. This result complements past research, which suggests that males are three times more likely to be diagnosed with an ASD (Constantino, 2014). In order to better understand the relationships between PNS index, ASD symptoms, and social cognitive skills more extensive research is required.

4.2 Limitations

The findings of this study should be considered with some limitations. The first one being that there was only one measure of social cognition used, being the RMET. One measure of social cognition was not enough as this topic can be quite complex and in order to increase reliability and validity of future study results, use of more than one social cognitive measure is needed. Along with there only being one social cognitive measure, the RMET has limitations in itself. The emotive terms used during this task are quite advanced and even though a definition list is provided, participants may have still been unable to fully comprehend the definitions. Participants may have never experienced the complex emotions included in the RMET (i.e. aghast or pensive), thus meaning this could have acted as a confounding variable. Another limitation within this study is the sample itself. The sample consisted of individuals whose AQ-10 scores were not above the cutoff of 6 ($M=3.64$ $SD=1.81$). Thus meaning that in general the participants unlikely to had ASD symptoms and are able to successfully maneuver their social environments. In order to alleviate this issue including a sample with individuals who have ASD symptoms is needed. This can be executed by including pre-screening measures in future research so that the sample is balanced with individuals who have ASD symptoms and typically developed individuals. Although participants' average

AQ-10 did not exceed the cutoff of 6, further item analyses of questions specifically relating to social skills should be completed. Although the sample size requirements were met as suggested by the power analysis, it was still a relatively small sample (N=74). Increasing the sample size would work to allow researchers to find small effects that are otherwise hidden by small sample sizes.

4.3 Strengths

Although there were limitations present, this study included strengths as well. For example RSA activity was controlled for respiration activity, which past research has shown to be key when using RSA as a cardiac vagal index (Grossman, Karemaker, and Wieling, 1991). The study was also completed in a laboratory, which housed a sound proof and temperature controlled room, in which the psychophysiological protocol was completed. This is important as changes in the physical environment such as notable changes in temperature or sound may influence an individual's RSA. Additionally, this research looked at a novel idea as no studies to date have examined the interplay of social cognition and PNS activity among adults with possible ASD symptoms.

4.4 Future Research

Future research will include the addition of more social cognitive measures such as the Movie for the Assessment of Social Cognition (MASC), which is a 15-minute film that includes varying social and emotive understanding situations. After a participant watches the film, they are asked to answer questions about the film and its' characters (Dziobek et al., 2006). Another task that will be added is The Emotion Face Morphing task, which involves the presentation of a series of morphed images that depict a transition from one facial expression (e.g., neutral face) to another (e.g., happy face).

Participants are instructed to indicate when they are able to discern the emotion of the transitioning face, as well as the emotion expressed by that face. Future sampling procedures may be improved with pre-screening measures, so that the sample is balanced with individuals who have ASD symptoms or an ASD, and typically developed individuals. Nonetheless, this study showed that more extensive research is needed when looking at symptoms of ASD, its relation to RSA, and the possible mediating effects of social cognitive skills on PNS indices.

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Appendix

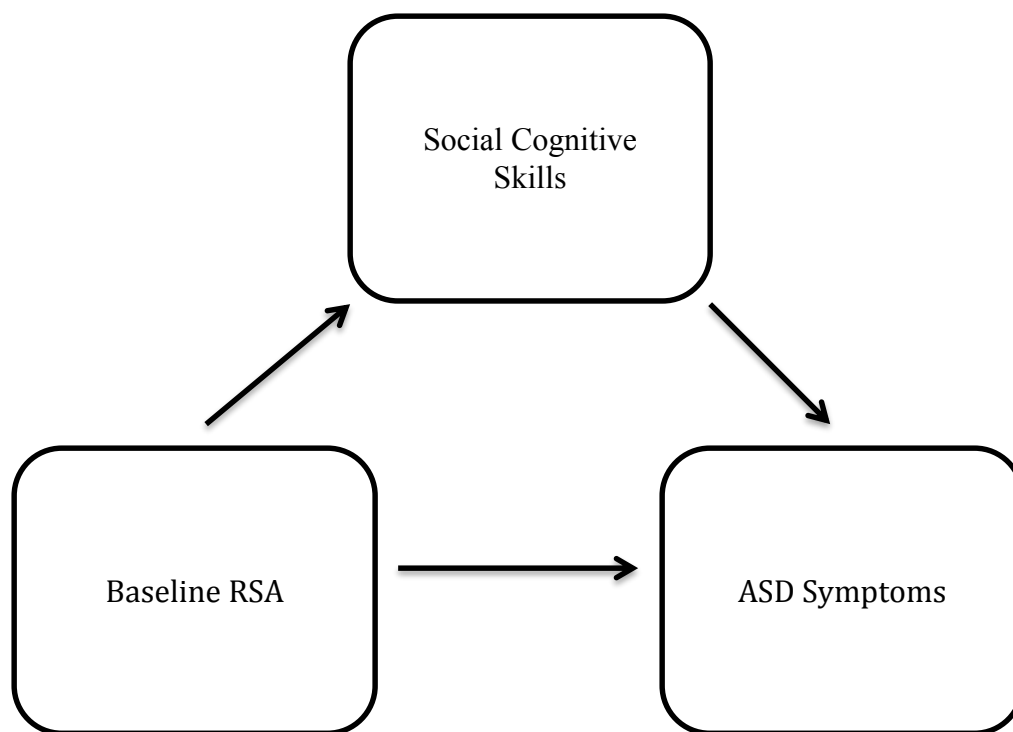


Figure 1. Conceptual model of RSA, Social Cognition and ASD Symptoms.

Table 1. Descriptive statistics and bivariate correlations among demographics, AQ-10, SCOG, and RSA measures. (N=74)

Measures	<i>M</i> (<i>SD</i>)	2.	3.	4.	5.	6.
1. Sex	.34 (.48)	.15	-.21	-.13	-.04	-.05
2. Age	29.62.(12.27)		.03	-.00	-.48**	-.46**
3. AQ-10	3.64 (1.81)			-.07	.00	.05
4. SCog	24.42. (3.88)				-.17	-.10
5. RSAPB	6.67 (1.36)					.67**
6. RSAFB	6.25 (1.33)					---

Note. Sex = high value represents males, Age = high value represents higher age, AQ-10= Autism Spectrum Questionnaire, SCog= Social Cognition as measured by the Minds in the Eyes Task. RSAPB = RSA during paced breathing, RSAFB = RSA during free breathing ** $p < .01$

Table 2. Hierarchical regression predicting ASD symptoms from demographic characteristics and RSA during free breathing.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	R ²
		B	SE	β			
1						1.65	.05
	Age	.00	.02	.03	.81	–	–
	Sex	-.80	.44	-.21	.08	–	–
2						.24	.05
	Age	.01	.02	.06	.66	–	–
	Sex	-.79	.45	-.21	.08	–	–
	RSAFB	.9	.2	.06	.63	–	–

Note. Age = high value represents higher age, Sex = high value represents males, RSAFB = RSA during free breathing.

Table 3. Hierarchical regression predicting Social Cognition from demographic characteristics and RSA during free breathing.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	R ²
		B	SE	β			
1						.54	.02
	Age	.00	.04	.00	.99	–	–
	Sex	-1.0	.97	-.12	.31	–	–
2						.99	.03
	Age	-.02	.04	-.10	.66	–	–
	Sex	-1.1	.97	-.13	.28	–	–
	RSAFB	-.40	.40	-.13	.32	–	–

Note. Age = high value represents higher age, Sex = high value represents males, RSAFB = RSA during free breathing.

Table 4. Hierarchical regression predicting ASD symptoms from demographic characteristics, RSA during free breathing, and Social Cognition.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	<i>R</i> ²
		B	SE	β			
1						1.4	.04
	Age	.00	.02	.00	.97	–	–
	Sex	-.73	.44	-.20	.10	–	–
2						.35	.05
	Age	.00	.02	.03	.84	–	–
	Sex	-.76	.45	-.21	.09	–	–
	RSAFB	.07	.20	.05	.72	–	–
	SCOG	-.4	.06	-.09	.48	–	–

Note. Age = high value represents higher age, Sex = high value represents males, RSAFB = RSA during free breathing, and SCOG= Social Cognition as measured by the RMET.

Table 5. Hierarchical regression predicting ASD symptoms from demographic characteristics and RSA during paced breathing.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	<i>R</i> ²
		B	SE	β			
1						1.65	.05
	Age	.00	.02	.03	.81	–	–
	Sex	-.80	.44	-.21	.08	–	–
2						.00	.05
	Age	.01	.02	.03	.81	–	–
	Sex	-.80	.45	-.21	.08	–	–
	RSAPB	.01	.20	.01	.63	–	–

Note. Age = high value represents higher age, Sex = high value represents males, RSAPB = RSA during paced breathing.

Table 6. Hierarchical regression predicting Social Cognition from demographic characteristics and RSA during paced breathing.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	R ²
		B	SE	β			
1						.54	.02
	Age	.00	.04	.00	.99	–	–
	Sex	-1.0	.97	-.12	.31	–	–
2						2.9	.06
	Age	-.03	.04	-.11	.43	–	–
	Sex	-1.1	.96	-.13	.26	–	–
	RSAPB	-.65	.38	-.23	.09	–	–

Note. Age = high value represents higher age, Sex = high value represents males, RSAPB = RSA during paced breathing.

Table 7. Hierarchical regression predicting ASD symptoms from demographic characteristics, RSA during paced breathing, and Social Cognition.

Steps	Measurements	Unstandardized Coefficient		Standardized Coefficient	<i>p</i>	<i>F</i>	<i>R</i> ²
		B	SE	β			
1						1.4	.04
	Age	.00	.02	.00	.97	—	—
	Sex	-.73	.44	-.20	.10	—	—
2						.28	.05
	Age	.00	.02	.00	.99	—	—
	Sex	-.77	.45	-.21	.09	—	—
	RSAPB	-.01	.20	-.01	.97	—	—
	SCOG	-.40	.06	-.09	.46	—	—

Note. Age = high value represents higher age, Sex = high value represents males, RSAPB = RSA during paced breathing, and SCOG= Social Cognition as measured by the RMET.