

THE ROLE OF THE RIGHT HEMISPHERE IN PROCESSING SARCASM IN ASPERGER'S
DISORDER

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Abstract

Individuals with Asperger's Disorder (AD) have difficulty with social interactions and understanding sarcasm. One source of these deficits is the deficient use of pragmatic language. Right hemispheric (RH) dysfunction has been linked to trouble understanding sarcasm and using pragmatic language. This study attempted to determine the role of the RH in sarcasm comprehension by using a computerized dichotic listening task. Participants with AD were matched with typically developing participants and completed a dichotic listening task, brief intelligence assessment and a perceived accuracy questionnaire. The results showed participants from both groups performed similarly on the dichotic listening task. Interestingly, those with AD did not appear to have insight into their ability to identify sarcastic or sincere tones while the typically developing group did.

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The Role of the Right Hemisphere in Processing Sarcasm in Asperger's Disorder

Despite Asperger's Disorder (AD) becoming a popular research subject in recent years, little is known about the hemispheric processing of social communication and cognition in AD (Ashwin, Wheelwright & Baron-Cohen, 2005). This study will attempt to extend previous research on language processing in typically developing individuals and those individuals with AD. This is important because people with AD have multiple communication problems and a better understanding of hemispheric processing of language will aid in understanding these symptoms. In the remainder of the introduction will review symptoms of AD, focusing on communication difficulties. This will be followed by a review of research on the role of the right hemisphere (RH) in comprehending pragmatic language- specifically sarcasm.

Asperger's Disorder (AD)

Individuals with Asperger's Disorder (AD) have problems with social interaction, exhibit repetitive and stereotypical behaviors and have problems effectively communicating with others (*DSM-IV*, TR, APA, 2000). According to the *Diagnostic and Statistics Manual of Mental Disorders* 4th edition Text Revision (*DSM-IV* TR) symptoms of AD must begin to present by at least age three with delays or abnormal functioning in social interaction, language used for social interactions, and symbolic or imaginative play (*DSM-IV* TR, 2000). However, unlike Autism and other Autism Spectrum Disorders (ASD) individuals with AD do not show clinically significant delays in cognitive or language development (*DSM-IV* TR, 2000). These individuals show normal to above average intelligence, good grasp of semantic language and vocabulary, but struggle understanding the implied messages that are common in social interaction (Gunter, Gharziuddin & Ellis, 2002). These deficits result in an inability to read social cues, understand others' emotions or thoughts, and understand the social aspects of speech (Thompson, Thompson

& Reid, 2010). The lack of social or emotional reciprocity is typically exhibited with one-sided social interactions and the inability to properly verbally and nonverbally interpret and express themselves (*DSM-IV TR*, 2000). These deficits in communication may result from the inability of those with AD to utilize conversational rules, failure to appreciate nonverbal cues, and a limited capacity to self-monitor (*DSM-IV TR*, 2000). These parts of speech are known as pragmatic language and have been shown repeatedly to be deficient in AD (Rajendran, Mitchell & Rickards, 2005).

Pragmatics & Asperger's Disorder

According to the American Speech-Language-Hearing Association's (ASHA) guidelines for treating individuals with Autism Spectrum Disorders (ASD) (ASD includes AD, Autism and Pervasive Developmental Disorder- Not Otherwise Specified) deficits in communication play a key role in emotional and behavioral regulation (ASHA, 2006). In fact, social communication is a core feature of many treatments; when these communication skills are improved they have been correlated with better behavioral and emotion regulation, increased academic performance, and improvement in several other areas (ASHA, 2006). The importance of communication abnormalities in AD make it a key feature which needs to be examined further. Previous research has indicated that difficulties in communication experienced by those with ASD are not confined to the semantic and lexical domains of language (Lewis, Murdoch & Woodyatt, 2007). One of the four most recognized language domains is pragmatics (Russell & Grizzle, 2008). Despite the importance of pragmatics it has often been left out of language screening tests and therefore has not played as central of a role in the description of impairments of individuals with ASD (Russell & Grizzle, 2008).

Pragmatics is a key component of language and it is directly related to social interaction (*DSM IV-TR*, 2000). Pragmatic language encompasses many social and linguistic skills including appropriate turn-taking, cohesive devices (keeping a conversation flowing with the topic), topic introduction, maintenance and change of conversation, and politeness (Prutting & Kirchner, 1987). Nonverbal pragmatic skills shown to be problems in ASD are deficiencies in the use of gestures, eye contact (core feature of ASD), body language, and facial expression (Philofsky & Hepburn, 2007; Prutting & Kirchner, 1987). Individuals with ASD have difficulty properly using verbal aspects of pragmatic language including problems initiating and sustaining conversation, lack of reciprocity in conversation, inappropriate turn taking, abnormal prosody (intonation and stress of speaking), inappropriate comments (do not follow societal rules), difficulties using pronouns, and inability to use non-literal speech (Philofsky & Hepburn, 2007; Young et al., 2005; Russell & Grizzle, 2008; *DSM IV-TR*, 2000). The inability to properly use verbal and nonverbal pragmatic language decreases their ability to effectively communicate with others.

In addition to deficient usage of pragmatic language, individuals with ASD also have problems comprehending pragmatic language when it is used by others. These individuals have problems comprehending several aspects of pragmatic language including overly literal language comprehension, difficulty understanding humor, difficulty interpreting facial and emotional expressions, unusual emotional interpretation of statements, trouble understanding references in speech and trouble with cohesion of topics (Philofsky & Hepburn, 2007; Young et al., 2005; *DSM IV-TR*, 2000). These deficits in the usage and interpretation of pragmatic language are compounded by inappropriate use of some pragmatic aspects of speech including idiosyncratic speech (made up words), and stereotyped or repetitive language (*DSM IV-TR*, 2000; Wetherby,

Woods, Allen, Cleary, Dickinson & Lord, 2004). Clearly, individuals with ASD have severe deficiencies in the usage and interpretation of pragmatic language.

Pragmatic aspects of language have been shown to be an important aspect of the communication deficits in ASD (Russell & Grizzle, 2008). The inability to properly use and comprehend pragmatic language has been shown to be an integral reason behind the inability of individuals with ASD to properly communicate and interact socially with others (Wetherby et al., 2004). These findings logically make sense because someone who cannot properly process their environment (linguistically or socially) or communicate their needs and feelings will not feel comfortable interacting with others. This inability to communicate and understand their environment may lead to frustration and acting out as a means of communication. Wetherby et al. (2004) state that this lack of skills necessary to communicate may result in children with ASD using unconventional and inappropriate methods of communications including aggression, tantrums and self-injurious behaviors.

Pragmatics and the Right Hemisphere

Language comprehension was originally thought to be solely done by the LH while the RH was designated for only non-verbal functions (including emotional and prosodic processing). However, this traditional understanding of language has been challenged by consistent research findings that show the RH plays a role in specialized language functions as well (Beeman & Chiarello, 1998; Ross, Monnot, 2008).

The RH has been shown to be essential for the non-verbal aspects of communication, such as gestures and emotional recognition (Ashwin, Wheelwright & Baron-Cohen, 2005). There is a large amount of literature that shows a RH advantage for processing emotional content

(prosody or affective aspects of speech) (Borod, Bloom & Haywood, 2005). Therefore, the RH is important for comprehension of verbal and nonverbal pragmatic aspects of speech.

The role of the RH has repeatedly been shown to contain systems for social communication, i.e. pragmatic speech, which compliment LH specialization in language which enhances effective social and interpersonal communications (Ashwin, Wheelwright & Baron-Cohen, 2005; Shamay-Tsoory et al., 2005; Uchiyama et al., 2006). Research has shown that in healthy individuals (no RH damage) the RH has a role in extralinguistic processes which include discourse comprehension, generating and comprehending non-literal language, understanding jokes, and integrating information across sentences (Blake, 2007). Another way to examine the role of the RH is to examine individuals who have experienced damage to the RH. These brain lesion (damage) studies show the effect of decreasing the role of the RH in comprehension of communication.

Right hemisphere damage effects affective prosody (the emotional content of speech), discourse and pragmatics (Blake, 2007). Several studies have shown aprosodia, the inability or reduced ability to produce or comprehend affective (emotional) aspects of language, to be a common symptoms experienced in those with RH damage (Blake, 2007). Blake (2007) reviewed literature on the treatment of communication dysfunction in individuals with RH damage and found pragmatic deficits to be central to overall communication dysfunction. In this study pragmatics and discourse were separated into different aspects of speech; both of which are affected by RH damage. Pragmatics was defined as involving skills such as eye contact, turn taking and related skills. Discourse was more centered on making inferences about others. However, even Blake (2007) noted that these share many common features including comprehension of context and its effect on appropriate social interactions. Damage to the RH

was found to be associated with discourse aspects of speech including problems understanding abstract, non-literal and or ambiguous information (multiple interpretation of statement possible). Right hemisphere damage was also associated with egocentric or over personalized responses, focus on irrelevant details, disorganized thoughts and impulsive not well thought out responses. Pragmatic deficits included difficulty with abstract reasoning, inferential reasoning, and poor eye contact. For the purposes of this study the differentiation of discourse and pragmatics is not important. Instead, it should be noted that RH damage has been long established to play a role in causing communication problems relating to pragmatic speech.

Wapner et al. (1981) found that those with RH damage had an impaired ability to discern between funny and humorous comments versus unfunny comments presented verbally. These findings that RH damage causes an inability to understand ironic statements (humor, sarcasm etc.) and distinguish lies from jokes has been replicated and expanded in the literature (Shamay et al., 2002; Shamay-Tsoory et al., 2005; Uchiyama et al., 2006). Part of the reason individuals with RH damage lose the ability to interpret ironic statements and infer the meanings of non-literal language is that RH damage limits the ability to infer the thoughts of others (Winner et al., 1998).

According to Gunter, Ghaziuddin and Ellis (2002) individuals with AD have difficulty producing and understanding pragmatics. The experimenters compared individuals with nonverbal learning disability syndrome (NLD) to those with AD on tests of pragmatic language communication, verbal and visual memory, visual-spatial abilities and bimanual motor skills (using both hands at same time). Nonverbal learning disability involves deficits in nonverbal communication, visio-spatial organization, psychomotor coordination, deficits understanding and expressing pragmatic and prosodic aspects of language, problems with social judgment social

perception and social interaction. NLD is known to be correlated with RH dysfunction. This experiment revealed those with AD to have similar neuropsychological profiles to NLD which implies RH dysfunction in the symptoms of AD. Specifically, Gunter et al.'s (2002) experiments showed that individuals with AD had difficulties appreciating humor, understanding metaphors and making inferences. These types of problems are common in individuals with RH dysfunction and play an important role in comprehending pragmatic aspects of speech.

Ross and Monnot (2008) used the Aprosodia Battery to examine patterns of aprosodia in those with focal ischemic strokes (strokes to specific areas resulting in oxygen deprivation and damaging functioning associated with the specific areas) to either the RH or LH. The Aprosodia Battery was developed to differentiate between patterns of aprosodia due to damage of either the RH or LH. Previous research has questioned the location of affective prosody because damage to both hemispheres produced forms of aprosodia. However, this study found that damage to the LH affected language processing and production (prosody) because both hemispheres work together to produce language. However, for an intended emotional tone of voice, known as affective prosody, to occur the RH is necessary. Damage to the RH produces an inability to produce affective prosody. Therefore, this study demonstrated that although LH damage can cause indirect effects on affective prosody, affective prosody is dominant and lateralized function of the RH.

Asperger's Disorder and the Symptoms relating to Right Hemisphere Dysfunction

It has been shown that individuals with AD exhibit many symptoms that are similar to those with RH damage and dysfunction discussed above (Thompson, Thompson & Reid, 2010). The following studies provide evidence of RH dysfunction in AD.

Some of the most prominent symptoms in AD are difficulties with social cognition, which includes processing facial and emotional expressions. These symptoms are present typically with normal executive function and intelligence and this results in peculiar forms of communication and problems understanding others (Ashwin, Wheelwright & Baron-Cohen, 2005). These difficulties with verbal and non-verbal pragmatic aspects of communication are analogous to those observed in individuals with RH damage. Ashwin, Wheelwright and Baron-Cohen (2005) examined how those with AD process facial emotion using a chimeric face task. Previous research has shown a left visual field (LVF) bias, the RH processing the LVF, for faces. Additionally, neuroimaging and lesion studies have shown the importance of the RH for processing facial identity and facial emotion. The chimeric face task involved choosing which chimeric faces (composites of same face with two different facial expressions) were angrier or sadder (emotional task), and then choose between two chimeric faces to identify (identification task) which most resembled the original face (presented with the chimeric face pair). Those with AD showed a LVF for both the identification and emotional task whereas controls only showed the LVF for the emotional task. These results suggest that individuals with AD show a different pattern of hemispheric processing when processing faces. This dysfunctional pattern of emotional processing may help explain why individuals have such trouble comprehending social cues and other pragmatic aspects of speech.

Thompson, Thompson and Reid conducted several studies which are applicable to the present study because they found neurological evidence of RH dysfunction in AD. According to Thompson, Thompson and Reid (2010) the two main clusters of symptoms exhibited by both AD and Autism are motor and sensory aprosodia. Sensory aprosodia is the inability to correctly interpret social innuendo, including verbal and nonverbal information. In those with

neurological damage, especially in the area of posterosuperior-temporal-lobe and posteroinferior-parietal-lobe (RH corresponding areas to Wernicke's area in LH), sensory aprosodia symptoms include an inability to understand emotional tones of sadness or happiness in someone's voice and trouble copying emotional tones. Motor aprosodia is the lack of prosody, also known as the inability to use emotionally appropriate vocal intonation and volume control in conversation. In AD, this has been seen with children using a monotone voice or speaking in a very loud voice when in stressful situations. Finally, those individuals with AD who exhibited sensory and motor aprosodia were shown to have decreased RH activity during EEG (Thompson et al., 2010).

Thompson and Thompson conducted several studies examining the use of EEG to understand AD and the utility of biofeedback for clinical purposes in several disorders including ASD. Thompson et al. (2009) showed that less activation in the right parietal-temporal lobe (shown by low, low wave beta activity and/or high, slow wave activity) is associated with difficulty interpreting social cues and emotions (sensory aprosodia). In the same study decreased activity (shown by the same types of activation discussed above) in the right frontal cortex is correlated with the inability to appropriately express emotion through tone of voice (motor aprosodia). Along with these areas, the cingulate gyrus was monitored through neurofeedback due to its role in affect regulation and control. The anterior cingulate (AC) is connected to the insula, amygdala and mirror neuron system which all play a role in affect regulation and control. Based on these findings, these specific areas of the brain became targets for neurofeedback and biofeedback in clinical trials with AD by these researchers.

Thompson, Thompson & Reid (2010) discussed the results of using biofeedback and neurofeedback (over 15 years) to help 150 individuals with AD learn social and academic skills.

Individuals received two weekly 40 minute sessions of biofeedback and neurofeedback, during which time they received social and academic training, over a 5 to 6 month period. In AD, there seems to be an overall dysregulation of cortical activity. This study attempted to show a combination of biofeedback and neurofeedback training can affect functional networks related to AD symptomatology and cortical activity can be “normalized.” This study showed increased normalization (i.e. that of typically developing individuals) of brain waves of the AC through training to decrease symptoms of AD. The results of the sessions for the majority of individuals were increased attention, achievement and intelligence levels. These trials provided preliminary data for the efficacy of using biofeedback for people with AD. More importantly, they showed dysregulated cortical activity, specifically in areas related to social and emotional communication, played a central role to symptoms of AD. This dysregulated cortical activity (i.e. hemispheric processing) in social and emotional communication shows that these symptoms in AD have a neurological basis. The Thompson et al. (2009 & 2010) studies provide evidence of hemispheric dysfunction for emotional and social communication; the target of the current study is clarifying the role of the right hemisphere in sarcasm comprehension in AD. These studies also support the current study’s hypotheses that dysfunctional hemispheric processing affects the core symptoms of AD and their ability to interpret sarcasm.

The similarity of symptoms experienced by those with AD and RH damage make it logical to further examine the role of abnormal hemispheric language processing in AD and the role of that RH dysfunction in the etiology of their symptoms. Therefore, it is likely the symptoms of decreased comprehension of pragmatic aspects of communication (verbal and nonverbal) in AD may be related to impaired RH functionality, and contribute to their social and

communicative symptoms. One area of pragmatic language which has been studied extensively is sarcasm.

Sarcasm

Irony is an indirect form of speech characterized by opposition between the literal meaning of the sentence and the speaker's meaning. One form of irony is sarcasm (Shamay-Tsoory, Tomer & Peretz, 2005). Sarcastic phrases are usually used to communicate implicit criticisms of the situation or the listener. To fully understand sarcastic utterances the listener must identify the opposition between the literal meanings and the implied meaning of the sentence; the speaker of the ironic sentence intends for the listener to detect the deliberate falseness of the statement because the statement will violate the context of the statement. In summary, sarcasm is a form of verbal irony where the indirect speech meaning is intended to be opposite from the literal meaning (Haverkate, 1990; McDonald & Pearce, 1996).

Those with AD have trouble understanding the emotional content of information, making inferences, understanding social rules and communicating effectively. A perfect example of a type of speech that is difficult for those with AD to understand is sarcasm. Research has consistently shown that individuals with AD have trouble understanding sarcasm and figures of speech (Rajendran, Mitchell & Rickards, 2005; Joliffe & Baron-Cohen, 1999; Uchiyama et al., 2006; Happe, 1994). The following studies present evidence of decreased abilities to comprehend sarcasm in AD and those with RH damage.

Deficits in the well established theory of mind (ToM) in AD may play a role in understanding the decreased understanding of sarcasm and pragmatic speech (Joliffe & Baron-Cohen, 1999). Joliffe & Baron-Cohen (1999) replicated and expanded upon previous research (Happe, 1994) using the Strange Stories Test, an established ToM test, by differentiating

diagnostic groups, ensuring comprehension of second-order ToM tasks and controlling for IQ level. Those with AD and Autism were compared to typically developing participants on the Strange Stories Test. For the Strange Stories Test, participants are presented with visual stimuli which include a picture of the story and the story written adjacent to the picture. The experimenter provides auditory stimuli by reading the written story to the participants. Then participants are asked to infer the meaning of actions or feelings of the characters in the story. The results showed those with AD performed the task more poorly than controls; and they had particular difficulty providing contextually appropriate mental state (pertaining to characters' mental state) answers.

Another study used neuroimaging on tasks of mentalizing, the ability to understand other people's behavior in terms of their mental state, and sarcasm identified areas of the RH as central to these tasks. Uchiyama et al. (2006) using 20 typically developing adults, found that sarcasm detection, which is part of the mentalizing system, is associated with activation of the medial prefrontal cortex and superior temporal sulcus; meaning activation in both LH and RH. During an fMRI, participants were presented visual information (story) and asked to infer the meaning and feelings of those in an ironic or non-ironic story. The experimenters stated the activation of the LH was likely due to the involvement of the LH in language processing required to perform the task. The activation of these areas in the RH is of particular importance because previous research has shown damage to the RH results in an inability to distinguish jokes from lies or accurately interpret second-order (thoughts about thoughts) mental states of others. Also, damage to the prefrontal cortex (PFC) has been shown to result in impaired empathy, and an inability to understand sarcastic utterances. Therefore, the results of the fMRI study provide neuroimaging evidence for these dysfunctions in the RH and PFC and decreased comprehension

of sarcasm. Uchiyama et al. (2006) postulated that their results may be related to the inability of those with AD to infer the thoughts of others effectively.

Similar to those with AD, people with RH damage have difficulties comprehending sarcasm. For example, one of the earliest studies by Tompkins and Mateer (1985) examined whether individuals with RH damage could comprehend vignettes (short phrases) with positive and negative mood. Both vignettes ended with an identical positive comment, resulting in comprehension of the positive vignettes as congruent positive vignettes (ending is congruent with positive vignette) or incongruent with negative vignettes. Essentially, the statement is either a true statement or a sarcastic statement. They were asked to judge the appropriateness of the final statement, in regards to the content and emotional tone, and answer questions about factual and inferential information from the vignettes. This study showed those with RH damage had difficulty understanding complex emotional information because they had trouble making inferences from the statements, as well as making the most accurate interpretation of the vignettes.

In a 2005 study by Shamay-Tsoory et al., individuals with brain damage to multiple areas were compared to healthy controls on sarcasm comprehension. This study broke down those with lesions to specific areas (LH, RH, frontal lobe, etc.) and found that those with RH damage, specifically the right prefrontal cortex (PFC), showed a significant decrease in their ability to comprehend sarcasm. Based on these findings they proposed their own theory of sarcasm comprehension. The theory states that both hemispheres are involved at some point. First, the right hemisphere, specifically the right PFC, identifies the social and emotional context as well as the speaker's intentions. Based on this theory, and their research findings, when the RH is damaged these individuals have difficulty understanding sarcasm, identifying social and

emotional context and understanding the speakers intention. In summary, the RH is important for understanding sarcasm because when this area is damaged it affects emotional recognition and processing.

Dichotic Listening Task

One of the most reliable methods of assessing hemispheric processing is a dichotic listening task (Voyer, Bowes & Techentin, 2008). In a dichotic listening task, the left and right ears are presented with different auditory inputs that compete for processing in the brain. The brain has a limited ability to process multiple stimuli simultaneously. This is known as a laterality effect, limited resources to process simultaneous stimuli result in a hemisphere only processing information sent from the ear assigned to each hemisphere initially. The brain processes sensory information contralaterally- information from one side of body (right) is processed by the opposite hemisphere (left) in the brain. Information presented to the right ear (RE) is processed by the left hemisphere (LH), known as right ear advantage (REA). Conversely, information presented to the left ear (LE) is processed with the right hemisphere (RH), known as a left ear advantage LEA (Voyer, et al., 2008). One of the earlier studies to establish this laterality effect using a dichotic listening task was Bryden and MacRae (1988). In this study participants were presented with short words spoken in different affective tones and instructed to detect the presence of a word or emotion. Their experiment showed a LE/RH advantage for emotion detection and a RE/LH advantage for word target detection. Therefore, dichotic listening tasks allow experimenters to measure hemispheric processing (via LE and RE) and determine which hemispheres are responsible for processing different types of information most effectively (Voyer et. al., 2008). This is measured by examining the participant's reaction time and accuracy for the information presented to each ear.

A large amount of research using dichotic listening tasks to study the processing of emotional context have found a LEA, which implicates the RH, for the comprehension of emotional context (affect, prosody, sarcasm, etc.) (Borod, Bloom & Haywood, 2005; Voyer, Bowes & Techentin, 2008). These studies have been conducted on both non impaired populations and those with specific ailments and brain damage. One important study with non-impaired individuals was conducted by Techentin and Voyer (2007) which found a LEA (RH processing) for detection of emotional tones and words which are incongruent. This suggests that incongruent emotional tones (i.e. sarcastic tone) convey emotional information beyond the obvious word/statement alone. The results from Techentin and Voyer (2007) imply the RH has an important role in language processing and in particular the reinterpretation of word meanings in relation to their accompanying emotional tone (Voyer et al., 2008). Sarcasm best reflects this word emotion incongruence described in Techentin and Voyer (2007). These findings of a LEA/RH in processing sarcasm are supported by studies examining participants with specific brain damage.

It has also been shown that sarcasm comprehension does not depend on “what” was said but instead on “how” it was said. Rockwell (2000) had participants listen to audio stimuli (statements told in context of a story) in three conditions, sarcastic, non-sarcastic, and posed sarcasm which relies most heavily on prosody and tone. After these statements had been recorded by professionals to ensure correct tone and content they were digitized so that the words themselves could not be detected. The only information presented was the tone, prosody and pitch of the statements. Rockwell argued that sarcasm is conveyed with lower pitch, louder intensity and slower tempo. This study supported this hypothesis and found that regardless of verbal content sarcastic statements could be identified by “sarcastic tone” alone.

One of the most important studies of sarcasm comprehension was conducted by Voyer, Techentin and Bowes (2008). Voyer et al. (2008) were interested in examining how accurately sarcasm could be detected by short context independent phrases as in the Rockwell (2000) study. Using a dichotic listening detection task, participants were asked to listen to target stimuli and identify which ear heard the sarcastic or sincere version of the same stimuli. Each of the 12 short phrases was recorded in both sincere and sarcastic tone where the only difference was their tone and prosody. Their results supported previous data and established the REA/LH for sincere phrases and LEA/RH for sarcastic phrases. This study solidified the hypothesis that the RH is crucial for the comprehension of sarcasm, plays a central role in understanding prosodic information and facilitates understanding of mood incongruent statements.

In summary, non-impaired individuals show a RH advantage when interpreting sarcasm; meaning that they rely on the RH to infer implied meanings and understand social aspects of speech (Voyer et al., 2008). This is further supported by studies examining participants with damage to the RH who have difficulty comprehending sarcasm, limiting their ability recognize and process emotion and understand emotionally complex information. The research on this topic repeatedly supports the RH functioning to be crucial in order to understand prosodic and emotional content. Because the role that the RH plays in communication and comprehension of pragmatic language, a better understanding of the role of the RH in AD may help explain communication problems faced by those with AD. Specifically, those with AD have problems understanding emotional content and display symptoms which are similar to those exhibited by people with RH damage. The purpose of this study was to examine if individuals with AD, will demonstrate the same RH advantage when attempting to interpret sarcasm. This will provide a

clearer picture about the role of the RH in processing pragmatic language, specifically sarcasm, in AD.

Current Study

This study used Voyer et al.'s (2008) dichotic listening task and stimuli to examine sarcasm processing in people with AD. The sincere (literal) and sarcastic (non-literal) phrases were presented binaurally (sound is processed simultaneously by both ears). Simply, one ear was presented with the sincere version, while the other ear was simultaneously presented with the sarcastic version. Participants were then instructed to indicate which ear heard the target phrase (sincere or sarcastic). The target phrase, either sincere or sarcastic was identified prior to the beginning of each block of the dichotic listening task. Participants were instructed to identify which ear heard the target phrase (one block will be sincere and another block sarcastic). The purpose of this study was to determine whether those with AD process sarcasm with similar, or dissimilar, laterality effects to a matched group of typically developing individuals. This dichotic listening task allows for the measurement of speed and accuracy of hemispheric processing of sincere and sarcastic language. This task provided an opportunity to better understand the neuropsychological processing of language, and the neuropsychological component of the social and communication deficits, experienced by those with AD.

Hypotheses

This study will explore three hypotheses. First, it is hypothesized participants with AD will be significantly less accurate than typically developing participants at identifying sarcastic tones. Previous research has shown that individuals with ASD have considerable difficulty understanding sarcasm and figures of speech (Happe, 1994; Jolliffe & Baron-Cohen, 1999; Rajendran, Mitchell & Rickards, 2005). As stated above, the ability to identify pragmatic

aspects of speech, understand irony and comprehend affective prosody, are impaired in those with AD. This makes it unlikely that the AD participants will be able to identify the sarcastic tone (form of irony) as accurately as typically developing participants. Second, based on previous studies, it is expected typically developing participants will show a LEA/RH for the identification of sarcasm (Voyer, Bowes, & Techentin, 2008). Finally, it is hypothesized the AD group will not show a LEA/RH for sarcasm identification. Previous research has shown probable linkages between RH dysfunction and AD including symptoms of decreased pragmatic and sarcasm comprehension. Therefore, it is unlikely they will rely on their LE/RH as typically developing participants with functional RH have been previously shown to rely on.

Method

Participants

Fifty-eight college age (18-30) participants were recruited for this study. Participants were right handed and reported English as their native language. The 58 participants were divided into two groups: Fourteen participants with a formal diagnosis of AD, and Forty-four participants without a diagnosis of AD (referred to as typically developing participants).

Participants were recruited within the same age range (18-30) and from similar environments (college campuses or receiving post-secondary services). Both groups also completed a brief measure of intelligence, health survey, handedness questionnaire and a perceived accuracy questionnaire in an effort to match participants from both groups as thoroughly as possible.

The AD group consisted of fourteen participants with a formal diagnosis of Asperger's Disorder (AD) from a Medical Doctor or licensed psychologist. These participants were recruited from local colleges and ASD support groups including: The Autism Society of

Indiana, The College Internship Program-Bloomington and the Disabled Students Development department at Ball State University. Participants who chose to participate were compensated for their time with 25 dollars. This monetary compensation was necessary to reach this small target population as well as ensure participation did not cause too harsh of a problem for them and their possible limited financial status. This monetary amount was appropriate because it did not constitute an offer that was too good to pass up and therefore was not coercive for those with AD to participate.

The matched control group consisted of 44 typically developing individuals from the Ball State University Psychological Science subject pool. Participants were given experimental participation points in return for their participation.

Materials

All participants completed the dichotic listening task used by Voyer et. al, (2008). This task assesses the ability to identify sarcastic and sincere tones presented to both ears. Audio stimuli were presented through Auvio 33-290 Noise Canceling Stereo Headphones. For each trial, participants heard two versions of the same statement presented by E Prime (2.0), one sincere and one sarcastic. Twelve critical phrases were read by the same female speaker. An example of a critical phrase is “You were a big help” (see the Appendix for a complete list of the 12 critical phrases). Depending on the tone with which this critical phrase was read by the speaker the meaning will change; it is this ability to identify the correct tone and infer the speaker’s meaning that was examined in this study. For half of the trials the sincere version was presented to the left ear and the sarcastic version to the right ear; the presentation was reversed for the remaining trails. These trials were divided into two counterbalanced blocks. In the one block, participants were asked to listen to the statements and identify which ear heard the

sarcastic tone. In the other block, participants were asked to identify which ear heard the sincere tone. Participants responded by pressing the designated “Left” and “Right” buttons (marked with stickers that read “Left” for the number 4 key, and “Right” for the number 6 key) on the keyboard with their right hand. The responses measured the participant’s accuracy at identifying the specified tone. This is the accuracy measure. For each block, the participants completed a total of 96 trials. Each block consisted of 48 trials in which 12 sincere phrases, were presented to one ear and 12 sarcastic phrases presented to the opposing ear. Each critical phrase was presented twice for each ear. For example, 12 sincere phrases were presented to the LE/RH and 12 sarcastic phrases presented to the RE/LH. Then the sarcastic/sincere phrases were presented to the other ear. To avoid order effects on the task, identification of sarcastic/sincere tone, was controlled by E Prime (2.0) so that each participant identified one or the other tones first; therefore, half of the participants identified sincere tones first and half of the participants identified sarcastic tones first. This was repeated twice for each participant (2 blocks of 48 trials, 96 total trials per participant).

Both groups also completed the *Kaufman Brief Intelligence Test- Second edition* (KBIT-2), rather than the *Wechsler Abbreviated Scale of Intelligence- Third edition* (WASI-III), due to limited time and the needs of the current study. Mottron (2004) conducted a meta-analysis on all studies between 2002 and 2009 with participants with Autism or AD which matched participants using some type of intelligence measure. It was found that the Wechsler intelligence tests are the most common and effective measures used with ASD for intelligence matching purposes. However, due to time constraints and needing to only screen for gross differences in intelligence levels the KBIT-2 was a better fit for the current study. Research has shown adjusted correlations of .82 or higher on all subtests and overall intelligence between results of the KBIT-

2 and WASI-III (Bain & Jaspers, 2010). Therefore, the KBIT-2 provided comparative results in a time efficient manner and met the needs of this study.

Procedure

Participants were brought to a room free from distractions, sat down at a desk and were welcomed to the experiment. At this point the experimenter explained what would occur if the participant chose to participate. Then the experimenter obtained informed consent (See Appendix for Informed Consent form). Participants then completed the Health Survey (Appendix) to ensure participants did not have any medical conditions that would impede their ability to complete the dichotic listening task. Each participant was then directed to the laptop computer with the instructions displayed on the monitor for the participant to read. The instructions were given prior to beginning the task and were given only once. After reading instructions, to ensure comprehension, participants were asked to explain the task aloud to the experimenter. After participants indicated they understood the directions they clicked the appropriate button on the keyboard and began the experiment. Participants then completed the Edinburgh Handedness Inventory (Oldfield, 1971) on a separate piece of paper between the first and second block of the dichotic listening task. After completing the dichotic listening task and handedness inventory participants completed the Perceived Accuracy Questionnaire (Appendix). This questionnaire asked participants to rate their ability to accurately identify both sarcastic and sincere phrases using a 1-100% rating scale. The experimenter then administered the KBIT-2. Following completion of the experiment, participants with AD received the \$25 compensation. Participants in the typically developing group were given experiment participation credit. Finally, participants were thanked for their participation and any questions they had were answered.

Participants were evaluated on several different measures to determine their eligibility to be included in the data set that was analyzed. First, all participants had to have a minimum KBIT-2 full score one standard deviation (85) below the mean (100) or higher. This criterion was necessary to ensure that performance during the dichotic listening task was not confounded by intelligence level. Second, participants must be between the ages of 18-30. Third, individuals must be right handed. Previous research has shown that left-handed individuals show different patterns of hemispheric dominance for language and other functions (Meguerditchian & Vauclair, 2008; Knecht, Drager, Deppe, Bobe, Lohmann et al., 2000). Therefore, to ensure participants were matched as thoroughly as possible left-handed participants were excluded. Fourth, individuals who endorsed items on the health questionnaire which may have affected their ability to concentrate, complete the task or affect reaction time were excluded. Factors included that could possibly slow reaction time and affect performance on the dichotic listening task included recent or multiple concussions, and hearing impairments.

Results

Upon completion of data collection, participants were screened to determine who would be excluded based on the exclusion criteria listed above. The original sample included 44 typically developing participants and 14 participants with AD. After using exclusion criteria the final sample size was reduced to 36 typically developing (22 male, 15 female) and 9 participants (5 male, female 4) with AD. In the typically developing group participants were excluded due to data corruption (3), age above cut off (1), KBIT-2 IQ requirement (1), recent concussions (1) and hearing loss (1). The five individuals in the AD group excluded met one or more of the exclusion criteria for left-handedness (3 total) and KBIT-2 IQ requirement (4 total). Table 1 lists all the individuals in the AD group with asterisks next to exclusionary criteria that were met.

Table 1

Asperger's Disorder Group Diagnoses, KBIT-2 Full Score and Exclusion Status

ID #	Handedness	Psychiatric Diagnoses	KBIT-2 Full Score
1	R	AD only	122
2	L*	Anxiety Disorder, epilepsy & RH cerebral palsy	94
3	R	AD & OCD	123
4	R	AD only	97
5	R	AD only	108
6	R	AD only	76*
7	R	AD only	118
8	R	Depression, ADHD	91
9	L*	Epilepsy, Depression & Anxiety Disorder	77*
10	L*	AD only	83*
11	R	ADHD	114
12	R	Depression	120
13	R	AD only	44*
14	R	Depression	108

Note. * indicates exclusion criteria being met and therefore exclusion from the final sample

L = left handed R= right handed

The typically developing group age ranged from 18-24 ($M=19.92$). Typically developing participants had a mean KBIT-2 full score of 100.14($SD= 8.87$), verbal IQ of 100.69 ($SD=$

11.464), and nonverbal IQ of 99.83 (SD= 8.706). Thirteen participants had a significant difference ($p<.05$) between their verbal and nonverbal IQ scores. Ten participants had a significantly higher verbal IQ score while three participants had a significantly higher nonverbal IQ score. Six participants endorsed having some form of psychiatric diagnosis including mood disorders (2), Attention Deficit Hyperactivity Disorder (ADHD) (2), learning/reading disorder (1) or having multiple comorbid conditions (1). Four participants were taking psychiatric medications. Medication classes included anxiolytics (1), selective serotonin reuptake inhibitors (SSRI) (1), psychostimulants (1) or multiple medications (1). 10.8% of those in the typically developing group were taking some form of psychiatric medication.

Those in the AD group had a mean KBIT-2 full score of 111.22 (SD= 11.278), verbal IQ of 118 (SD= 13.964) and a nonverbal IQ of 100.78 (SD= 11.245). The age ranged from 19-25 ($M=21$). Seven participants in the AD group had a significantly ($p<.05$) higher verbal IQ score than their nonverbal IQ score. Because all of those in the AD group already had one psychiatric diagnosis (Asperger's Disorder) focus was placed on those with comorbid psychiatric diagnoses. Five participants endorsed having multiple psychiatric diagnoses including mood disorders (3), obsessive compulsive disorder (OCD) (1), and ADHD (1). Five participants were taking multiple psychiatric medications. Medication classes included SSRI, psychostimulants, antipsychotics, and anxiolytics. 55.6% of the selected AD group was taking multiple psychiatric medications.

Hypotheses Results

The first hypothesis predicted participants in the AD group would be significantly less accurate identifying sarcasm than those in the typically developing group. An independent samples t-test was performed to measure the accuracy of both groups identifying sarcasm. The

Levene's test of equality of variance was significant, $F(1,43) = 7.047, p = .011$. The t-test (unequal variances assumed) revealed no mean differences for accuracy levels identifying sarcasm between typically developing ($M=.6696$) and AD ($M=.6273$) groups, $t(27) = 1.217, p = .234$. Therefore, the first hypothesis was not supported because there was no statistically significant ($p < .05$) difference between the AD group and typically developing group to identify sarcastic tones. Table 2 displays the overall mean for both groups identifying sarcasm.

Table 2

Mean Accuracy as a Function of Ear, Target Type & Group

Group	Sarcastic			Sincere		
	LE/RH	RE/LH	Mean	LE/RH	RE/LH	Mean
Typ Dev.	.6597	.6794	.6696	.6523	.6753	.6638
AD	.6389	.6157	.6273	.6522	.6418	.6470

Note. Typ Dev. = Typically Developing group AD = Asperger's Disorder group
 LE/RH = Left Ear/Right Hemisphere RE/LH = Right Ear/Left Hemisphere

The second hypothesis predicted typically developing participants would show a left ear advantage (LEA/RH) for identification of sarcasm. A 2 X 2 Ear (left, right) x Target (sarcastic, sincere) Analysis of Variance with repeated measures for both variables was performed on typically developing participants only. This analysis of variance found no statistically significant interaction between ear and tone, such that there was no ear/hemispheric advantage for identifying sarcasm for the typically developing group, $F(1,143) = .442, p = .507$. Although not significant ($p > .05$), for sincere tones typically developing participants were more accurate with

their LE/RH ($M=.6753$) than their RE/LH ($M=.6523$); but for sarcastic tones their RE/LH ($M=.6794$) was more accurate than the LE/RH ($M=.6597$).

In addition, the main effect for Target was not significant, $F(1,143) = .032, p = .858$; there was no mean difference in accuracy between sarcastic or sincere tones. The main effect of Ear was not significant, $F(1,143) = .003, p = .959$; there was no mean difference between left ear and right ear. Table 2, displays the interaction between ear and tone for sarcasm for the typically developing group.

Finally, a 2 x 2 Ear x Target Analysis of Variance with repeated measures on both variables was run on participants in the AD group in order to test the third hypothesis. It was hypothesized that the AD group would not show a LEA/RH for identification of sarcasm. The results of this analysis of variance revealed no statistically significant Ear X Target interaction, $F(1, 35) = .014, p = .907$. Although not significant, participants in the AD group were more accurate identifying sarcasm with their LE/RH ($M=.6389$) than their RE/LH ($M=.6157$); for sincere tones the AD group was more accurate with their LE/RH ($M=.6522$) than RE/LH ($M=.6148$). Table 2 lists the interaction between ear and tone for the AD group.

In addition, the main effect for Target was not significant, $F(1,35) = .133, p = .718$; there was no mean difference in accuracy between sarcastic or sincere tones. The main effect for Ear was also not significant, $F(1,35) = .096, p = .758$; there was no difference in accuracy between left ear and right ear.

Exploratory Analyses

Additional post-hoc analyses were conducted to examine the data in more detail. First, participants' scores on the KBIT-2 full score, verbal IQ and nonverbal IQ were compared by group. An independent samples t-test revealed a significant difference between the AD

($M=111.22$) group and typically developing participants ($M=100.14$) on their KBIT-2 full scores, $t(43) = -3.171, p = .003$. The Levene's test for equality of variances was not significant $F(1,43) = .981, p = .328$. An independent samples t-test found participants with AD had a statistically higher verbal IQ score ($M=118$) than typically developing participants ($M= 100.69$), $t(43) = -3.880, p = .001$. The Levene's test for equality of variances was not significant $F(1,43) = 1.296, p = .261$. An independent samples t-test did not find any statistically significant differences between typically developing ($M= 98.83$) and AD ($M= 100.78$) nonverbal IQ scores, $t(43) = -.565, p = .575$. The Levene's test for equality of variances was not significant $F(1, 43) = .411, p = .525$.

Table 3

Group Mean KBIT-2 Scores, Standard Deviations (SD) and Ranges

KBIT-2 Scores	Groups	
	<u>Asperger's Disorder</u>	<u>Typically Developing</u>
KBIT-2 mean full score	111.22	100.14
KBIT-2 SD	11.278	8.887
KBIT-2 range	91-123	87-123
Verbal IQ mean	118	100.69
Verbal IQ SD	13.964	11.464
Verbal IQ range	96 -139	81-141
Nonverbal IQ mean	100.78	98.83
Nonverbal IQ SD	11.245	8.706
Nonverbal IQ range	82 -120	88 -132

Perceived Accuracy

Participants were asked to complete a brief questionnaire to measure their perceived accuracy for identifying sincere and sarcastic tones. The perceived accuracy of each group was compared to how well they actually performed on the dichotic listening task. Pearson correlation coefficients were computed to find the relationships between perceived accuracy and accuracy for both tones and ears on the dichotic listening task.

In the typically developing group there was a significant positive relationship between perceived accuracy for sincere tones and accuracy for sincere tones for the RE/LH, $r = .372$, $n = 36$, $p = .028$. This group also showed a significant positive relationship between perceived accuracy for sarcastic tones and accuracy identifying sarcastic tones in LE/RH, $r = .414$, $n = 36$, $p = .013$. This relationship between perceived accuracy for sincere and sarcastic tones matched the pattern for hemispheric dominance for sarcastic and sincere tones established by previous studies. Therefore, these typically developing participants correctly perceived their ability to identify sarcastic tones for their LE/RH and RE/LH for sincere tones.

In the AD group Pearson correlation coefficients did not reveal any significant ($p < .05$) relationships between perceived accuracy and accuracy for either sincere or sarcastic tones. No correlation coefficients approached significance. Therefore, there does not appear to be any relationship between perceived ability to correctly identify both sarcastic or sincere tones and their performance on the dichotic listening task.

Both groups' perceived accuracy for sincere and sarcastic tones were also compared. An independent samples t-test revealed no statistically significant differences between typically developing ($M=67.57$) and AD ($M=61.33$) groups for perceived accuracy for identification of sincere tones, $t(42) = 1.024$, $p = .312$. The Levene's test for equality of variances was not

significant $F(1,42) = 2.858, p = .312$. An independent samples t-test also revealed no statistically significant differences between typically developing ($M=69.37$) and AD ($M=70.00$) groups for perceived accuracy of sarcastic tones, $t(42) = -.099, p = .922$. The Levene's test for equality of variances was not significant $F(1,42) = .200, p = .922$. Therefore, both groups perceived their ability to identify sarcastic and sincere tones at a relatively similar level of accuracy.

Finally, intelligence scores were compared to accuracy identifying both tones on the dichotic listening task. This was done using participants for each group individually. First, KBIT-2 full scores for both groups were compared to their accuracy identifying sarcasm and sincere tones for specific ears. Second, KBIT-2 verbal IQ scores were compared to accuracy identifying tones for specific ear. Third, KBIT-2 nonverbal IQ scores were compared to accuracy identifying tones for specific ears. Table 4 presents the results of these correlations for typically developing participants and the AD participants. Significant correlations are identified by asterisk and bold font.

Table 4

Pearson's Correlation Coefficients between KBIT-2 Scores and Means for Accuracy Identifying Sarcastic and Sincere Tones in each Ear.

	<u>KBIT-2 Scores</u>		<u>Sarcasm</u>		<u>Sincere</u>	
		Sarcasm LE	Sarcasm RE	Sincere LE	Sincere RE	
			Asperger's Disorder			
KBIT-2 Full	-.251		.567	.084		-.238
Nonverbal	-.137		.591	-.041		-.668*
Verbal	-.273		.332	.150		.136

		Typically Developing		
KBIT-2 Full	.001	.162	.065	.198
Nonverbal	.046	.166	.033	.148
Verbal	.017	.088	.048	.136

Note. * = $p < .05$ LE= Left ear RE= Right ear

KBIT-2 Full = KBIT-2 Full Score Nonverbal = KBIT-2 nonverbal IQ

Verbal = KBIT-2 verbal IQ

For the entire sample, combining typically developing and AD group participants, Pearson correlation coefficients did not reveal any significant ($p < .05$) correlations between KBIT-2 scores and accuracy measures. Pearson correlation coefficients also did not reveal any statistically significant correlations between any KBIT-2 scores and accuracy measures for the typically developing group either.

For the AD group, Pearson correlation coefficients revealed a statistically significant ($p < .05$) negative relationship between nonverbal IQ and sincere tones in the RE/LH, $r = -.668$, $n = 9$, $p = .049$. Therefore, as participants' nonverbal IQ increased their accuracy identifying sincere tones with their right ear decreased; as their nonverbal IQ decreased accuracy identifying the sincere tone increased with their right ear.

Discussion

In summary, none of the three hypotheses were supported. The first hypothesis that the AD group would be significantly less accurate identifying sarcasm was not supported. An independent samples t-test revealed no mean differences for accuracy levels identifying sarcasm between typically developing and AD groups.

Second, the hypothesis that typically developing participants would have a LEA/RH for identification of sarcasm was not supported. A 2 X 2 Ear (left, right) x Target (sarcastic, sincere) Analysis of Variance found no statistically significant RH advantage for identifying sarcasm for the typically developing group. Although not statistically significant, a data pattern was found showing a RE/LH advantage for sarcasm identification. This data pattern trends away from the direction of the second hypothesis.

The third hypothesis postulated those in the AD group would not have a right hemisphere advantage for sarcasm identification. Although not statistically significant, the data pattern showed that those in the AD group relied on their right hemisphere for the identification of both sarcasm and sincere tones. Despite this non-significant data trend, the third hypothesis was not supported. Those with AD did not show a statistically significant right hemisphere advantage for the identification of sarcasm. The reason the lack of right hemisphere advantage for sarcasm identification does not support hypothesis 3, which predicted this, is because those in the AD group did not show a statistically significant advantage for any hemisphere for sarcasm identification.

However, it is difficult to say this lack of significant LE/RH dominance for sarcasm identification is truly an indicator of RH dysfunction in AD for several reasons. First, no significant hemispheric advantage was found for sarcasm. This ambiguity in hemispheric dominance of sarcasm identification decreases the confidence that can be placed in this finding. Second, non-significant trends in the data showed that those with AD were more accurate with their RH for the identification of sarcasm. Therefore, perhaps if the sample size were larger or more representative this non-significant finding would become significant and this hypothesis would be supported. Third, typically developing participants who had been shown in previous

studies to have a RH advantage for sarcasm identification, did not show this same pattern in this study. This makes comparison between groups more difficult. The typically developing participants were meant to act as a control to show a replicated finding of RH dominance for sarcasm identification (Voyer et al., 2008). Without a significant RH dominance for sarcasm identification in this group, comparisons with the atypically developing (AD) group become more problematic and decrease the amount of confidence that can be placed in this finding.

A previous study also did not find any difference between typically developing participants and those with high-functioning Autism using a dichotic listening task to identify prosodic elements of speech (emotions in this instance) (Baker, Montgomery, Abramson, 2010). This study compared these two groups ability to recognize emotions (happiness, sadness, anger and neutrality) in sentences which were digitized so that the words could not be detected. This study found that the groups did not differ significantly in their ability to recognize these emotions. They concluded that the difficulty those with Autism have processing emotion is not isolated to emotions presented verbally. Although this study focused on recognizing emotions and not sarcasm it has definite applications to the current study. The Baker, Montgomery, Abramson (2010) study is one of very few studies that has used the dichotic listening task on those with ASD. The results of this study, in addition to the current study, show it is difficult to pinpoint the exact way individuals with AD process information differently than typically developing individuals.

The lack of support for the first and second hypotheses is also problematic. The lack of disparity between groups on accuracy identifying sarcasm has ramifications for the conclusions made about the typically developing group, AD group and comparisons between groups. The lack of difference between groups identifying sarcasm further weakens the support for

hypothesis three. Although there may have been data to show there was no significant LE/RH advantage for sarcasm identification, both groups identified sarcasm in a similar fashion; meaning that both groups failed to show established characteristics for these groups. This limits the ability for these results to generalize beyond the current study.

Typically developing participants also did not show the hypothesized RH advantage for sarcasm identification. As discussed above, this severely limits the ability to compare these two groups. This problem is magnified by the non-significant trend in the data that showed typically developing participants showed a RE/LH advantage for sarcasm identification. This non-significant LH advantage for sarcasm identification is contrary to numerous studies showing the exact opposite effect being the norm. It is unclear why the current sample of typically developing participants did not show the pattern of hemispheric processing found in previous studies for sarcasm. One possible explanation would be that the participants were not motivated to give their best effort. As members of the Psychological Science Subject Pool participants are required to participate in four total experiment hours, or complete an alternate assignment, to complete their introduction to psychology course. Therefore, it is possible these participants may have rushed through the experiment to fulfill their class requirement. The dichotic listening task is a difficult task and if participants did not put forth their best effort it may have resulted in this unaccounted for pattern of hemispheric advantage for sarcasm.

Following planned analyses post-hoc comparisons of both groups' perceived ability to identify both tones was also examined. Pearson correlation coefficients revealed positive relationships between typically developing participants' perceived accuracy and their actual accuracy for identification of sincere and sarcastic tones on the dichotic listening tasks.

Typically developing participants correctly perceived their ability to identify sarcastic tones for

their LE/RH; and RE/LH for sincere tones. There were no statistically significant relationships between perceived and actual accuracies of either tone in the AD group. Finally, an independent samples t-test revealed no statistically significant difference between groups' perceived ability levels for identification of sincere or sarcastic tones. For sincere tones, no statistically significant differences between typically developing and AD groups for perceived accuracy were found. For sarcastic tones, no statistically significant differences existed between typically developing and AD groups for perceived accuracy. Therefore, although there was a significant relationship between the typically developing group's ability to predict their accuracy for sincere and sarcastic tones by ear, there was no statistically significant disparity between perceived accuracy levels between groups.

Examining the disparity between perceived accuracy identifying sarcasm and actual accuracy may lead to interesting insights into AD. It is interesting that there were no statistically significant relationships between their perceived ability and actual performance on the dichotic listening task in the AD group. This disparity may lead to insight into the condition of AD.

The finding that those in the typically developing group were able to predict their ability to identify sarcasm and sincere tones implies these participants had an awareness of these abilities. This insight into their abilities is a key difference between groups. The lack of clear correlations between perceived and actual ability to identify tones in AD implies that they do not have the insight into their own abilities that typically developing participants were found to have. This lack of insight into one's abilities, inability to recognize how effectively one is interpreting non-literal communication (i.e. sarcasm) may be directly related to the core symptoms of abnormal social interaction and inability to communicate effectively with others. Although the

current study did not find a relationship between this awareness of abilities and performance on the dichotic listening task, it may be a contributing factor to the social and communication symptoms that are hallmarks of AD.

Although no formal hypotheses were formed about the relationship between perceived accuracy and ability to identify sarcasm in this study, there are implications for both over and under predicting their ability to identify sarcasm in AD. If it is found that they over predict their ability to interpret sarcasm this could be associated with their social and communication problems. For instance, they may misinterpret others' meanings regularly and this could lead to confusion in both parties. In future studies if it is found that they believe they are more accurate than they truly are it may show a lack of insight into their social skills deficiencies and provide some support to the RH dysfunction theory. Those with RH damage are not aware that they are no longer as capable of interpreting sarcasm as those without brain damage. Therefore, this lack of insight in both groups may be some evidence that dysfunctional RH language processing could be implicated with sarcasm comprehension issues in AD.

Conversely, if in future studies those with AD are found to under predict their ability to identify sarcasm this could be a source of their apprehension in social situations. If they feel they are less skilled than others at interpreting sarcasm this may be an indication that they are less confident using other forms of non-literal communication as well. This apprehension about understanding sarcasm and other forms of non-literal communication would therefore be a very viable theoretical and practical target for future studies. Targeting interventions to improve social skills, recognize sarcasm, better understand pragmatic aspects of speech, improve perception of their own abilities and appropriate usage of nonverbal communication methods all would improve communication skills in those with AD.

Performance on the KBIT-2 by both groups was also compared. Using the final samples (after exclusionary criteria applied to sample) those in the AD group had a statistically significant higher KBIT-2 full scores and verbal IQ scores. According to the *DSM-IV TR* individuals with AD often have average to above average intelligence so this finding is not without precedent (APA, 2000). It is possible that their higher overall KBIT-2 scores and their verbal IQ scores influenced their performance on the test. Loveland et al. (1997) found that the ability of young adults with autism to perceive verbal and nonverbal emotions depended primarily on cognitive abilities rather than diagnosis. In their study the main influence was the cognitive capacity aspect rather than the Autism diagnosis. This finding was supported by other research using the dichotic listening task to identify emotions, where those with high-functioning autism performed similarly to typically developing controls and scored similarly on intelligence measures (Baker, Montgomery, Abramson, 2010). Based on the results of these previous studies, and the higher verbal and overall intelligence levels of the AD group in the current study, it is likely their intelligence level affected the ability to see differences on performance of the dichotic listening task.

Correlations between group performance on the KBIT-2 (overall, verbal and nonverbal) and their accuracy identifying specified tones were also examined. Pearson correlation coefficients revealed a statistically significant negative relationship between left hemisphere (right ear) and sincere tones in the AD group. As participants' nonverbal IQ increased their accuracy identifying sincere tones with their right ear decreased; as their nonverbal IQ decreased their sarcasm identification increased. This was the only significant relationship found in either group.

This thesis attempted to extend research into language processing of sarcasm utilizing a validated tool, the dichotic listening task, to a group that had previously had not been tested using this medium. One important conclusion can be made from this study concerning the use of this task. This study found that participants had no problem understanding the task and performed at a relatively equal level to their typically developing counterparts. This is important because although no significant differences between the two groups performance occurred, this study provided evidence the task can be used in the future with this population. With a larger sample size it is possible that there would have been significant difference between the two samples and make it more valuable in future AD research.

Limitations

The lack of empirical support for three hypotheses revealed several shortcomings of the current study as well point out areas that can be improved upon in future studies.

The first shortcoming of this study was the small sample size of the AD group. The sample size of 9 severely decreased the power of the study and limits the confidence in the conclusions of this study. Although the sample size was extremely small making exclusion criteria less restrictive would not be an effective method of increasing sample sizes. This would introduce more unaccounted variance and further weaken conclusions. The only way to increase the sample size would be to increase recruitment parameters to different groups, over larger areas and time to collect data.

One reason for this small sample size is because it was extremely difficult to reach and recruit participants with AD to participate in this experiment. Recruitment efforts focused mainly on local colleges and universities. This recruitment method was used because it was an effective means of ensuring that those in both groups had relatively equal education levels.

Recruiting from colleges limited the amount of more severely impaired individuals with AD because the severity of their condition would likely impede their ability to successfully progress to college level education. Therefore, recruiting from colleges was used to attempt to decrease the likelihood of lower intelligence levels being a confounding variable. Unfortunately, this method was not as effective as anticipated. Although several universities were contacted through their disability services departments, potential participants were either not informed or did not want to participate.

Second, the disparity in sample sizes between the typically developing and AD groups is another limitation of this study. This is problematic because it is likely that the larger sample size of the typically developing group produced a more representative picture of this sample while the AD group may not be as representative of a sample. This is especially important on a task such as the dichotic listening task where multiple trials are needed to get an accurate mean performance. Therefore, those in the AD group may have been affected by outliers and not be the best representation of the sample. This makes comparisons between the two unequal sized groups more difficult and conclusions less clear.

The third shortcoming of this study was that those in the AD group had multiple diagnoses and were taking multiple medications. The presence of multiple psychiatric disorders made it more difficult to conclude definitively it was their AD diagnosis rather than another disorder that could have affected performance on the dichotic listening task. The disorders present in the AD group included- depression, anxiety, OCD, and ADHD. These disorders affect how the participants process their environment and may have affected performance on the dichotic listening task. Additionally, it is possible the medications taken by participants in the AD group affected their ability to complete the dichotic listening task. Several of these

medications have unintended side effects which can affect cognitive and affective processes which could have affected their performance. Ideally, participants would be excluded if they had comorbid psychiatric diagnoses or were taking specific psychiatric medications to control these confounding variables. In the current study this was not possible because it would have further decreased the size of the already small AD group.

Fourth, the majority of participants were recruited from a program designed for individuals with ASD where services (tutoring, social groups, residential, etc.) are provided to aid them in their college experience. This extra assistance and supportive community may have improved their ability to socialize and recognize sarcasm. These improved social skills and ability to recognize sarcasm may be different from other individuals with AD and decrease generalizability of these findings.

Fifth, some measurement error could have been introduced by using two experimenters to collect data. The principal investigator was a graduate psychology student but an undergraduate research assistant was also used to collect data in the typically developing group. It is possible that the two experimenters explained tasks differently and or administered aspects of the experiment differently. The primary investigator attempted to reduce this possibility by giving the undergraduate research assistant a script to follow as well as training prior to data collection.

Future Directions

The exclusionary criteria, although effective in the current study, can be improved upon in future studies. These criteria were successful in limiting the number of confounding variables such as handedness, intelligence levels and health concerns. However, these exclusion criteria should definitely become more sophisticated to limit confounding variables. Including specific

medications and diagnoses as exclusionary criteria will provide a clearer picture of how AD alone affected performance on the dichotic listening task.

Second, expanding how perceived accuracy is measured may provide more insight to sarcasm processing and perceived ability. In the typically developing group it was shown that participants were able to correctly predict their accuracy identifying sarcasm with their left ear and sincerity with their right ear. Even though participants were not asked to predict how each ear did separately it is interesting that statistical analysis showed agreement between their perceived ability and true ability to identify target tones. Future studies could ask participants to focus on the ability of each ear to identify both tones to support the results of the current study.

Third, including other measures of right hemisphere (RH) functioning may be necessary to further correlate AD with right hemisphere damage. The lack of statistically significant differences between groups on identification of tones on the dichotic listening task decreases the ability to conclude any relationship between hemispheric functioning and AD symptomatology. Therefore, to make a stronger connection between RH functioning and AD, using a battery of cognitive and neuropsychological measures of RH functioning would be beneficial.

Fourth, inclusion of a sarcasm comprehension measure will increase the value of using a dichotic listening task. Previous research examining those with ASD using dichotic listening tasks included screening task that assessed their ability to understand their target phrases or words (Baker, Montgomery & Abramson, 2010). Baker, Montgomery and Abramson (2010) examined individuals with high-functioning Autism ability to recognize four emotions. In this study they included a brief measure asking participants to define these emotions prior to beginning the dichotic listening task. Inclusion of a similar task that would ask individuals to define sarcasm could be beneficial.

Fifth, inclusion of other measures that examine participants' abilities to recognize sarcasm and thoughts of others correctly could be beneficial. Previous research has shown The Strange Stories test was an effective tool to measure the ability to identify sarcasm in AD (Jolliffe & Baron-Cohen, 1999). Using previously proven measures of sarcasm comprehension with the dichotic listening task would likely provide a more comprehensive understanding of sarcasm comprehension in AD. The use of these proven methods of sarcasm comprehension in AD with the dichotic listening task could provide convergent validity if the measures are found to be positively correlated. The Strange Stories test would also be interesting to compare to the dichotic listening task because it is a visual task. The differences in ability to recognize sarcasm in these two forms, visual (reading the scenario and text bubbles) and auditory, may identify specific pathways that are affected more than others. Theory of Mind (ToM) tests could also be a helpful measure to include. These measure the ability of someone to gauge what others are thinking. This ability to perceive others' thoughts and intentions are crucial to social interaction, non-verbal communication and interpreting sarcasm. Inclusion of other tests of sarcasm comprehension and ToM measures into a battery of tests could provide better insight into communication issues in AD.

Sixth, inclusion of measures of sarcasm that involve visual rather than auditory comprehension. The dichotic listening task only utilizes auditory processing of information and therefore may be missing the aspect of environmental processing where the problem may be. Previous research has shown that individuals with ASD have trouble identifying emotions visually using chimeric facial tasks and other visual markers of emotion (Ashwin, Wheelwright, Baron-Cohen, 2005; Uchiyama, Seki, Kageyama, Saito, Koeda, et al., 2006). This is very important in sarcasm comprehension because one must recognize the disparity between the

literal meaning of communication and the intended message. Cues include nonverbal information such as facial expression, gestures and environmental cues. Inclusion of a visual recording of individuals being sarcastic and sincere may offer an interesting way to measure the role visual information is used by those with AD. As stated above the Strange Stories Test relies on visual processing of information to identify sarcasm and this could provide more insight into other sensory methods of processing sarcasm. The current study was not able to find a difference between typically developing individuals and those with AD on the auditory task alone; inclusion of visual tests of sarcasm comprehension may reveal more about how those with AD process sarcasm.

Conclusions

The current study was only able to find marginal support for the hypothesis that those with AD did not have a LE/RH advantage for sarcasm identification. However, this finding is inconclusive because no significant hemispheric advantage was found for sarcasm identification in the AD group. Although in the literature there appears to be a link between RH dysfunction and the inability comprehend sarcasm in AD the current study was not able to find this connection in the sample examined. Participants in the AD group performed similarly to typically developing participants identifying sarcasm and sincere tones. This lack of support for these previously established norms of hemispheric dominance for sarcasm identification is particularly problematic. This implies flaws in either the version of the dichotic listening task used in this study or the samples. One explanation for the lack of differences between samples on the dichotic listening task would be the AD group having higher overall KBIT-2 and verbal intelligence levels. In either case, this further hampers making any firm conclusions based on this data. The main limitation of this study was the small AD sample size. This limited sample

size decreased power severely and limited the ability to make empirically supported conclusive statements about the results of this study.

This thesis did find some interesting group differences for perceived accuracy and actual accuracy on the dichotic listening task. Typically developing participants showed agreement between their perceived and actual abilities to identify sincere tones with their LE/RH and sarcastic tones with their RE/LH. Those in the AD group did not have this insight into their ability. This lack of insight into their ability to identify sarcasm may lead to better understanding the symptoms of abnormal social interaction seen in AD.

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Appendix

Critical Phrases from Voyer et al. (2008) study

“Tell me about it.”

“Thanks a lot.”

“That worked well.”

“That’s just great.”

“Wasn’t that fun?”

“What a great day.”

“You’re a big help.”

“Aren’t you smart?”

“Aren’t you special?”

“Isn’t this exciting?”

“Isn’t she friendly?”

“Nice outfit”

CONSENT FORM

The Role of the Right Hemisphere in Processing of Sarcasm in Asperger's Disorder

Purpose of Study

The purpose of this is to clarify the role of the right hemisphere in processing sarcasm. Previous research has shown that the right hemisphere plays a role in interpreting sarcasm in typically developing individuals. The present study will attempt to extend this research into individuals with Asperger's Disorder. A better understanding of how this population processes sarcastic language will help clarify the causes for communication and social deficits seen in this population as well provide a potential target for treatment to help this population.

Inclusion/Exclusion Criteria

To participate in this study you must be between the ages of 18-24, be right handed, have a minimum of a high school education (or equivalent) and English must be your first and primary language. Participants are being recruited from Ball State University's Psychological Science Subject pool and from local autism support groups. If you identify as having Asperger's Disorder this diagnosis must be made by a Medical Doctor or a licensed psychologist.

Participation Procedure and Duration

If you choose to participate you will complete a health questionnaire, a dichotic listening task, the Edinburgh Handedness Inventory, and a brief standardized intelligence measure. The health questionnaire will ask you questions about your physical and psychological health. For the dichotic listening task you will listen to spoken phrases through headphones and then identify which ear heard a particular phrase. The intelligence measure will be the Kaufman Brief Intelligence Test, second edition. This is a brief standardized assessment of intelligence which will take approximately twenty minutes to complete. The full participation time will be approximately 45 minutes to an hour and a half.

Data Anonymity

All information obtained during participation will be anonymous. This means that no personally identifiable information will be associated with the data, and there will be no way of identifying your identity from the data obtained. Data from the dichotic listening task will be kept on the experimenter's password protected laptop. All data from the Health questionnaire, Edinburgh Handedness inventory, KBIT-2 protocol, Perceived Accuracy questionnaire and informed consent will be stored in a locked file. This locked file will only be accessible to those directly involved in the study and be in the faculty supervisor's secure lab space. Signed informed consent will be kept separate from participants' responses.

Data Storage

The laptop and paper data will be stored in a locked file in the faculty supervisor's secure research laboratory. This file will only be accessible by members of the research team. The identification number will be the only information used to identify the participant following the data collection. Informed consent and W4 forms will be kept separate from participants' responses. Members of the research team include the primary investigator, Darren Smucker; research assistant, Samantha Amick; and faculty advisor Thomas Holtgraves.

All data will be kept until the second summer session 2011 for data analysis. Following the second summer session of 2011 the paper data will be shredded and digital information will be transferred from the primary investigators laptop to a password protected flash drive for later data analysis.

Risks or Discomforts

There are no anticipated risks of participating in this study.

Who to contact should you experience any negative effects from participation in this study

Emergency medical treatment is available if you become injured or ill during your participation in this research project. You will be responsible for the costs of any medical care that is provided. It is understood that in the unlikely event of an injury or illness of any kind as a result of your participation in this research project that Ball State University, its agents, and employees will assume whatever responsibility is required by law. If any injury or illness occurs in the course of your participation in this research project, please notify the principal investigator.

Counseling services are available to you through the Counseling Center at Ball State University (765-285-1376) if you develop uncomfortable feelings during your participation in this research project. You will be responsible for the costs of any care that is provided [note: Ball State students may have some or all of these services provided to them at no cost]. It is understood that in the unlikely event that treatment is necessary as a result of your participation in this research project that Ball State University, its agents and employees will assume whatever responsibility is required by law.

Benefits

There is no direct benefit to participants in this study. However, the results of this increase our understanding of communication difficulties in people with Asperger's Disorder.

Compensation

Participants from the Psychological Science Subject Pool will be given one hour of credit for their participation. Participants with a formal diagnosis of Asperger's will receive \$25.00 compensation for their time.

Voluntary Participation

Your participation in this study is completely voluntary and you are free to withdraw your permission at anytime for any reason without penalty or prejudice from the investigator. Please feel free to ask any questions of the investigator before signing this form and at any time during the study

IRB Contact Information

For questions about your rights as a research subject, please contact Director, Office of Research Compliance, Ball State University, Muncie, IN 47306, (765) 285-5070, irb@bsu.edu

If you would like any further information please contact the primary investigator at dmsmucker@bsu.edu.

Title of Study

Role of the Right Hemisphere in Processing Sarcasm in Asperger's Disorder

Consent

I, _____, agree to participate in this research project entitled, "The Role of the Right Hemisphere in Processing Sarcasm in Asperger's Disorder." I have had the study explained to me and my questions have been answered to my satisfaction. I have read the description of this project and give my consent to participate. I understand that I will receive a copy of this informed consent form to keep for future reference.

To the best of my knowledge, I meet the inclusion/exclusion criteria for participation (described on the previous page) in this study.

Participant's Signature

Date

Researcher Contact Information

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Health Survey

Participant Identification Code: _____

The following set of questions is to screen for factors known to affect sensory information processing. Please be as honest as possible. Put a check next to all the following that apply to you.

1. What is your date of birth?

2. Have you ever hit your head and experienced a concussion? Yes No
 If yes, please explain and include the date and number of concussions experienced.

1)Date	How
--------	-----

3. Since birth have you ever had any other medical problems? Yes No
 If yes, please explain.

4. Since birth have you ever been hospitalized? Yes No
 If yes, please explain.

5. Have you had any hearing problems? Yes No
 If yes, please explain.

6. Are you on any medications? Yes No
 If yes, please list them all

7. Do you have now or have you ever had any of the following? Check yes or no.

Neurological disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Brain disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Vascular disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Stroke	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Learning deficiency or disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Reading deficiency or disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Attention-deficit disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Hyperactivity	<input type="checkbox"/> Yes	<input type="checkbox"/> No
Autism Spectrum Disorder	<input type="checkbox"/> Yes	<input type="checkbox"/> No

If you checked yes for any of the items in question 8, please describe your diagnosis briefly.

8. Do you have a formal diagnosis of Asperger's Disorder? Yes No
If yes, when did you receive this diagnosis and was given by a Medical
Doctor or a licensed psychologist?

9. Do you currently have any other formal psychiatric disorder diagnoses?
 Yes No
If you checked yes, please describe your diagnoses

Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column*. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks*. If in any case you are really indifferent, *put a check in both columns*.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
2. Drawing	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
3. Throwing	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
4. Scissors	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
5. Toothbrush	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
6. Knife (without fork)	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
7. Spoon	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
8. Broom (upper hand)	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
9. Striking Match (match)	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
10. Opening box (lid)	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<u>TOTAL(count checks in both columns)</u>	<input type="text"/>	<input type="text"/>

Difference	Cumulative TOTAL	Result
<input type="text"/>	<input type="text"/>	<input type="text"/>

Scoring:

Add up the number of checks in the “Left” and “Right” columns and enter in the “TOTAL” row for each column. Add the left total and the right total and enter in the “Cumulative TOTAL” cell. Subtract the left total from the right total and enter in the “Difference” cell. Divide the “Difference” cell by the “Cumulative TOTAL” cell (round to 2 digits if necessary) and multiply by 100; enter the result in the “Result” cell.

Interpretation (based on Result):

- below -40 = left-handed
- between -40 and +40 = ambidextrous
- above +40 = right-handed

Participant Identification Code _____

Date _____

1. What percentage (0% to 100%) of the time did you accurately identify the source (left or right) of the sincere phrases? _____
2. What percentage (0% to 100%) of the time did you accurately identify the source (left or right) of the sarcastic phrases? _____

Examiner _____