An exploration of sarcasm detection in children with Attention Hyperactivity Deficit
Disorder

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Abstract

The present research explored the ability of children with ADHD to distinguish between sarcasm and sincerity. Twenty-two children with a clinical diagnosis of ADHD were compared with 22 age and verbal IQ matched typically developing children using the Social Inference–Minimal Test from The Awareness of Social Inference Test (TASIT, McDonald, Flanagan, & Rollins, 2002). This test assesses an individual's ability to interpret naturalistic social interactions containing sincerity, simple sarcasm and paradoxical sarcasm. Children with ADHD demonstrated specific deficits in comprehending paradoxical sarcasm and they performed significantly less accurately than the typically developing children. While there were no significant differences between the children with ADHD and the typically developing children in their ability to comprehend sarcasm based on the speaker's intentions and beliefs, the children with ADHD were found to be significantly less accurate when basing their decision on the feelings of the speaker, but also on what the speaker had said. Results are discussed in light of difficulties in their understanding of complex cues of social interactions, and non-literal language being symptomatic of children with a clinical diagnosis of ADHD. The importance of pragmatic language skills in their ability to detect social and emotional information is highlighted.

Keywords: ADHD, Sarcasm, Social interaction, Social deficits, TASIT.

1. Introduction

Attention-Deficit Hyperactivity Disorder (ADHD) is one of the most common mental disorders of childhood, affecting up to 5.29% of children internationally (Polanczyk, de Lima, Horta, Bierderman & Rohde, 2007). The disorder is identified by three cognitive symptoms: inattention, hyperactivity and impulsivity. The inattention subtype is characterised by difficulty sustaining attention, being easily distracted and/or failure to follow instructions or to listen when spoken directly. In contrast, the hyperactive-impulsive subtype is characterised by someone who is in perpetual motion, has trouble waiting his or her turn and/or will often interrupt conversations by blurting out comments at inappropriate times (DSM-5, APA, 2013). While research has traditionally focussed on these cognitive deficits, recent research has emphasised the implicit social difficulties associated with ADHD. For example, children with ADHD are rated lower on cooperation, assertion, self-control and peer-approval, compared to children without ADHD (Kats-Gold & Priel, 2009). They are often rigid in different social situations and unresponsive to social cues (Da Fonseca, Seguier, Santos, Francois & Deruelle, 2009), resulting in up to half of children with a diagnosis of ADHD experiencing peer rejection (Hoza et al., 2005).

1.1. Social Deficits in ADHD

The ability to accurately interpret the intentions and points of view of others is crucial for everyday social interaction. These abilities incorporate a range of skills, from the basic perception of affective prosody, facial expression and body posture, to the more complex skills of understanding others' perspectives ("Theory of Mind", Harris & Pexman, 2003). These understandings underpin more complex competencies including cooperation, assertion, and flexibility, which in turn are learned and honed through experience. As such, early impairments in basic understanding of social cues can act as a negative catalyst, increasing the frequency of negative social interactions (Pelham & Fabiano, 2008), and handicapping

the development of more complex social skills. Further, emotional competence is implicitly endemic in social competence (Kats-Gold & Priel, 2009; Denham et al., 2003). Everyday interactions demand the intuitive integration of all these skills; therefore simple deficits can affect all areas of social functioning.

The precise nature of social deficits in children with ADHD remains elusive, as the majority of research to date has traditionally focussed on the ability to recognise emotions from facial expressions. Past literature has consistently demonstrated deficits in basic facial affect recognition in children with ADHD (Da Fonseca et al., 2009; Yuill & Lyon, 2007; Cadesky, Mota & Schachar, 2000; Singh et al., 1998), with deficits appearing to be particularly salient in the recognition of negative emotions (Williams et al., 2008; Pelc, Kornreich, Foisy, & Dan, 2006; Cadesky et al., 2000; Singh et al., 1998). However, the simplicity of the typical research paradigm, where participants match affective labels or stories to facial expressions, is illustrated in the ceiling performance shown by both the ADHD and nonclinical participants (Downs & Smith, 2004). Therefore suggesting the task poorly replicates typical complex social interactions.

The understanding of contextual cues has also been found to be more difficult for children with ADHD compared to typically developing peers. For example, Da Fonseca and colleagues (2009) demonstrated the importance of context on our ability to recognise emotions by asking participants to detect the emotion of masked faces, presented in an array of different visual scenes. Results showed that children with ADHD were worse than the typically developing control children at identifying the correct emotions. In addition, more recent findings have reported children with ADHD to perform less well at recognising cues of emotion compared to children with mild to moderate learning difficulties matched for age and intelligence. Importantly, the task used in this study more closely resembled real emotional expression than conventional static stimuli (Ludlow, Garrood, Lawrence &

Gutierrez, 2014). These results highlight that difficulties in recognising contextual information may also form part of the emotion recognition deficits reported in individuals with ADHD.

1.2. Pragmatic Language Difficulties

Parents and teachers of children with ADHD frequently report children with ADHD to have language problems (Bignell & Cain, 2007; Bishop & Baird, 2001), with as many as half of these children reported as having difficulties with language (Cohen et al., 2000; Tirosh & Cohen, 1998). Furthermore, research findings have revealed that many children with ADHD are delayed in their development of spoken language and self-speech (Berk & Potts, 1991; Rankin et al., 2009).

Pragmatic language difficulties are also well documented in children with ADHD. These difficulties include social and emotional aspects of social exchanges, such as screaming or yelling (Adams, Baxendale, Lloyd, & Aldred, 2005; Martin & McDonald, 2003), in addition to behaviours associated to spoken language, such as topic initiation, the ability to wait one's turn, the amount and fluency of discourse, and the volume and tone of language (Prutting & Kirchner, 1987). Furthermore, receptive pragmatic deficits in ADHD have been characterised by overly literal language comprehension, unusual emotional interpretations, and trouble understanding humour. Regarding expressive pragmatics, reported problems have included the use of facial expressions and gestures, difficulty in making and maintaining conversation, lack of prosody, and difficulties with the use of pronouns (Staikova, Gomes, Tartter, McCabe, & Halperin, 2013; Geurts & Embrechts, 2008; Lord, Rutter, & LeCouteur, 1994).

The importance of pragmatic ability for social understanding in children with ADHD has been illustrated by Leonard, Milich and Lorch (2011), who investigated the relationship between pragmatic language ability, as assessed by the Children's Communication Checklist

(Bishop, 1998), and levels of hyperactivity and inattention. Their results found that the significant relationship between the levels of hyperactivity and deficits in social skills was fully mediated by pragmatic language ability. However, pragmatic language ability only partially mediated the relationship between levels of inattention and deficits in social skills. In addition, children with ADHD have been shown to score higher on ratings of pragmatic deficits and social difficulties compared with typically developing children (Bishop & Baird, 2001), but have been found to be more similar to children with Autism Spectrum Disorder (ASD), in showing more problems with pragmatics compared to their structural language (Geurts & Embrechts, 2008; Geurts et al., 2004).

1.3. Conversational Inference

Real-life interactions are embedded in a context that requires the interpretation of social information. Indeed, findings have shown that situational/contextual cues can be more helpful when judging emotional information than facial expressions alone (Kolb, Wilson & Taylor, 1992; Barrett, Lindquist & Gendron, 2007). Successful social interactions also require the understanding of non-literal language. For example, verbal irony and sarcasm are often used to either indirectly convey attitudes and beliefs, or for the purposes of generating humour (Harris & Pexman, 2003; Pexman et al., 2011).

While in most situations there is concordance between linguistic and affective prosody (e.g., sad words are paired with sad language), there are situations where they differ. The differentiation of sarcasm and sincerity provides a good example of this, and thus provides a pertinent insight into the comprehension of affective prosody. In addition, affective prosody provides important contextual cues during social interactions, since facial expressions are rarely encountered in isolation without verbal cues of affect. Affective prosody can also aid in recognising emotional states using suprasegmental vocal modulations

such as intonation and stress (Banse & Scherer, 1996; Grandjean, Banziger, & Scherer, 2006). Indeed, research has shown children with ADHD to have problems in processing affective prosody. For example, Shapiro, Hughes, August and Bloomquist (1993) found children with ADHD to be less accurate than typically developing children at matching affective prosody to affective facial expressions. Corbett and Glidden (2000) also found that participants with ADHD to show poorer performance than typically developing children at labelling the affective tone of semantically neutral statements. Such findings support the assertion that deficits in affective processing extend to prosodic indicators of affect (Shapiro et al., 1993).

1.4. Sarcasm and Social Communication

Sarcasm is a type of ironic speech where implied criticism is expressed via contextual or paralinguistic cues (Rankin et al., 2009). Its role in social exchanges is to increase the theatrics of the delivery (McDonald, 1999), while at the same time intensifying the politeness of the speaker (Jorgensen, 1996), and dampening the aggression of the critical comment (Dews & Winner, 1995; Rankin et al., 2009). Sarcastic speech is often characterised by a specific paralinguistic profile, which is important in signalling to the listener to avoid the interpretation of the utterance as sincere. In addition, the paralinguistic profile can also include an increased span and amplitude of voice frequency and more resounding stress; as well as non-acoustic features such as reducing the intensity of one's facial expression (Anolli, Ciceri, & Infantino, 2000; Rockwell, 2007).

As sarcasm is a type of social cue, it is possible that children with ADHD might have difficulty in distinguishing between sarcasm and sincerity. This may be due to problems in their general ability to identify cues of emotion. However, it may also be related to more cognitive deficits such as slower information processing speed, reduced verbal and nonverbal new learning, and poorer working memory (McDonald et al., 2006). Importantly, there is

evidence that a range of clinical populations with known social difficulties in identifying others' emotions and language deficits typically struggle to understand sarcasm. For example, individuals with autism, schizophrenia, fronto-temporal dementia, frontal lobe deficits and traumatic brain injury, have all been shown to have problems in identifying sarcasm from contextual cues (Mathersul, McDonald & Rushby, 2013; Kosmidis, Aretouli, Bozikas, Giannakou, & Ioannidis, 2008, Kipps, Nestor, Acosta-Cabronero, Arnold, & Hodges, 2009; McDonald & Pearce, 1996; McDonald, 1992). Taken together, the prevalence of ADHD and its negative effect on social interactions provides a compelling argument for addressing and understanding social deficits in this population further.

1.5. The current study

This study aimed to assess the ability of children with ADHD to recognise sincerity and sarcasm using The Awareness of Social Inference Test (TASIT, McDonald, Flanagan, & Rollins, 2002), a videotape-based measure designed to assess social perception with interpersonal vignettes reflecting everyday expressions. The test consists of three kinds of exchanges: sincere, where the speaker means what he/she says; sarcastic, where the same ambiguous script is enacted in such a way that it is clear the speaker is meaning something quite different to that literally asserted; and paradoxical sarcasm, where the script literally makes no sense unless it is assumed one speaker is being sarcastic (McDonald, 2012).

To our knowledge this is the first study to address sarcasm detection using the TASIT in an ADHD population. More specifically this study addresses three questions: 1. Do children diagnosed with ADHD show problems in their understanding of sarcasm? 2. If so, are the differences in their understanding of sarcasm dependent on the speakers' actions, their speech, thoughts, and/or feelings? 3. Can individual symptoms of ADHD predict the ability to identify sarcasm? It was hypothesised that the children with ADHD would show deficits across both paradoxical and sarcastic conditions, the only two exchanges requiring an

understanding of non-literal language. In addition, based on evidence suggesting that children with ADHD often struggle in their understanding of others feelings and also have difficulties with their use of pragmatic language, it was expected that children with ADHD would show more difficulties in identifying sarcasm based on what the speakers intended to say, and also based on the speakers' thoughts and feelings. Finally, given previous research has established a link between hyperactivity and social skills, it was predicted that children with higher levels of hyperactivity would be the children who may show the most deficits in their understanding of sarcasm.

2. Method and Materials

2.1. Participants

Twenty-two children (15 males, 7 females), aged between 11.3 and 15 years (M=12.9 years, SD=1.13) with a clinical diagnosis of ADHD took part in the study. Participants were recruited from three schools located in Greater London, the South East of England and the West Midlands in the UK. Each of these schools specialises in working with children with social, emotional and mental health (SEMH) difficulties. Participants were also recruited through adverts placed on ADHD support forums. In order to participate in the study, all participants were required to have a formal clinical diagnosis of ADHD and no known comorbid clinical diagnosis of either an autism spectrum disorder or an emotion/disruptive behaviour disorder. One participant had an official diagnosis of hyperactive/impulsive subtype, 1 participant had the inattentive subtype and the remaining 20 participants had a diagnosis of the combined ADHD subtype. Both the participating schools and the parents of each child taking part were required to confirm any official diagnosis. All participants were taking prescribed medication for their ADHD symptoms.

A control group was carefully selected based on age of the children with ADHD and were recruited from two different mainstream schools. The control group included 22 typically developing children from 11.5 to 15 years (M=11.8, SD=1.5), and had no known diagnosis of any clinical disorder. The resulting groups were matched for gender, chronological age and receptive language ability.

2.2. Measures

2.2.1. British Picture Vocabulary Scale-III (BPVS-III)

Receptive language ability was assessed using the British Picture Vocabulary Scale III (BPVS-III, Dunn, Dunn, Styles, & Sewell, 2009). In this test the child is asked to identify one of four pictures that best depicts the meaning of the word said by the administrator. The scores are then standardised according to the age and gender of the child to provide a measure of the child's verbal ability. This measure was used to match the children with ADHD with a group of typically developing children with similar levels of receptive language ability. This matching was done to ensure that any differences in performance across the sarcasm task could not be accounted for simply by any differences in receptive language ability.

2.2.2. Conners' 3rd Edition-self-report

The children completed the Conners' self-report short rating scales, a standardised assessment of ADHD symptoms, suitable for administration to clinical and non-clinical samples. The self-report measure is appropriate for children and adolescents between 8-18 years of age. The short version was used, which consists of 39 questions in 5 key areas of interest: inattention; hyperactivity and impulsivity; learning problems; aggression and family relations. Each question consists of a statement such as 'I blurt out the first thing that I think of' or 'I struggle to complete hard tasks'. Participants respond on a 4-point Likert scale

where 1 indicates the person completely disagrees with the statement and a 4 indicates the person completely agrees with the statement. Responses were scored according to the 5 subscales of interest and transformed into standardised T-scores to compare between participants, and to differentiate between typical and atypical behaviours. T-scores above 65 indicate scores elevated above typically reported concerns (Conners, 2008). The use of self-reports are often recommended to be used once children have reached a certain age and level of cognitive development (Galloway & Newman, 2017). For ADHD symptoms, children and adolescent self-report questionnaires have been shown to be a reliable measure in distinguishing between groups with and without ADHD symptoms (Cheung et al., 2015). Therefore in the current study, the use of the self-report measure provided a comparison of ADHD symptoms between the ADHD and the typically developing children.

2.2.3. Conners' 3rd Edition-parent-report

Parents completed the Conners' Parent-Rating Full length Scale (Conners, 2008) for the ADHD children, in order to confirm that all children reached the clinical level of symptoms required for a diagnosis of ADHD. Due to the fact the ratings of parents on this specific measure will often form part of a clinical diagnosis for a child with ADHD, only parents of children who already had a clinical diagnosis were invited to complete the parent's ratings. The parents' report provides an evaluation of the key areas of *inattention* (likely to be inattentive, organisational problems and problems finishing tasks); *hyperactivity and impulsivity* (inability to sit still, feel restless and impulsive behaviour); *learning problems* (struggling with schools based tasks); *executive functioning* (difficulties in planning, prioritising and organising); *aggression* (difficulty in regulating their own emotions and prone to become irritable and angry easily); *peer relations* (difficulty making and sustaining friendships). The parent circles a number on a 4-point Likert scale ranging from 0 to 3 for

each statement, with a 0 representing 'in the past month, this was not true at all about my child / It never happened' and a 3 representing 'in the past month, this was very much true about my child / It happened very often. Responses were scored according to the 5 subscales of interest and transformed into standardised T-scores. As with the self-report, T-scores over 65 indicate above typical reported concerns (Conners, 2008).

2.2.4. The Social Inference-Minimal Test (Part 2) of the TASIT

Sarcasm recognition was measured using part 2 of The Awareness of Social Inference Test (TASIT), which comprises videotaped vignettes of everyday social interactions (McDonald, Flanagan & Rollins, 2002). This test assesses participants' understanding of conversational meanings that are determined by paralinguistic cues. It comprises 15 short, (15-60 seconds) vignettes that contain dialogues between two trained actors, conveying either a sincere or sarcastic exchange .Each of the vignettes was scored as 1 (correct) or 0 (incorrect) for identifying what the actor was doing, saying, thinking and feeling, producing a maximum possible score of 60 (a maximum total score of 4 for each vignette). The scores can also be subdivided into three subscales corresponding to each type of exchange (sincere, simple sarcasm and paradoxical sarcasm). These vignettes test one's ability to perceive information that is implied rather than has been directly stated. It requires the person watching the vignettes to distinguish sarcastic inference based on the appearance and overall manner of the actors, such as their facial expression, gestures or tone of voice. For the sincere and simple sarcasm conditions the content of the verbal script could be similar in content. For example, "I'd be happy to do it. I've got plenty of time" could be used as a script for each type. However, in the sincere verbal exchanges (five vignettes) the directed speakers mean what they are saying, i.e., the words spoken and the paralinguistic cues are consistent, so the person is saying what the person means. Using the example script provided above, the correct

interpretation for the sincere condition would be that the person was happy to help and felt they had the time. In contrast, for the simple sarcasm exchanges (five vignettes) one of the actors is being sarcastic (the literal meaning is different to the actual message the speaker is trying to express) but this can only be determined by reading the paralinguistic cues, such as facial expression, prosody of the voice and posture of the body and hand, to identify the overall meaning of the speaker. Therefore, using the same example script as before, for the simple sarcasm condition the speaker may convey the same verbal content but would use exaggerated facial, body and vocal language to show they meant the opposite (Rankin et al., 2009). Finally, in the paradoxical sarcasm exchanges (five vignettes) the dialogue between the two actors does not make sense unless sarcasm is recognised. If the actor is not identified as being sarcastic, it is more difficult to determine the speaker's intentions (examples of the actual script used for a sincere, simple sarcasm and paradoxical sarcasm exchange are shown in Table 1).

Table 1: Examples of sincere and sarcasm exchanges from the TASIT*

Sincere / Simple sarcasm Exchange (depending on paralinguistic cues)	*Micheal: Sorry I can't take that class I said I'd take on Friday.* *Ruth: That's ok, I know you're busy. Don't worry about it.*
Paradoxical Sarcastic Exchange	*Gary: Are you sure you've got your passport?* *Keith (sarcastically): Oh, yes I tore it up and threw it away.* *Gary: Good, that's Ok then*

* Taken from (McDonald, Flanagan, Rollins, & Kinch, 2003)

2.3. Procedure

Full ethical approval was obtained from the ethics committees of both the University of Birmingham and the University of Hertfordshire, and all procedures outlined by the British Psychological Society (BPS) were followed. Written consent was obtained from the parent

and/or guardian. In addition, written and verbal consent were gained for each participant. All

participants were tested separately in a classroom at their own school. All participants

completed the BPVS first, followed by the Conners' self-rating scales, and finally the TASIT.

Before completing the TASIT, participants were explained that they will watch a series of

videos and they will have to answer a series of statements about each one of them. The

statements of each video included descriptions of the actor's specific intentions ('do' probes),

what the actor wanted to verbally convey ('say' probes), what the actor was thinking ('think'

probes), and the emotional state of actor ('feel' probes). An example of a question a

participant would receive based on what the speaker wanted to convey; 'Is she trying to say

she wanted to go out that night?' or based of what the speaker felt 'Is she happy to cancel?'

Each statement was answered via a YES/NO response card. At the beginning of the task there

was a practice item to allow the participants to familiarise themselves with the task. The

answers determine whether the viewer was able to understand the meaning and intentions of

the different exchanges.

2.4. Analysis

Scores of each of the 5 subscales of the Conners self-rating scales were also analysed

with a repeated measures analysis of variance, with a 2 (Group: ADHD vs. Typically

developing between-participants factor) x 5 (Conners: inattention vs. hyperactivity /

impulsivity vs. learning problems vs. aggression vs. family relations, within-participants

factor) mixed factor design. The correct identification of the 3 types of sarcasm presented in

the TASIT test was analysed using repeated measures analysis of variance, with a 2 (Group:

ADHD vs. Typically developing between-participants factor) x 3 (Sarcasm: Sincere vs.

Simple vs. Paradoxical, within-participants factor) x 4 (Probe: Do vs. Say vs. Think vs. Feel,

within-participants factor) mixed factor design. Multiple Regressions were also carried out

using each of the 5 subscales of the Conners self-rating scale, BPVS scores and chronological age as predictors of the 3 types of sarcasm.

3. Results

3.1. Group matching criteria

An independent samples t-test confirmed no significant difference in chronological age between groups, $t(42)= .29$, $p= .77$). The groups were also matched on verbal ability using the standard scores of the BPVS-III (Dunn et al., 2009). Again, results revealed no significant differences between the groups, $t(42)= 1.57$, $p= .12$.

3.1.2. Conners ratings of ADHD symptoms

To confirm there were differences in ADHD symptoms between the two groups of children, the five scales of the Conners self-report were analysed with a repeated measures analysis of variance, with a 2 (Group, between-participants) x 5 (rating scale, within-participants) mixed design. Results of this analysis revealed a significant main effect of Group, $F(1, 42)= 125.77$, $p<.001$. $\eta^2=.75$. A significant main effect of rating scale was also present, $F(4, 168)= 2.64$, $p=.04$, $\eta^2= .06$, as well as a significant Group x Rating scale interaction, $F(4, 168)= 6.95$, $p<.001$, $\eta^2= .14$. Further analysis of this interaction using Bonferroni corrections, revealed significant differences between the groups on the scales of inattention, hyperactivity/impulsivity, learning problems, and aggression (all $t(42) > 3.56$, all $p< .001$). Means for each group across the different ADHD scales are shown alongside the matching criteria in table 2.

Table 2. Mean and Standard Deviations for Group Matching Criteria, and Conners' Rating Scales

	Typically developing children				ADHD children			
	Mean	SD	Min	Max	Mean	SD	Min	Max

Matching Criteria								
BPVS	95.05	11.64	75	115	90.18	8.68	70	108
Age in Months	154.36	12.92	135	176	155.73	17.74	123	186
Conners' Self Rating								
Inattention	47.64	4.80	40	58	74.59	12.08	40	90
Hyperactivity/Impulsivity	47.95	4.27	40	54	67.95	9.59	46	85
Learning Problems	47.00	8.72	40	69	66.41	13.6	40	90
Aggression	53.45	12.08	42	77	68.18	15.19	49	90
Family Relations	52.05	12.82	42	89	57.18	8.52	42	74
Conners' Parents Ratings								
Inattention					70.92	16.40	52	90
Hyperactivity					77.04	17.99	44	90
Learning					70.00	15.38	45	90
Executive Function					66.58	14.06	43	90
Aggression					68.77	18.66	45	90
Peer relations					76.81	15.69	48	90

3.1.3. Performance across the three types of sarcasm and their different probes

Analyses were first carried out in order to address whether children with ADHD would be poorer in their identification of sarcastic exchanges than the typically developing children. They were also carried out to determine whether the children with ADHD would be poorer at identifying sarcasm regardless of their answer being based on what the actor was doing, saying, thinking or feeling. Means and standard deviations across these measures are shown in Table 3.

Table 3. Mean and Standard Deviations of the TASIT Sarcasm Scores and TASIT probe questions by Group

		Typically developing children				ADHD children			
		Mean	SD	Min	Max	Mean	SD	Min	Max
TASIT									
Do	Sincere	4.09	0.61	3.00	5.00	4.23	0.69	3.00	5.00
	Simple	3.50	0.59	2.00	5.00	3.31	0.78	2.00	5.00
	Paradoxical	3.14	0.63	2.00	4.00	2.68	0.89	1.00	4.00
	Total	3.58	0.47	2.67	4.33	3.41	0.60	2.00	4.67
Say	Sincere	4.09	0.61	3.00	5.00	4.18	0.79	2.00	5.00
	Simple	3.23	0.61	2.00	4.00	2.32	1.21	0.00	5.00
	Paradoxical	3.18	0.73	2.00	4.00	1.55	1.05	0.00	4.00

		M	SD	Min	Max	M	SD	Min	Max
	Total	3.50	0.43	2.67	4.33	2.68	0.69	1.67	4.33
Feel	Sincere	3.86	0.56	3.00	5.00	4.40	0.59	3.00	5.00
	Simple	3.554	0.59	3.00	5.00	3.14	0.88	2.00	5.00
	Paradoxical	3.18	0.39	3.00	4.00	2.41	0.91	0.00	4.00
	Total	3.53	0.38	3.00	4.33	3.32	0.62	2.00	4.67
Think	Sincere	3.86	0.63	3.00	5.00	4.04	0.65	3.00	5.00
	Simple	3.36	0.65	2.00	5.00	3.14	1.12	1.00	5.00
	Paradoxical	3.00	0.69	1.00	4.00	2.59	1.05	1.00	4.00
	Total	3.41	0.51	1.67	4.67	3.26	0.78	1.67	4.67
Total	Sincere	3.98	0.39	3.00	4.50	4.22	0.45	3.25	5.00
	Simple	3.41	0.38	2.75	4.25	2.98	0.81	2.00	4.75
	Paradoxical	3.13	0.35	2.50	3.75	2.31	0.79	0.75	3.75

A repeated measures analysis of variance with a 2 (Group, between participants) x 3 (Sarcasm, within participants) x 4 (Probes, within participants), revealed a significant main effect of Group, $F(1, 42)= 5.56$, $p= .02$, $\eta^2= .12$, with the ADHD group showing poorer performance in their overall identification of the exchanges ($M_{Typically\ developing}= 3.50$, $SD= .32$; $M_{ADHD}= 3.17$, $SD= .59$). The main effect of Sarcasm was significant, $F(2, 84)=155.47$, $p< .001$, $\eta^2= .79$. Analysis using Bonferroni corrections ($p< .016$) revealed the sincere exchanges were recognised significantly more often than simple sarcasm, $t(43)= 8.95$, $p< .001$; and paradoxical sarcasm, $t(43)= 11.52$, $p< .001$; and simple sarcasm was identified more than paradoxical sarcasm, $t(43)= 7.59$, $p< .001$; $M_{sincere}= 4.10$, $SD= .43$; $M_{simple}= 3.19$, $SD= .66$, $M_{Paradoxical}= 2.72$, $SD= .73$. Results also revealed a significant main effect for the type of Probe, $F(3, 126)= 9.57$, $p< .001$, $\eta^2= .18$. Analysis using Bonferroni corrections ($p< .008$) revealed that more exchanges were identified with use of 'do' probes compared to the 'say' probes, $t(43)= 4.21$, $p< .001$; and more exchanges were identified with the use of the 'feel' probes compared to 'say' probes, $t(43)= 3.94$, $p< .001$.

There was a significant Group x Sarcasm interaction, $F(2, 84)= 22.60$, $p< .001$, $\eta^2= .35$. Analysis of this interaction using Bonferroni corrections ($p= .008$) revealed no significant differences between the groups in the sincere exchanges, $t(42)= 1.89$, $p= .07$, or

the simple sarcasm exchanges, $t(42)= 2.26$, $p= .03$. However, there was a significant difference for the paradoxical sarcasm type $t(42)= 4.42$, $p< .001$, with the children with ADHD showing poorer performance. In addition, there was also a significant Probe x Group Interaction, $F(3, 126)= 8.05$, $p< .001$, $\eta^2= .16$. Analysis of this interaction using Bonferroni corrections ($p=. 006$) revealed no significant differences between the groups on the 'do' ($t(42)= 1.02$, $p= .31$), 'think' ($t(42)= .76$, $p= .45$), or 'feel' ($t(42)= 1.37$, $p= .18$) probes. However there was a significant difference in the 'say' probes, with the ADHD group identifying significantly fewer exchanges when asked to identify them based on what the person was saying, $t(42)= 4.69$, $p< .001$.

The Sarcasm x Probe interaction was also significant, $F(6, 252)= 3.58$, $p= .002$, $\eta^2= .08$. Analysis of this interaction using Bonferroni corrections ($p< .004$) revealed that for the four probes, the identification of the sincere exchanges was significantly better than the simple exchanges and the paradoxical exchanges, which also differ significantly (all $p< .001$). Importantly, these effects were qualified by a significant Group x Sarcasm x Probe interaction, $F(6, 252)= 3.16$, $p= .02$, $\eta^2= .06$. Further analysis with Bonferroni corrections ($p= .002$), revealed children with ADHD to show poorer performance compared to controls across the paradoxical sarcasm only when using the 'say' and 'feel' probes.

3.1.4. The relationship between symptoms of ADHD and performance across the TASIT

Multiple regressions were also carried out to address the relationship between ADHD symptomology (inattention; hyperactivity and impulsivity; learning problems; aggression and family relations) and performance across the three subscales (sincere, simple, paradoxical) of the TASIT. For the children with ADHD none of five symptoms were found to be predictors of sincere, $R^2= .22$, $F(5, 21)= .92$, $MSE= 3.23$, $p= .49$; or paradoxical sarcasm, $R^2= .32$, $F(5, 21)= 1.53$, $MSE= 8.95$, $p= .24$. However for simple sarcasm the overall model was

significant, R^2= .52, $F(5, 21)$= 3.50, MSE= 6.56, p= .03. This analysis also revealed a negative significant effect of aggression, β= -.52, t= -2.81, p= .01.

For the typically developing children no overall model was significant for sincere, R^2= .29, $F(5, 21)$= 1.28, MSE= 2.14, p= .32; simple sarcasm, R^2= .44, $F(5, 21)$= 2.46, MSE= 1.61, p= .08 or paradoxical sarcasm R^2= .36, $F(5, 21)$= 1.79, MSE= 1.96, p= .17.

Given that parents' ratings of ADHD symptoms are often incorporated into the diagnosis process of ADHD, further analysis was also carried out using the parents' ratings on the ADHD content scales for the ADHD children. A multiple linear regression using the five ADHD symptoms (inattention; hyperactivity and impulsivity; learning problems; executive function; aggression and peer relations) as predictors of sincere and simple and paradoxical sarcasm was carried out for the ADHD children. These results also revealed no significant overall model for any of the symptoms as predictors of sincere, R^2= .49, $F(6, 21)$= 2.40, MSE= 2.27, p= .08; simple sarcasm, R^2= .35, $F(6, 21)$= 1.37, MSE= 9.48, p= .29; or paradoxical sarcasm, R^2= .33, $F(6, 21)$= 1.23, MSE= 9.44, p= .34.

3.1.4. Other predictors of performance across the TASIT

Finally, multiple regressions were carried out using BPVS scores and chronological age as predictors of each of the three types of sarcasm, for both the ADHD and typically developing children. Neither the BPVS scores nor chronological age predicted the performance of either group (results are shown in Table 4).

Table 4: Regression coefficients for BPVS and Chronological age as predictors of sarcasm scores.

	Typically Developing Children			ADHD Children		
	Sincere	Simple	Paradoxical	Sincere	Simple	Paradoxical

BPVS (Verbal IQ)	-.001 (.99)	-.009 (.97)	.05 (.83)	.21 (.36)	.32 (.16)	.23 (.32)
Chronological Age	-21 (.38)	.11 (.62)	.13 (.58)	-.02 (. 93)	.11 (.63)	-.13 (.55)

Note: p values are in parentheses

4. Discussion

The current study investigated the ability of children with ADHD to identify complex cues of social interactions. Children with ADHD were found to be less accurate at identifying paradoxical sarcasm compared to the typically developing children. However, when no irony was intended and the verbal content matched the non-verbal content (sincere exchanges), or when it was clear that the speaker meant something different to what was being asserted (simple sarcasm), the children with ADHD performed at similar levels to the typically developing children. The finding of no significant differences between the groups for both these exchanges demonstrates that all of the children were able to perform the basic structure of the task, such as understanding the actors' speech, and following the conversation flow. In contrast, the finding that the ADHD group was significantly poorer at identifying paradoxical sarcasm is congruent with previous research showing deficits of complex social and emotional cues (e.g. Yuill & Lyon, 2007; Cadesky et al., 2000; Da Fonseca et al., 2009).

Although pragmatic language difficulties have commonly been reported in children with ADHD (Adams et al., 2005; Martin & McDonald, 2003), and have been shown to be as extreme as those found in children diagnosed with ASD (Bishop & Baird, 2001), little research to date has addressed specific receptive pragmatic deficits and their role in interpreting complex social interchanges, such as sarcasm. Instead research has tended to focus on more general deficits in receptive pragmatic ability and not those directly related to the understanding of emotions. Deficits in emotion understanding have often been considered

independently, and have typically being tested using a simple emotion face recognition

paradigm (Da Fonseca et al., 2009; Yuill & Lyon, 2007). The resemblance of the TASIT to

everyday social situations highlights difficulties in the ability to recognise social and

contextual cues, and shows that both verbal and non-verbal affect are important for

individuals with ADHD to be able to interpret sarcasm, particularly when there is a mismatch

between what they see and what is being said (McDonald, 1999). Only when the speaker

used exaggerated facial, vocal, and body language to indicate sarcasm, as was the case in the

simple sarcasm condition, the children with ADHD were able to show a similar performance

to the typically developing children.

Importantly, the type of probe question was found to differentiate the ADHD and

typically developing children. While both groups were able to correctly infer sincerity and

sarcasm based on the actions and thoughts of the speaker in each of the vignettes, the children

with ADHD were found to be significantly poorer only when identifying paradoxical sarcasm

based on the discourse and emotional state of the speaker. Being able to understand the

speakers' intentions and beliefs are all characteristic of mentalizing abilities (McDonald &

Flanagaan, 2004), the results are therefore suggestive that the children with ADHD were able

to make some inferences based on the speakers' beliefs but struggled when making

inferences based specifically on speakers' feelings. In addition, the children with ADHD also

showed poorer performance than the typically developing children in their understanding of

what the person was saying, and this may indicate that problems in pragmatic language

ability underlie some of their ability to distinguish between sincerity and sarcasm.

Although most individuals should be able to understand clear, unequivocal social

situations, as illustrated by the control group in our study, the children with ADHD appear to

struggle in their understanding of more ambiguous social situations. While previous findings

have shown the hyperactive component to be a good predictor of deficits in social and

emotional ability (Leonard et al., 2011; Ludlow et al., 2014), none of the key ADHD symptoms (hyperactivity, impulsivity and inattention), as rated by both the children and their parents, predicted their ability to identify sarcasm. While the findings suggest that no individual symptom of ADHD is able to predict which of the children to be most at risk for having problems in their social understanding, it is worth noting that nearly all the children with ADHD included in the current study had a diagnosis of the combined inattentive and hyperactive/impulsive ADHD type. Therefore, future research addressing children with predominantly inattentive type or predominantly hyperactive/impulsive ADHD may be able to determine and/or rule out whether specific symptoms can make children more prone to social deficits.

An important strength of the current study is the inclusion of the TASIT as it involves audiovisual representations of social interactions and it is more ecologically valid than written forms of sarcastic interaction (McDonald, 1999). Furthermore, the TASIT has been shown to correlate with both tasks of social problem solving and emotion recognition (McDonald et al., 2006), and is predictive of real-world difficulties with social interactions (McDonald et al., 2004). However, the forced choice response format of the TASIT may be criticised as being less representative of real-world problems, and thus future research should address freely generated responses in order to build on the ecological validity of the findings from the TASIT.

It should be noted that this is a small-scale study and some caution is necessary in generalizing the results to other children with ADHD, particularly a non-UK based sample or children diagnosed with a difference diagnostic classification system. For example, the children in the current study all had a diagnosis from the UK using the previous DSM-IV criteria (APA, 1994). The criteria for ADHD as outlined in the DSM-IV (1994), has been shown to adopt less stringent criteria to those diagnosed with the European equivalent,

International Classification of Diseases (ICD-10, WHO, 2007). This is important as it has

been shown that prevalence rates can vary by 5% to 1% when using these two different

classification systems (Döpfner, Breuer, Wille, Erhart, & Ravens-Sieberer, 2008), suggesting

that some of the children in the current study may have not reached the threshold for ADHD

when using the ICD-10 criteria. However, the modest sample sizes reflect our rigorous

matching criteria in order to provide closely matched groups, and we have been careful to

select individuals with ADHD who have no other comorbid diagnosis.

There are some limitations of the study that are also important to note. For example,

despite being careful to match the children on receptive verbal ability, this measure may not

have controlled for some of the more common language difficulties found in the ADHD

children. While some studies have found no significant differences in receptive language

abilities of children with ADHD and their typically developing peers (Barkley, DuPaul, &

McMurray, 1990), impairments in oral expressive abilities have often been found on other

standardised measures (Kim & Kaiser, 2000). Another limitation of the current study was the

exclusion of additional language measures to assess different aspects of social

communication (e.g., pragmatics, semantics and syntax), which would help to identify the

aspects of language most predictive of the ability to understand sarcasm.

In summary, the findings demonstrate children with ADHD to be poorer in their

understanding of ambiguous social situations. While the children with ADHD were able to

understand sarcasm when it was clear non-literal meaning was intended, the children

struggled with the more subtle form of sarcasm. The likeness of the task to everyday social

situations is suggestive that deficits in understanding non-literal language may contribute to

some of the deficits in social skills in the ADHD group, and this appears to be independent of

their overall receptive language ability. Future research now needs to concentrate on the

direct relationship between the different types of ADHD (hyperactivity and inattention) and

pragmatic language difficulties, as this may prove crucial in identifying children requiring social skills training, and to adapt it as a potential method of treatment in children and adolescents with ADHD.

5. References

Adams, C., Baxendale, J., Lloyd, J., & Aldred, C. (2005). Pragmatic language impairment: case studies of social and pragmatic language therapy. *Child Language Teaching and Therapy*, *21*(3), 227–250. 10.1191/0265659005ct290oa

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Washington, DC.

Anolli, L., Ciceri, R., & Infantino, M. G. (2000). Irony as a game of implicitness: Acoustic profiles of ironic communication. *Journal of Psycholinguistic Research*, *29*(3), 275–311. 10.1023/A:1005100221723

Banse, R., & Scherer, K. R. (1996). Acoustic profiles in vocal emotion expression. *Journal of Personality and Social Psychology*, *70*(3), 614–636.

Barkley, R. A., DuPaul, G. J., & McMurray, M. B. (1990). Comprehensive evaluation of attention deficit disorder with and without hyperactivity as defined by research criteria. *Journal of consulting and clinical psychology, 58*(6), 775-789. 10.1037/0022-006X.58.6.775

Barrett, L. F., Lindquist, K. A., & Gendron, M. (2007). Language as context for the perception of emotion. *Trends in Cognitive Sciences*, *11*(8), 327–332. 10.1016/j.tics.2007.06.003

Berk, L. E., & Potts, M. K. (1991). Development and functional significance of private speech among attention- deficit hyperactivity disordered and normal boys. *Journal of Abnormal Child Psychology*, *19*(3), 357–377. 10.1007/BF00911237

Bignell, S., & Cain, K. (2007). Pragmatic aspects of communication and language comprehension in groups of children differentiated by teacher ratings of inattention and hyperactivity. *British Journal of Developmental Psychology*, *25*(4), 499–512. 10.1348/026151006X171343

Bishop, D. V., & Baird, G. (2001). Parent and teacher report of pragmatic aspects of communication: use of the children's communication checklist in a clinical setting. *Developmental Medicine and Child Neurology*, *43*(12), 809–818.

Cadesky, E. B., Mota, V. L., & Schachar, R. J. (2000). Beyond words: how do children with ADHD and/or conduct problems process nonverbal information about affect? *Journal of the American Academy of Child and Adolescent Psychiatry*, *39*(9), 1160–1167. 10.1097/00004583-200009000-00016

Cheung, C.H.M., Rijdiik, F., McLoughlin, G., Farone, S.V., Asherson, P., Kuntsi, J. (2015). Childhood predictors of adolescent and young adult outcome in ADHD. *Journal of psychiatric research, 62,* 92-100. 10.1016/j.jpsychires.2015.01.011

Cohen, N. J., Vallance, D. D., Barwick, M., Im, N., Menna, R., Horodezky, N. B., & Isaacson, L. (2000). The interface between ADHD and language impairment: An examination of language, achievement, and cognitive processing. *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*(3), 353-362. 10.1111/1469-7610.00619

Conners, C. K. (1997). *Conners rating scales*. Toronto, Canada: Multi-Health Systems.

Conners, C. K. (2008). *Conners 3rd edition manuals*. Toronto, Canada: Multi-Health Systems.

Corbett, B., & Glidden, H. (2000). Processing affective stimuli in children with attention-deficit hyperactivity disorder. *Child Neuropsychology*, *6*(2), 144–155. 10.1076/chin.6.2.144.7056

Da Fonseca, D., Seguier, V., Santos, A., Poinso, F., & Deruelle, C. (2009). Emotion
Understanding in Children with ADHD. *Child Psychiatry and Human Development*,
40(1), 111–121. 10.1007/s10578-008-0114-9

Denham, S. A., Blair, K. A., DeMulder, E., Levitas, J., Sawyer, K., Auerbach–Major, S., &
Queenan, P. (2003). Preschool emotional competence: Pathway to social
competence?. *Child development, 74*(1), 238-256. 10.1111/1467-8624.00533

Dews, S., & Winner, E. (1995). Muting the Meaning A Social Function of Irony. *Metaphor
and Symbol*, *10*(1), 3–19. 10.1207/s15327868ms1001_2

Döpfner, M., Breuer, D., Wille, N., Erhart, M., Ravens-Sieberer, U. (2008). How often do
children meet ICD-10/DSM-IV criteria of attention deficit-/hyperactivity disorder and
hyperkinetic disorder? Parent-based prevalence rates in a national sample–results of
the BELLA study. E*uropean child & adolescent psychiatry, 17*(1), 59-70.

Downs, A., & Smith, T. (2004). Emotional Understanding, Cooperation, and Social Behavior
in High-Functioning Children with Autism. *Journal of Autism and Developmental
Disorders*, *34*(6), 625–635. 10.1007/s10803-004-5284-0

Dunn, L. M., Dunn, D. M., Styles, B., & Sewell, J. (2009). *The British picture vocabulary
scale*. GL Assessment Limited.

Galloway, H., & Newman, E. (2017). Is there a difference between child self-ratings and
parent proxy-ratings of the quality of life of children with a diagnosis of attention-
deficit hyperactivity disorder (ADHD)? A systematic review of the literature. *ADHD
Attention Deficit and Hyperactivity Disorders*, 1-19.

Geurts, H. M., & Embrechts, M. (2008). Language profiles in ASD, SLI, and ADHD. *Journal
of Autism and Developmental Disorders*, *38*(10), 1931–1943. 10.1007/s10803-008-0587-1

Geurts, H. M., Verté, S., Oosterlaan, J., Roeyers, H., Hartman, C. A., Mulder, E. J., …
Sergeant, J. A. (2004). Can the Children's Communication Checklist differentiate

between children with autism, children with ADHD, and normal controls? *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *45*(8), 1437–1453. 10.1111/j.1469-7610.2004.00850.x

Geurts, H. M., & Embrechts, M. (2008). Language profiles in ASD, SLI, and ADHD. *Journal of Autism and Developmental Disorders, 38*(10), 1931-1943.doi:10.1007/s10803-008-0587-1

Grandjean, D., Bänziger, T., & Scherer, K. R. (2006). Intonation as an interface between language and affect. In *Progress in Brain Research* (Vol. 156, pp. 235–247).

Harris, M., & Pexman, P. M. (2003). Children's Perceptions of the Social Functions of Verbal Irony. *Discourse Processes*, *36*(3), 147–165. 10.1207/S15326950DP3603_1

Hoza, B., Gerdes, A. C., Mrug, S., Hinshaw, S. P., Bukowski, W. M., Gold, J. A., Arnold, L.E., Abikoff, H.B., Conners, C.K., Elliot, G. R., Greenhill, L.L., Hechtman, L., Jensen, P. S., Kraemer, H.C., March, J.S., Newcorn, J.H., Severe, J.B., Swanson, J.M., Vitiello, B., Wells, K.C. & Wigal, T. (2005). Peer-Assessed Outcomes in the Multimodal Treatment Study of Children With Attention Deficit Hyperactivity Disorder. *Journal of Clinical Child & Adolescent Psychology*, *34*(1), 74–86. 10.1207/s15374424jccp3401_7

Jorgensen, J. (1996). The functions of sarcastic irony in speech. *Journal of Pragmatics*, *26*(5), 613–634. 10.1016/0378-2166(95)00067-4

Kats-Gold, I., & Priel, B. (2009). Emotion, understanding, and social skills among boys at risk of attention deficit hyperactivity disorder. *Psychology in the Schools*, *46*(7), 658–678. 10.1002/pits.20406

Kim, O. H., & Kaiser, A. P. (2000). Language characteristics of children with ADHD. *Communication disorders quarterly, 21*(3), 154-165.

Kipps, C. M., Nestor, P. J., Acosta-Cabronero, J., Arnold, R., & Hodges, J. R. (2009). Understanding social dysfunction in the behavioural variant of frontotemporal dementia: the role of emotion and sarcasm processing. *Brain*, *132*(3), 592–603. 10.1093/brain/awn314

Kolb, B., Wilson, B., & Taylor, L. (1992). Developmental changes in the recognition and comprehension of facial expression: Implications for frontal lobe function. *Brain and Cognition*, *20*(1), 74–84. 10.1016/0278-2626(92)90062-Q

Kosmidis, M. H., Aretouli, E., Bozikas, V. P., Giannakou, M., & Ioannidis, P. (2008). Studying social cognition in patients with schizophrenia and patients with frontotemporal dementia: Theory of mind and the perception of sarcasm. *Behavioural Neurology*, *19*(1-2), 65–69. 10.1155/2008/157356

Leonard, M. A., Milich, R., & Lorch, E. P. (2011). The role of pragmatic language use in mediating the relation between hyperactivity and inattention and social skills problems. *Journal of Speech, Language, and Hearing Research: JSLHR*, *54*(2), 567–579. 10.1044/1092-4388(2010/10-0058)

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, *24*(5), 659–685.

Ludlow, A. K., Garrood, A., Lawrence, K., & Gutierrez, R. (2014). Emotion Recognition From Dynamic Emotional Displays in Children With ADHD. *Journal of Social and Clinical Psychology*, *33*(5), 413–427. 10.1521/jscp.2014.33.5.413

Martin, I., & McDonald, S. (2003). Weak coherence, no theory of mind, or executive dysfunction? Solving the puzzle of pragmatic language disorders. *Brain and Language*, *85*(3), 451–466.

Mathersul, D., McDonald, S., & Rushby, J. A. (2013). Automatic facial responses to affective stimuli in high-functioning adults with autism spectrum disorder. *Physiology & Behavior*, *109*, 14–22. 10.1016/j.physbeh.2012.10.008

McDonald, S. (1992). Differential pragmatic language loss after closed head injury: Ability to comprehend conversational implicature. *Applied Psycholinguistics*, *13*(03), 295–312. 10.1017/S0142716400005658

McDonald, S. (1999). Exploring the process of inference generation in sarcasm: A review of normal and clinical studies. *Brain and Language*, *68*(3), 486–506. 10.1006/brln.1999.2124

McDonald, S. (2012). New frontiers in neuropsychological assessment: Assessing social perception using a standardised instrument, The Awareness of Social Inference Test. *Australian Psychologist*, *47*(1), 39–48. 10.1111/j.1742-9544.2011.00054.x

McDonald, S., Bornhofen, C., Shum, D., Long, E., Saunders, C., & Neulinger, K. (2006). Reliability and validity of The Awareness of Social Inference Test (TASIT): a clinical test of social perception. *Disability and rehabilitation, 28*(24), 1529-1542. 10.1080/09638280600646185

McDonald, S., & Flanagan, S. (2004). Social perception deficits after traumatic brain injury: interaction between emotion recognition, mentalizing ability, and social communication. *Neuropsychology, 18*(3), 572-579. 10.1037/0894-4105.18.3.572

McDonald, S., Flanagan, S. and Rollins, J. (2002). *The Awareness of Social Inference Test (TASIT): Manual.* Pearson, London.

McDonald, S., Flanagan, S., Rollins, J., & Kinch, J. (2003). TASIT: A New Clinical Tool for Assessing Social Perception After Traumatic Brain Injury. *The Journal of Head Trauma Rehabilitation*, *18*(3). McDonald, S., & Pearce, S. (1996). Clinical insights

into pragmatic theory: Frontal lobe deficits and sarcasm. *Brain and Language*, *53*(1), 81–104. 10.1006/brln.1996.0038

Pelc, K., Kornreich, C., Foisy, M.-L., & Dan, B. (2006). Recognition of emotional facial expressions in attention-deficit hyperactivity disorder. *Pediatric Neurology*, *35*(2), 93–97. 10.1016/j.pediatrneurol.2006.01.014

Pelham Jr, W. E., & Fabiano, G. A. (2008). Evidence-based psychosocial treatments for attention-deficit/hyperactivity disorder. *Journal of Clinical Child & Adolescent Psychology*, *37*(1), 184–214. 10.1080/15374410701818681

Pexman, P. M., Rostad, K. R., McMorris, C. A., Climie, E. A., Stowkowy, J., & Glenwright, M. R. (2011). Processing of Ironic Language in Children with High-Functioning Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *41*(8), 1097–1112. 10.1007/s10803-010-1131-7

Polanczyk, G., de Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: a systematic review and metaregression analysis. *The American Journal of Psychiatry*, *164*(6), 942–948. 10.1176/ajp.2007.164.6.942

Prutting, C. A., & Kittchner, D. M. (1987). A clinical appraisal of the pragmatic aspects of language. *Journal of Speech and hearing Disorders, 52*(2), 105-119. 10.1044/jshd.5202.105

Rankin, K. P., Salazar, A., Gorno-Tempini, M. L., Sollberger, M., Wilson, S. M., Pavlic, D., Stanley, C. M., Glenn, S.,Weiner, M.W., & Miller, B. L. (2009). Detecting sarcasm from paralinguistic cues: anatomic and cognitive correlates in neurodegenerative disease. *Neuroimage, 47*(4), 2005-2015. 10.1016/j.neuroimage.2009.05.077

Rockwell, P. (2007). Vocal features of conversational sarcasm: A comparison of methods. *Journal of psycholinguistic research, 36*(5), 361-369.

Shapiro, E. G., Hughes, S. J., August, G. J., & Bloomquist, M. L. (1993). Processing of

emotional information in children with attention-deficit hyperactivity disorder.

Developmental Neuropsychology, *9*(3-4), 207–224. 10.1080/87565649309540553

Singh, S. D., Ellis, C. R., Winton, A. S., Singh, N. N., Leung, J. P., & Oswald, D. P. (1998).

Recognition of facial expressions of emotion by children with attention-deficit

hyperactivity disorder. *Behavior Modification*, *22*(2), 128–142.

10.1177/01454455980222002

Staikova, E., Gomes, H., Tartter, V., McCabe, A., & Halperin, J. M. (2013). Pragmatic

deficits and social impairment in children with ADHD. *Journal of Child Psychology*

and Psychiatry, 54(12), 1275-1283. 10.1111/jcpp.12082

Szatmari, P., Bartolucci, G., Bremner, R., Bond, S., & Rich, S. (1989). A follow-up study of

high-functioning autistic children. *Journal of Autism and Developmental Disorders*,

19(2), 213–225.

Tirosh, E., & Cohen, A. (1998). Language deficit with attention-deficit disorder: A prevalent

comorbidity. *Journal of Child Neurology, 13*(10), 493-497.

10.1177/088307389801301005

Williams, L. M., Hermens, D. F., Palmer, D., Kohn, M., Clarke, S., Keage, H., Clarke, S.,

Keage, H., Clark, R.C & Gordon, E. (2008). Misinterpreting emotional expressions in

attention-deficit/hyperactivity disorder: evidence for a neural marker and stimulant

effects. *Biological Psychiatry*, *63*(10), 917–926. 10.1016/j.biopsych.2007.11.022

World Health Organisation (2007) '*International Statistical Classification of Diseases and*

Related Problem'. 10th revision.

Yuill, N., & Lyon, J. (2007). Selective difficulty in recognising facial expressions of emotion

in boys with ADHD. *European Child & Adolescent Psychiatry*, *16*(6), 398–404.

10.1007/s00787-007-0612-5