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RIGHT CEREBRAL HEMISPHERE LANGUAGE AND COMMUNICATION FUNCTIONS IN FEMALES AND MALES WITH AUTISM SPECTRUM DISORDERS AND NORMAL INTELLIGENCE

The purpose of the study was to compare the functioning of adolescents with autism spectrum disorders (ASD) and typically developing adolescents matched for age and IQ, in terms of right hemisphere language communication. Sex differences in that area were also analyzed. Seventy-nine individuals with normal intelligence with ASD, fluent in their native spoken language and aged 10-20 years (41 females), and 79 typically developing individuals (control group, 39 females) were tested. The Polish adaptation of the Right Hemisphere Language Battery (RHLB-PL) was used for participants aged 13-20 years, while children aged 10-12 years were tested using an experimental version of the RHLB-PL for young children designed by E. Łojek. Individuals with ASD scored lower in the Humor Test and Discourse Analysis, and made more remarks in the Comments Test about the tasks than the control group. The two groups scored differently in two measures of verbal intellectual skills in the Wechsler Scale: Arithmetic and Comprehension. Individuals with ASD scored lower than controls on both of those measures. No sex differences were found for any of the measured variables.

Key words: autism spectrum disorders, sex differences, language, communication, right cerebral hemisphere

Background

Autism spectrum disorders (ASD) are a group of neurodevelopmental disorders characterized by deficits in social communication and repetitive,

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restrictive patterns of behavior and interests (APA, 2013; WHO, 2002). They occur in at least one out of every 100 individuals, with approximately half of those individuals having normal intelligence (Christiansen et al., 2016; Fombonne et al., 2016).

Language communication difficulties are typical for ASD. The most apparent problems are in pragmatics, but other aspects of communication tend to be affected as well. Difficulties emerge in non-verbal communication, including eye contact (Bal et al., 2010), facial expression, and understanding (e.g., Harms, Martin & Wallace, 2010). The speech of individuals with ASD is often repetitive or echolalic (Sterponi & Shankey, 2014; for review see also Gernsbacher et al., 2016). They make more linguistic errors of all sorts (Kim et al., 2014), have problems understanding and using language and emotional prosody, exhibit poor grasp of metaphors, and demonstrate less adaptive humor styles (e.g., Rundbalnd & Annaz, 2010; Samson et al., 2013).

Many of these language communication skills are associated with right cerebral hemisphere (RCH) dysfunctions (see Łojek, 2007; Łojek, Skotnicka, & Bryan, 2000). The right hemisphere plays an important role in processing complex linguistic data and in semantic processes. Its dysfunction results in problems extracting information from context, inappropriate verbal expression, impaired understanding of prosody, linguistic conventions, ambiguous information, and non-standard meanings of words (Ferre & Joanette, 2016). Other difficulties are associated with discourse comprehension and production, maintaining contact with interlocutor and conversational cooperation, as well as appreciation of shared knowledge and reflection (Jodzio, Łojek, & Bryan, 2005). Right cerebral hemisphere deficits may impede the ability to explain metaphors, resulting in their literal interpretation, and lead to poor grasp of abstraction, humor, irony, sarcasm, and deception, as well as a limited understanding of intent (Łojek, Skotnicka, & Bryan, 2000; Tompkins, Boada, & McGarry, 1992). Impairments in theory of mind have also been attributed to right hemisphere activity (Balaban, Friedmann, & Ziv, 2016). A study by Pluta et al. (2017) also showed that communication skills – as measured by the RHLB-PL – can predict theory of mind in patients after cerebral stroke.

Individuals with ASD experience difficulties in understanding abstract expressions, metaphors, and humor (Zheng et al., 2015). Their preferred type of humor is more straightforward, often involving funny sounds and situational jokes, and one that requires no complex analysis of the actors' intentions (Samson et al., 2013). Furthermore, these individuals have impaired perception and production of emotional and linguistic prosody (Kim et al., 2014), although some empirical data suggest that they correctly recognize emotional prosody even though they are unable to use it themselves (Grosman et al., 2013). Thus, there are many parallels in the language functioning of individuals with ASD and of people with right hemisphere

damage, as confirmed by Lewis, Woodyatt and Murdoch (2008) in one of the very few studies on this issue.

In the population of typically developing individuals, sex differences are present in some aspects of language communication. These include prosodic information processing and prosody production. Women tend to grasp information conveyed by affective prosody in tasks that require semantic processing faster than men (Schrimer, Kotz, & Friderici, 2002). Differences have also been found in speech rate, intonation, and variability: women speak faster and with more variations in pitch (Fitzsimons et al., 2001). Differences between typically developing females and males are also present in respect of emotion recognition ability of voices. In a study conducted by Demenescu, Mathiak, and Mathiak (2014), females performed better than males in a task that measured the recognition of emotions from voices, but this gender difference emerged only among middle-aged and older participants. Other findings regarding gender differences on emotion recognition ability lack agreement. Some studies have reported a general effect of gender on emotion recognition ability (Mill et al., 2009; Hall, & Matsumoto, 2004), whereas others have not (Circelli et al., 2013; Ross & Monnot, 2011). Furthermore, numerous studies have reported sex differences in the processing of humor (Du et al., 2013; Feng, Chan, & Chen, 2014; Ku, Feng, Chan, Wu, & Chen, 2017). Women engage more mental resources to integrate cognitive and emotional components during humor processing. In contrast, men activate more automated processes during the transition from cognitive operations to emotional response of the humor elaboration stage (Chang, Ku, & Chen, 2017). No obvious effects were apparent in subjective ratings at the behavioral level.

The issue of sex differences seems particularly interesting in the context of ASD, as this population is characterized by a strong male bias (4:1 or 3:1 male/female ratio, Christiansen et al., 2016; Loomes, Hull, & Mandy, 2017). However, the number of females with ASD diagnosis has been on the rise in recent years (Loomes, Hull, & Mandy, 2017), driving more research on the clinical presentation of ASD in this sub-population. The relatively sparse literature on sex differences in ASD suggests that the symptoms of ASD may have a different presentation in women than in men (Lai et al., 2011). Lai et al. (2013) showed that women with ASD demonstrated less typically autistic behavior, including in language communication. Hartley and Sikora (2009) found sex differences with respect to communication in young children with ASD. However, Lai et al. (2012) failed to demonstrate such differences in a study using a large battery of cognitive and communication function measures. It is possible that these differences become less distinct with age. The studies that failed to detect such differences were conducted on older children, adolescents, or adults.

Considering the limited number of studies on sex differences in ASD and the shortcomings of those that have been conducted, such as failure to match study groups on the basis of intellectual development, more work is needed in this area. The purpose of the present study was to compare the functioning of females and males with ASD in terms of language communication dependent on the right cerebral hemisphere with that of their peers, matched for age and IQ. We hypothesized that individuals with ASD will demonstrate lower efficiency than typically developing individuals in linguistic and pragmatic language functions. We expected to find such differences particularly in discourse ability, appreciation of humor, ability to comprehend and explain metaphors, and prosody. As this was an exploratory study with respect to sex differences in language communication functions, no hypotheses were proposed in that regard. Additional analyses included verbal intellectual skills measured using the Wechsler Intelligence Scale and the relationships between these skills and right-hemisphere language communication abilities. Similar analyses were conducted on children and adolescents with ADHD (Jędrzejowska & Borkowska, 2011), but the present study is exploratory in that respect also as regards adolescents with ASD.

Method

The study is part of a larger project devoted to analysis of sex differences in adolescents with ASD (N N106 352940).

Participants

Seventy-nine individuals with ASD aged 10-20 years, including 41 girls (M = 14.8 years, SD = 3.86) and 38 boys (M = 13.57 years, SD = 3.66 years), and 79 typically developing adolescents (control group), including 39 girls (M = 13.7 years, SD= 3.14) and 40 boys (M = 14.24 years, SD = 3.18 years) participated in the study. The control group was matched to ASD individuals for age and IQ. All participants functioned within the intellectual norm (IQ > 70) and were fluent in their native spoken language as defined in Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999), i.e. they used complex sentences in their spontaneous speech.

Individuals with ASD had a psychiatric diagnosis of Asperger syndrome (approx. 90% of the group) or childhood autism, based on the ICD 10 diagnostic criteria (WHO, 2002). Individuals with co-morbid significant vision, hearing, and motor deficits were excluded from the study. The majority of the sample (approx. 60 percent) were additionally tested with ADOS (Lord et al., 1999), and the remaining participants with the Autism Quotient (AQ; Baron-Cohen et al., 2001) to confirm the diagnosis.

Age and intellectual development information for ASD girls and boys and the control group are provided in Table 1.

Table 1. Age and intellectual functioning of girls and boys with ASD and controls

Variable	ASD group			Control group		
	Total	**Girls**	**Boys**	**Total**	**Girls**	**Boys**
	M (SD)	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***	***M (SD)***
Age (years)	13.56 (3.66)	14.8 (3.86)	12.22 (2.93)	14.24 (3.18)	13.7 (3.14)	14.76 (3.17)
IQ Full scale	103.77 (17.62)	103.22 (17.19)	104.37 (18.28)	105.73 (11.65)	105.03 (12.25)	106.43 (11.15)
IQ Verbal scale	105.10 (19.09)	105.34 (16.83)	104.84 (21.49)	106.70 (13.23)	105.97 (14.28)	107.40 (12.27)
IQ Non-verbal scale	101.56 (19.24)	100.29 (18.97)	102.92 (19.69)	104.38 (13.38)	104.00 (13.68)	104.75 (13.26)
N	79	41	38	79	39	40

No statistically significant differences between ASD and the control group were found in Full scale IQ in the Wechsler Intelligence Scale ($t(135,273) = -.826$; $p > .05$). There were also no differences in that respect between girls and boys with ASD ($t(77) = -.288$; $p > .05$), nor between girls and boys in the control group ($t(75) = .531$; $p > .05$). The ASD group also did not differ from the control group in mean age ($t(156) = -1.239$; $p > .05$). In the control group, girls did not differ in age from boys ($t(76)=1.496$; $p > .05$), while the girls with ASD were slightly older than the boys in this group ($t(77)=3.320$; $p < .05$).

Instruments

Language communication functions in participants aged 13-20 years were measured using the Right Hemisphere Language Battery (RHLB; Bryan, 1989), in the Polish adaptation (RHLB-PL) by E. Łojek (2007). Children aged 10-12 years were tested using a slightly modified, experimental version of the RHLB-PL which was designed for young children by E. Łojek. The battery measures 11 aspects of language communication (Table 2).

Discourse Analysis includes 15 rating scales: (1) supportive routines (e.g., politeness), (2) humor, (3) questions (gaining information), (4) assertive behaviors (e.g., making complain), (5) narrative (e.g., length of utterances), (6) variety of topic content, (7) level of formality between participants, (8) turn-taking, (9) discourse comprehension, (10) prosody, (11) organization of the output, (12) completeness of discourse, (14) eye contact, and (15) use of gestures. Participant behavior is assessed on a 4-point scale from 0 (severely limited performance) to 4 (typical discourse skills).

Table 2. Description of RHLB-PL tests

Test	Description	Score range
Inferential Meaning Test	Measures comprehension of text fragments based on the participant's own general knowledge and the ability to infer from context.	0-12
Lexical-Semantic Test	Measures the understanding of words and the ability to pick their graphical referents. Requires lexical-semantic knowledge, phonemic hearing and visuospatial analysis.	0-13
Humour Test	Requires comprehension of complex linguistic material and grasp of textual humour. The tasks involve choosing the correct story ending in 10 jokes. The options of responses include: the correct ending, a simple ending with neutral content (a concrete type of error) and a surprise ending that does not relate to the body of the joke (an abstract type of error).	0-12
Picture Metaphor Test	Assesses abstract verbal material analysis and understanding of common metaphors. Involves picking out of 4 pictures the 1 that best reflects the meaning of the metaphor used in a given sentence.	0-12
Written Metaphor Test	Checks abstract thinking based on analysing complex language material and understanding of common metaphors. Involves choosing the best of 3 explanations of a metaphor contained in a sentence.	0-12
Picture Metaphor Explanation Test	Tests the ability of participants to express common metaphors (used in the Picture Metaphor Test) in their own words.	0-12
Written Metaphor Explanation Test	Tests the ability to explain in own words metaphors contained in statements from the Written Metaphor Test read to the participant.	0-12
Emotional Prosody Test	Assesses understanding of tone of voice used in uttering nonsense phrases played from a recording. Participants are asked to name emotions (happiness, sadness or anger).	0-16
Linguistic Prosody Test	Involves determination of grammatical mood (indicative, interrogatory, imperative) with which the speaker on the recording utters a nonsense phrase.	0-16
Comments Test	Assessment of spontaneous tendency to make impulsive comments about the tests (measured in the Inferential Meaning and Humour Tests). This is the only test where higher scores indicate greater difficulties.	0-12
Discourse Analysis	Assesses the ability to interact with another person. The assessment refers to spontaneous conversation during the test.	0-60

Modifications made to the RHLB-PL for children were aimed at making the test materials more clear and adequate for the assessment of children. The language of the instructions was modified without changing the meaning

of the tasks. The heroes and settings of stories in the Inferential Meaning Test, as well as some jokes in the Humor Test, were also changed to render them more appropriate for children.

Intellectual skills were measured using the Wechsler Intelligence Scale for Children (WISC-R PL), in its Polish adaptation by Matczak, Piotrowska, and Ciarkowska (2008), while for participants aged 16 and over the Wechsler Adults Intelligence Scale (WAIS-R PL) was used, adapted by Brzeziński et al. (2004). Full Scale IQ, Non-verbal IQ, and Verbal IQ scores were used in the study, along with the following verbal scale test scores: Information, Similarities, Arithmetic, Vocabulary, Comprehension, and Digit Span.

Procedure

The study was approved by the Ethics Committee of the University of Warsaw, Faculty of Psychology. Parental written consent for the study was obtained for all individuals with ASD and underage typically developing individuals.

Due to the overriding aim of the project, namely sex differences in social and cognitive functioning of adolescents with ASD, several actions were undertaken to achieve access to females with these disorders. Parents of adolescents with ASD were contacted via centers and foundations that provide diagnostic and therapeutic services to individuals with autism spectrum disorders, inclusive and special schools, psychological and pedagogical counseling centers, and the Polish National Autism Society. In addition, an invitation to take part in the study was published on the web page of the Faculty of Psychology, University of Warsaw. Participants were recruited throughout the whole country, including Szczecin, Poznań, Gdańsk, Białystok, Wrocław, Warsaw, Kraków, Kalisz, Łódź, Zielona Góra and Toruń. The recruitment process and research lasted continuously throughout 2011-2016.

Parents of children in the control group were contacted mainly via schools. Students were recruited from all over Poland, particularly in Warsaw, Częstochowa, Toruń and Gdańsk.

The tests were conducted individually, usually at the participant's home, and in some cases at schools or at the premises of the Faculty of Psychology or therapeutic centers.

Statistical analysis

As the distribution of RHLB-PL scores deviated from normal and the variance of scores in individual measured variables was not homogeneous, the Mann-Whitney U-test was used for group comparisons. Scores in the Wechsler Intelligence Scale were analyzed using Student's T test for independent samples, and the effect size was calculated using Cohen's *d* coefficient. Bonferroni corrections were applied to compensate for multiple

comparisons, and a significance level of $p < .001$ was adopted for all analyses. In order to calculate correlations between the RHLB-PL test scores and Wechsler Intelligence Scale scores, Spearman's *rho* correlation analysis was employed (with Sidak correction due to multiple analyses, with $p < .001$). Statistical analysis was carried out using IBM SPSS version 24.

Results

Table 3 presents the descriptive statistics of RHLB-PL scores obtained by the groups in the study.

The ASD group scored lower than controls in the Humor Test and Discourse Analysis ($U = 2044$, $Z = - 3.842$; $p < .001$, Cohen's $d = 0.62$, eta squared = .089; and $U = 436$, $Z = - 9.906$; $p < .001$, Cohen's $d = 2.218$, eta squared = .552, respectively). Differences in the Humor Test occurred in the overall score (see above), as well as in two types of responses: correct (in ASD group $M_{rank} = 68.17$; in control group $M_{rank} = 93.99$) and neutral (92.85 and 69, respectively). In the case of the abstract type of error, the difference was not statistically significant. As for Discourse Analysis, we found differences in all 15 aspects of discourse ($p < .001$), with the individuals with ASD scoring lower than participants in the control group. In the Comments Test ($U = 1793$, $Z = - 4.97$; $p < .001$, Cohen's d = 0.79, eta squared = .135), the mean in the ASD group was higher than in the control group; this is the only test in the RHLB-PL battery in which higher scores are indicative of more severe problems. Statistically significant differences between the ASD group and controls are shown in Figure 1.

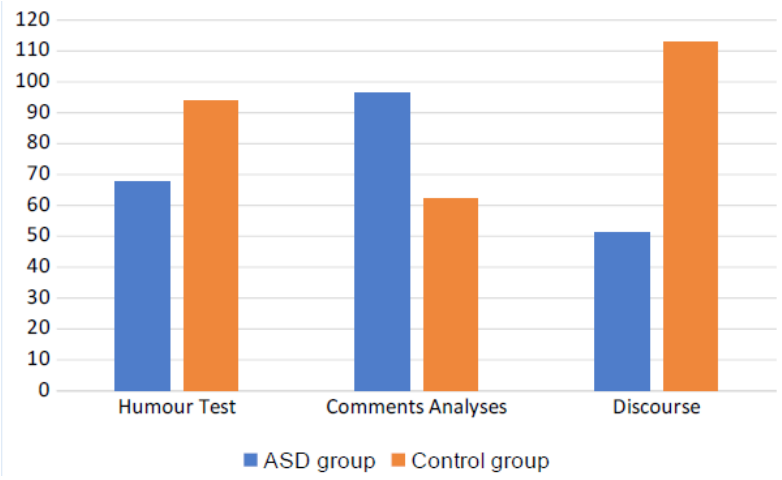

Figure 1. Mean rank differences in RHLB-PL tests between the ASD group and control group.

Table 3. Descriptive statistics of RHLB-PL subtests in girls and boys with ASD and in the control group.

Test	Total		Girls		Boys	
	M (SD)	**Mean rank**	***M (SD)***	**Mean rank**	***M (SD)***	**Mean rank**
ASD group						
Inferential meaning	13.09 (2.44)	72.70	13.32 (2.64)	43.38	12.84 (2.21)	36.36
Lexical- Semantic Test	11.80 (1.14)	76.08	11.98 (1.06)	43.45	11.61 (1.19)	36.28
Humour Test	8.13 (2.67)	67.72	8.26 (2.3)	42.69	7.71 (2.85)	38.66
Comments Test	3.76 (5.27)	96.30	4.17 (5.91)	42.44	3.32 (4.53)	37.37
Picture Metaphor Test	7.04 (3.30)	70.50	7.12 (3.48)	41.34	6.95 (3.15)	38.55
Written Metaphor Test	8.95 (2.30)	74.32	9.07 (2.10)	40.59	8.82 (2.53)	39.37
Picture Metaphor Explanation Test	6.81 (2.72)	73.36	7.15 (2.84)	42.89	6.71 (2.4)	36.88
Written Metaphor Explanation Test	7.54 (2.86)	69.88	7.56 (2.87)	40.29	7.53 (2.89)	39.68
Emotional Prosody Test	12.48 (2.77)	74.91	12.44 (2.65)	38.90	12.53 (2.95)	41.18
Linguistic Prosody Test	13.29 (2.85)	73.84	13.02 (3.04)	37.83	13.58 (2.64)	42.34
Discourse	51.3 (11.87)	43.52	43.83 (12.86)	42.03	43.88 (10.53)	40.1
Control group						
Inferential meaning	13.92 (1.662)	86.30	13.77 (1.47)	36.26	14.08 (1.83)	43.65
Lexical- Semantic Test	12.01 (0.940)	82.92	11.97 (0.99)	39.36	12.05 (0.90)	40.63
Humour Test	9.66 (1.348)	94.44	9.24 (1.39)	37.86	9.66 (0.63)	43.42
Comments Test	0.94 (1.786)	62.70	0.38 (1.14)	35.51	1.48 (2.13)	46.33
Picture Metaphor Test	8.58 (2.085)	88.50	8.33 (2.44)	38.95	8.83 (1.66)	41.03
Written Metaphor Test	9.72 (0.733)	84.68	9.64 (0.84)	38.36	9.8 (0.61)	41.60
Picture Metaphor Explanation Test	7.70 (1.877)	85.64	7.72 (1.65)	37.96	7.95 (1.74)	41.99
Written Metaphor Explanation Test	8.82 (1.403)	89.12	8.67 (1.61)	39.10	8.98 (1.17)	38.36
Emotional Prosody Test	13.08 (2.159)	84.09	12.92 (2.17)	38.14	13.23 (2.17)	38.36
Linguistic Prosody Test	13.91 (2.847)	85.16	14.28 (1.72)	39.83	13.55 (3.62)	40.18
Discourse	59.71 (0.75)	113.48	59.67 (0.69)	119.4	59.76 (0.82)	123.34

M – Mean, *SD* – Standard deviation

No sex differences in RHLB-PL scores were found in any of the groups. There were no such differences either in the total scores for any of the scales, types of responses in the Humour Test, or the individual dimensions in the Discourse Analysis.

The results obtained by participants with ASD and controls in Wechsler Scale verbal tests were also analysed. The relevant descriptive statistics are given in Table 4.

Table 4. Descriptive statistics of scores in Wechsler Scale's verbal tests

Variable	ASD group			Control group		
	Total	Girls	Boys	Total	Girls	Boys
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Information	11.51 (3.56)	11.29 (3.02)	11.74 (4.1)	10.63 (2.78)	10.56 (2.89)	10.7 (2.87)
Similarities	11.62 (3.17)	11.66 (3.27)	11.58 (3.1)	10.68 (2.61)	10.15 (2.39)	11.2 (2.75)
Arithmetic	9.59 (4.12)	9.32 (3.61)	9.89 (4.63)	11.54 (2.62)	11.23 (2.71)	11.85 (2.53)
Vocabulary	10.48 (4.11)	10.68 (3.71)	10.26 (4.54)	10.15 (2.86)	9.77 (2.35)	10.53 (3.27)
Comprehension	10.34 (4.17)	10.76 (4.16)	9.89 (4.18)	12.0 (2.79)	12.1 (2.63)	11.9 (2.97)
Digit span	10.3 (4.17)	10.06 (4.25)	10.62 (4.13)	10.18 (2.71)	10.08 (2.82)	10.29 (2.63)

M – Mean, *SD* – Standard deviation

Statistically significant differences between the ASD groups and the control group in verbal intellectual skills were found in Arithmetic ($t(156) = -3.351$, $p < .001$; Cohen's d = 0.536) and Comprehension ($t(156) = -2.939$, $p < .005$, Cohen's $d = 0.468$). In both these cases the ASD group scored lower than typically developing peers. No sex differences were found in any of the groups in the study.

Correlations between Wechsler Scale verbal test scores and RHLB-PL scores in the ASD group and the control group were weak ($rho < 0.3$), which is why they are not shown here.

Discussion

We found statistically significant differences between individuals with ASD and typically developing individuals in three RHLB-PL measures: Humour Test, Comments Test, and Discourse Analysis. In all those tests the scores of individuals with ASD suggested lower performance in the measured function compared to adolescents in the control group.

The results are partly consistent with expectations. Discourse Analysis in the RHLB-PL assesses the ability to interact in a spontaneous conversation while being tested, and clearly exposes deficits typical for ASD. Limited conversation and social interaction skills are among the key impairments characteristic of ASD (APA, 2013; WHO, 2002). The previously described difficulties of individuals with ASD in holding a conversation are manifested, among others, in engaging in lengthy monologues on specific subjects, failing to consider whether a subject is interesting for the partner, conversing in a manner that is inappropriate for the context, failing to account for the comments of others, and the inability to distinguish between salient and unimportant information (Bryńska, 2011; Tager-Flusberg, 2004). These limitations were reflected in the Discourse Analysis results. Group differences were present across all subscales of the scale, which potentially supports its usefulness in research on communication skills in individuals with ASD.

Results in the Humour Test are also consistent with predictions. As rightly noted by Silva et al. (2007), humour is a social phenomenon that often arises in a social context. Sharing it with others is also a social event that is socially rewarded. Thus, individuals with ASD are expected to present limitations in that respect. Although some studies have found no differences between individuals with ASD and other groups in certain types of humour (e.g., Samson & Hegenloh, 2010; Weiss et al., 2013), a study by Emerich et al. (2003) which, similarly to our study, asked adolescents with Asperger syndrome or autism with normal intelligence to choose funny endings for a short story, found their abilities to be lacking compared with typically developing adolescents. Performing the Humour Test in RHLB-PL correctly requires understanding of complex language material and noticing funny, implicit elements, and as such presents a challenge to the adolescents with ASD in the study. Group differences emerged in the test total score and the number of correct and neutral responses: when compared to participants in the control group, individuals with ASD chose fewer correct endings of presented jokes and more incorrect, concrete endings. To illustrate the type of problems, let us look at a sample task in the children's version of the test: "'Let's practice addition,' says dad to Matthew. 'I'm sure you know that two plus two equals four. What about two plus three?' To which Matthew responds:…" Participants choose from three endings: (a) Five (neutral, concrete response); (b) Math is my favourite subject (abstract response); and (c) Dad, why is it always you who gets the easier problem? (correct, humorous response). More frequent selection of concrete, non-humorous joke endings by ASD participants is consistent with their communication profile, which is characterised by concrete, literal understanding of language and difficulty comprehending non-literal utterances (Barton, 2011; Hobson, 2012). Understanding humour often means parallel processing of the literal meaning of a statement and the speaker's intended meaning, which requires an

understanding of their thoughts and intentions, as well as perspective taking, all of which individuals with ASD find particularly challenging (Uchiyama et al., 2012).

Comments Test measures participants' inclination to make spontaneous comments while completing two of the RHLB-PL tests (Inferential Meaning and Humour Tests). The experimenter neither encourages comments nor prohibits them. He/she also offers no remarks on the comments made by the participant, only asking them to return to the task. The higher rate of comments made by individuals with ASD suggests that they find it problematic to refrain from such behaviour. Some authors researching narratives in children with ASD have reported that they tend to include bizarre, inappropriate, or irrelevant information (Loveland et al., 1990). Since the RHLB-PL child version has not been normalized, our results cannot be compared with population scores. The comments made by adolescents with ASD were not analysed in terms of content, which could offer better insight into the nature of these behaviours. It should be noted, however, that the scores obtained by participants with ASD in this test were highly varied. There was a subgroup of individuals who made no comments or remarks (n = 23), there were those who made a single comment (n = 13), and those who made multiple comments (n = 44). Future studies could benefit from exploring the neurocognitive profile and the level of social skills in individuals within each group. This could be an interesting contribution to the analysis of variation in the presentation of disorders present in the population of individuals with ASD.

Equally interesting are the results in those areas of language communication where no differences were found between adolescents with ASD and controls. This was the case, for example, in perception of emotional and linguistic prosody. Our findings are consistent with information reported by some other researchers (e.g., Grossman et al., 2010; Grossman et al., 2013). It should be noted, however, that the empirical results in this area are inconclusive, likely due to highly discrepant methodologies used in different studies (McCann & Peppé, 2003). Performance in tasks that measure prosody in children and adolescents with ASD within the intellectual norm can depend on a number of factors, including the level of language development (e.g., Lyons, Schoen Simmons, & Paul, 2014), type of emotion being measured, attentional demands, as well as other features of the task (Diehlet al., 2008; Gebauer et al., 2014). An interpretation of the findings from the present study must take into account the fact that participants listened to a voice-over reading of nonsense phrases. This way they were able to fully focus on intonation, without having to analyse the content. Furthermore, participants had a choice of verbally naming the emotion or pointing to its name on a card, which also made the task easier. In addition, the experimental condition is much simpler than a typical social situation, in which intonation is only one

of the elements required to understand an utterance. Messages in which intonation changes the meaning of the phrase are particularly challenging (see research on the grasp of irony, Banasik 2017). It is worth mentioning that Jędrzejowska and Borkowska (2011) described a different profile of differences in RHLB scores between children with ADHD and typically developing counterparts. The only differences they found were in Picture Metaphor Test scores. And while Jędrzejewska and Borkowska used their custom modification of RHLB-PL, which somewhat limits direct comparison between the two studies, presumably there is a certain characteristic functioning of individuals with ASD in terms of right-hemisphere language communication that differentiates them from people with ADHD. Working memory and inhibition processes play important roles in metaphor processing (Bartczak & Bokus, 2014). Thus, deficits in working memory and inhibition, typical for individuals with ADHD, may affect metaphor production and comprehension. Adolescents with ASD also experience difficulties in working memory, but most studies have not revealed significant impairment in inhibition in this group (Luna et al., 2007). In another study with RHLB and individuals with ASD (Lewis et al., 2008), statistically significant differences between that group and controls were found in the Humour Test (as in our study), as well as in Inferential Meaning and Production of Emphatic Stress. Lewis et al. (2008) obtained no statistically significant differences in metaphor comprehension and explaining, nor in prosody. Neither Discourse Analysis nor Comments Test were performed in their study. It is noteworthy, however, that the ASD group showed higher variability of scores in individual RHLB-PL scales as compared to the control group. This might be to some extent the result of a ceiling/floor effect in the Comment test for control group. Even so, it should be taken into account when analyzing the RHLB scores in ASD individuals.

No statistically significant differences in any of the assessed aspects of language communication were found between girls and boys with ASD. To some extent this could be a consequence of the strict approach to statistical analysis and the adopted significance level ($p < .001$). The results of previous studies on individuals with ASD are unclear with respect to sex differences in language and communication (e.g., Hartley & Sikora, 2009; Lai et al., 2012). The fact that no such differences were found in our study supports the conclusion that the deficits and problems in verbal processing, especially semantics, are similar in males and females with ASD (Beacher et al., 2012). It should also be noted that sex differences in communication reported for the general population are small (Dindia & Canary, 2006).

We also found group differences in the level of development of some verbal intellectual skills. The study groups were matched for general IQ and did not differ in terms of verbal and nonverbal IQ. Differences in skill profiles emerged in Arithmetic and Comprehension, with adolescents with

ASD scoring lower than typically developing adolescents. Lower Comprehension scores in individuals with ASD compared to typically developing individuals is one of the most common characteristics of the intellectual profile in ASD (e.g., Goldstein et al., 2001; Mayes & Calhoun, 2003; Mouga et al., 2016). It should be noted, however, that the results of research on the intellectual profile of individuals with ASD are highly inconsistent. As was the case in the RHLB-PL, in our study there were no significant differences between girls and boys with ASD in verbal intellectual skills. Kumazaki et al. (2015) reported similar findings. When participants are carefully matched for IQ, sex differences in the development of specific intellectual abilities are not statistically significant.

The presence of only weak correlations between RHLB-PL scores and Wechsler Scale verbal test scores may suggest that these instruments measure different abilities. In a similar analysis, Jędrzejowska and Borkowska (2011) found a number of significant positive correlations (moderately strong) in a group of children with ADHD. Perhaps the differences in the findings of these two studies could be explained by the characteristic aspect of functioning of individuals with ASD, namely, the relative independence of intellectual level and communication skills. Black and colleagues (2009) found that in children with ASD with normal intelligence, the difference between verbal and non-verbal IQ is associated with autism social symptoms, but not with communication symptoms. They reported a significant (though weak) correlation between verbal IQ and communication difficulties ($r = -0.32$). It would be useful to continue studying these relationships in individuals with ASD in respect of various aspects of communication skills. Moreover, RHLB measures lexical-semantic processes, transformation of complex language information and emotional prosody, while Wechsler Scales measure slightly different aspects of language competence, such as concept comprehension, verbal fluency and ability of verbalization. It seems that the RHLB brings some unique information on language functioning that is not provided by Wechsler scales.

Conclusion, strengths, and limitations of the study

The results of the present study suggest that adolescents with ASD experience certain difficulties with right-hemisphere language communication functioning. Problems are particularly apparent in humour, discoursive skills, and commenting while completing tasks. In contrast, no differences were found between adolescents with ASD and typically developing peers matched for IQ level and age in terms of emotional and linguistic prosody, drawing inferences, lexical-semantic tests, or the ability to comprehend and explain metaphors. The two groups scored differently in two measures of

verbal intellectual skills in the Wechsler Scale: Arithmetic and Comprehension. In both, individuals with ASD scored lower than controls.

At the same time, having matched the groups carefully for IQ, we found no sex differences in adolescents with ASD in language communication or verbal intellectual skills. The lack of detected differences may be partly explained by the rigorous *p*-value (< .001) adopted due to the type of analysis (multiple comparisons).

Our findings provide new information about the functioning of girls and boys with ASD within the intellectual norm, and suggest avenues for further research in this area. It would be interesting to distinguish subgroups within ASD individuals that differ in their profiles of language communication skills, and to compare these abilities with social skills and adaptive functioning levels. It could also be useful to analyse the developmental progress of children with ASD in terms of figurative language and other aspects of communication. A valuable frame of reference could be offered by studies on typically developing preschool children (Banasik & Bokus, 2013; Bokus, 2004; Dryll & Bokus, 2016; Garstka & Bokus, 2009).

The limitations of this study must be borne in mind when interpreting its results. It employs the RHLB-PL scale designed for neuropsychological evaluation of patients with right cerebral hemisphere damage (Łojek, 2007). The nature of some tasks may have contributed to the relatively high scores of individuals with ASD, e.g., with regard to prosody or metaphor comprehension. Furthermore, some participants were assessed using a modified version of the RHLB-PL (adapted for children), the psychometric and clinical properties of which have not yet been fully established. Controlled matching for IQ and age of participants in the girls and boys with ASD groups and the control group are certainly strengths of this study, although a downside was the relatively small size of each group.

As a closing remark, it should be mentioned that in real-life social situations individuals with ASD often have significantly more problems communicating with other people than the results of studies on specific language or communication skills in laboratory settings suggest. Understanding this complex phenomenon requires analysis of multiple factors that could not be captured in this study.

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