The Relationship between Sex, Empathy, Systemizing, and Autistic Traits in Primary School Children[*]

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The aim of this study was to determine the relationship between sex, empathy, systemizing, and autistic traits in primary school children. The sample included 353 primary school children aged 7-11 years. The children's versions of the Empathy Quotient – EQ-C, Systemizing Quotient – SQ-C, and children's version of the Autism Spectrum Quotient - AQ– C were used as primary outcome measures. Girls had higher empathy, while boys had higher autistic traits. Empathy and systemizing were moderately positively correlated, but both were good predictors of autistic traits. The effect of sex on autistic traits was mediated by empathy as well as by the difference between systemizing and empathy. These results partially support assumptions of the Empathizing-Systemizing theory and the Hypersystemizing theory of autism, which should be further evaluated in a population with the autism spectrum disorder.

Keywords: empathizing, systemizing, Hypersystemizing theory, autism

Highlights:

- Empathy, systemizing and the difference between the two were predictors of autistic traits in primary school students.
- Girls had higher empathy, while boys had higher autistic traits.
- Sex effect on autistic traits was mediated by the difference between systemizing and empathy and empathy alone.

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by persistent deficits in social communication and social interaction, as well as by repetitive patterns of behavior, interests, and activities (American Psychiatric Association, 2013). According to a recent review (Zeidan et al., 2022), the prevalence of ASD in the general population is approximately 1%, with great variance between studies. Autistic traits are also present in the general population in milder forms (Ruzich et al., 2015). People with mild, subclinical symptoms of ASD belong to the so-called "broader autistic phenotype", which is usually associated with relatives of persons with ASD (e.g., Hurley et al., 2007). Nevertheless, there are studies that found traits of broader autistic phenotype in general populations, without relatives with ASD (e.g., Jamil et al., 2017; Stojković et al., 2018).

Baron-Cohen et al. (2001) developed the Autism Spectrum Quotient (AQ), which is the first instrument designed for self-report assessments of autistic traits in the general population that can be used for the assessment of the broader autistic phenotype and showed that groups with ASD had significantly higher AQ than typically developing (TD) groups. Similar results were found with the Children's Version of Autism Spectrum Quotient (AQ-C, Auyeung et al., 2008) as a parent-report. Cut-off score of 76 points showed good sensitivity (95%) and specificity (95%). Scores above cut-off were registered in 2% of TD girls, 7% TD boys (4% of total TD group) and 95% of children with ASD (Auyeung et al., 2008). Authors conclude that, although AQ above the cut-off score is correlated with ASD diagnosis, it is not sufficient for diagnosis. People with scores above the cut-off can be seen as persons at risk and might require a detailed clinical assessment for ASD (Auyeung et al., 2008; Baron-Cohen et al., 2001). ASD is diagnosed only when autistic traits cause significant discomfort and difficulties in everyday functioning and when all diagnostic criteria are met (APA, 2013). Additional research is required for investigating whether AQ and AQ-C could be used as screening instruments (Auyeung et al., 2008; Baron-Cohen et al., 2001).

ASDs are diagnosed four times more often in males than in females (APA, 2013; Loomes et al., 2017). Research based on scales for assessment of autistic traits in the TD population showed that on average, boys had higher AQ than girls (Auyeung et al., 2008, 2009a; Palomba et al., 2012; Wakabayashi et al., 2007). On the other hand, there are studies that did not find the expected gender differences in AQ (Saenz, 2014).

Gender is the most considered factor of empathy and systemizing (Groen et al., 2015). Empathy is a drive to identify another person's thoughts and feelings and react to these with appropriate emotion (Baron-Cohen et al., 2003). Systemizing is a drive to analyze and construct systems and can be applied only on closed systems that follow clear rules (e.g., if A, then B) (Baron-Cohen et al., 2003; Lawson et al., 2004).

Most studies found higher empathy in girls, and higher systemizing in boys (Auyeung et al., 2009b, 2012; Escovar et al., 2016; McGrath & Zook, 2011; Palomba et al., 2012; Tavassoli et al., 2018; Wakabayashi, 2013), with more pronounced differences in affective than in cognitive empathy (Dimitrijević et al., 2012; Jolliffe & Farrington, 2006; Knafo et al., 2008; Von Horn et al., 2010).

However, there are also studies that did not confirm expected gender differences (Author, 2020; Eisenberg et al., 1996; Saenz, 2014; Sallquist et al., 2009).

The Empathizing-systemizing (E–S) theory views empathy and systemizing as independent dimensions. Combining these dimensions results in five cognitive profiles (brain types). Brain type is determined by calculating the difference between systemizing and empathy scores (i.e., D-score). Balanced type means that empathy and systemizing are approximately equally developed. Type E means that empathy is higher than systemizing, while Type S means that systemizing is higher than empathy (Greenberg et al., 2018). People with a difference between systemizing and empathy higher than two standard deviations (SD) are labeled as extreme types (Baron-Cohen et al., 2003). Research that found very low associations between empathy and systemizing supports assumptions about distinctiveness and independence of these dimensions (Auyeung et al., 2009b, 2012; Baron-Cohen et al., 2003; Greenberg et al., 2018; Wakabayashi, 2006, 2013; Wheelwright et al., 2006; Wright & Skagerberg, 2012). Same studies found that types E and Extreme E are more often in females, so they are sometimes labeled as "female" and "extreme female brain". In contrast, types S and Extreme S are more often in males and are labeled as "male" and "extreme male brain".

Baron-Cohen et al. (2003) use the E-S theory to describe autism as a condition characterized by unimpaired (or even superior) systemizing and empathy deficit, which means that people with autism have an extreme male brain. The empathy deficit explains difficulties people with ASD have in social functioning, while unimpaired systemizing can explain islands of spared abilities and specific interests. This explanation is sometimes labeled as Extreme male brain theory, which can lead to the wrong conclusion that people with ASD are characterized by other traits that are more pronounced in males (e.g., aggression; Greenberg et al., 2018). That is why lately authors themselves label this theory as Hypersystemizing theory of autism. Authors propose that superior systemizing in people with ASD is based on sensory hypersensitivity and attention to details (Baron-Cohen & Lombardo, 2017). Studies that used AQ considered the qualitative nature of autistic traits continuously present in general population, with ASD representing an extreme of that continuum (e.g., Ruzich et al., 2015). On the other hand, some authors suggest that the difference between individuals with ASD and typical population, as well as those with clinical conditions, is qualitative rather than quantitative, e.g. Ashwood et al. (2016) found that people with generalized anxiety disorder might have autistic traits beyond the cut-off score, without having ASD. That is why it is very important to keep in mind that the presence of autistic traits is not equivalent to the diagnosis of ASD.

Another misunderstanding associated with Hypersystemizing theory is that people with ASD lack empathy. Some research showed that people with ASD (compared to control group matched by gender, age and intelligence) have significantly lower levels of cognitive empathy, while differences in affective empathy were not significant (Dziobek et al., 2008; Rueda et al., 2015, according to Greenberg et al., 2018).

Autistic traits (measured by AQ) are positively correlated with systemizing quotient (SQ) and negatively correlated with empathy quotient (EQ; Greenberg

et al., 2018; Sindermann et al., 2019; Wright & Skagerberg, 2012). In other words, people with higher autistic traits also have higher systemizing and lower empathy. This correlation is confirmed in TD children (Rudra et al., 2016), as well as in people with ASD (Wheelwright et al., 2006). However, there are also studies that did not find the expected correlation between AQ and EQ in children with ASD (Rudra et al., 2016). Children with ASD, compared to TD children, have higher AQ and SQ, but lower EQ (Allison et al., 2012; Auyeung et al., 2008; Rudra et al., 2016; Tavassoli et al., 2018; Wakabayashi et al., 2007). The gender effect was weaker than the group effect (TD/ASD), the interaction between gender and group was also significant. Gender differences in ASD group were weaker than in the TD group (Baron-Cohen et al., 2014; Greenberg et al., 2018), or they were not significant at all (Baron-Cohen et al., 2001; Wakabayashi et al., 2007; Wheelwright et al., 2006).

The aim of this study was to determine the relationship between sex, empathy, systemizing and autistic traits in primary school children. More specifically, the study was designed to explore if there were sex differences in empathy, systemizing and autistic traits in primary school children and to what extent individual differences in empathy and systemizing could explain individual differences in autistic traits.

We expected that (H1) girls would have higher levels of empathy, while boys would have higher levels of systemizing, D-score and autistic traits; (H2) there was a low negative correlation between empathy and systemizing; (H3) more overt autistic traits were related to lower levels of empathy and higher levels of systemizing and, consequently, higher D-score; (H4) empathy and systemizing were significant predictors of autistic traits after controlling for sex and age.

Method

Participants

The sample included 353 (44.7% boys) primary school children aged 7 to 11 years ($M = 8.95$, $SD = 1.19$), with no age differences between sexes ($t = -0.03$, $df = 326.96$, $p = .97$; boys: $M = 8.95$, $SD = 0.10$; girls: $M = 8.95$, $SD = 0.80$). Mothers were most often the ones to complete the questionnaires (82.5%), followed by fathers (15.3%), both parents together (1.9%), and others (.3%).

Questionnaires

Back translations from English into Serbian were made for questionnaires regarding empathy and systemizing (Auyeung et al., 2009b), so as autistic traits (Auyeung et al., 2008). One of the authors of this paper translated questionnaires from English to Serbian. A professional translator (with academic degree in English language) independently backtranslated the Serbian translation of the questionnaires into English. Another author of this paper (fluent in English) compared the original and back-translated English versions. The few disagreements that were found between these versions were resolved through a discussion between authors of this paper, e.g., literal translation of sentence "Play games with children that involve pretending" (question 55. in AQ-C, Auyeung et al., 2008), did not sound natural and familiar in Serbian, so another phrase with the same meaning was used: "igre pretvaranja/kobajagi igre".

Sociodemographic Data

The sociodemographic questionnaire consisted of questions regarding sex (male/ female), age and child's and family member's disability (yes /no).

Empathy and Systemizing

Empathy and systemizing were measured by using the Children's Versions of the Empathy Quotient – EQ-C and Systemizing Quotient – SQ-C scales (Auyeung et al., 2009b). The EQ-C and SQ-C scales consist of 27 and 28 items, respectively, which are combined in a unified questionnaire for easier administration. Parents completed the questionnaire indicating how strongly they agree with each statement regarding their child. Answers "definitely agree" on positively formulated statements were scored 2, answers "slightly agree" were scored 1, while answers "slightly disagree", or "definitely disagree" were scored 0. Answers were recoded so that higher scores indicated higher levels of empathy/systemizing. Questionnaires with two or more missing answers on each scale were considered incomplete and were omitted from further analysis. If responses for one or two items were missing, the total score was calculated by multiplying the average score with the number of items in each scale. Cronbach's alpha coefficients for EQ-C and SQ-C were .93 and .78 in previous research (Auyeung et al., 2009b), and .75 (for both scales) in this study.

Standard scores (EQst, SQst) are calculated by subtracting the average score from the raw score and dividing the result with the maximum possible score. A difference score is calculated by the formula $D = (SQst - EQst) / 2$ (Auyeung et al., 2009b). The composite of standard scores was calculated by the formula $C = (SQst + EQst) / 2$ (Goldenfeld et al., 2005).

Autistic Traits

The assessment of autistic traits was based on The Children's Version of Autism Spectrum Quotient - AQ-C scale (Auyeung et al., 2008) that initially consisted of 50 items grouped into five areas (subscales): social skills, attention switching, attention to detail, communication and imagination. Again, parents indicated how strongly they agree with each statement regarding their child, by using a 4-point scale ranging from 0 (definitely disagree) to 3 (definitely agree). Answers were recoded so that higher scores indicated higher levels of autistic traits. Since typically developing children had higher scores than children with ASD on three items, authors of the scale removed those items from the final analysis. Therefore, the total score was based on 47 items and the maximum possible score was 141 (Auyeung et al., 2008; Auyeung et al., 2009a; Melling & Swinson, 2016; Weiss et al., 2012). Questionnaires with four or more missing answers on this scale were considered incomplete and were omitted from further analysis. If three or less items were missing, the total score was calculated by multiplying the average score with the number of items. Cronbach's alpha for internal consistency was .79 in this study.

Procedure

The research was approved by the Ethics Committee of the Faculty of Special Education and Rehabilitation, University of Belgrade. The research took place in primary school "Janko Veselinović" in an urban part of Belgrade (municipality Voždovac), which was selected based on convenience. The authors distributed 528 copies of the questionnaire to the school corresponding to the number of students in the school. The questionnaires were followed by a cover letter for parents that guaranteed that participants would stay anonymous and that the obtained data would be used solely for scientific purposes. Teachers administered 485 questionnaires to parents. A total of 378 parents (77.9% response rate) returned anonymously completed questionnaires. Additionally, 25 participants were excluded from further analysis: three because of their age (younger than seven years), eight because of missing information about sex, eight because of the child's disability, and six because of the family member's disability.

Results

Results of descriptive statistical analyses are presented in Table 1[1]. Observed score range was slightly lower than theoretically expected, no participants had score 0 on any questionnaire. No participants had AQ higher than 76 points, which would indicate need for additional assessment due to risk of ASD.

Table 1
Descriptive statistics

	N	Min	Max	M	SD	Kolmogorov-Smirnov Test	
						Z	p
EQ	351	14	54	39.20	6.02	0.05	.04
SQ	350	8	50	29.36	7.36	0.05	.02
D-score	350	-0.20	0.24	0.00	0.07	0.03	.20
AQ	346	9	73	40.25	11.10	0.03	.20

Note. N - number of the respondents; Min - minimal score; Max - maximal score; M - mean; SD - standard deviation; Z - Kolmogorov-Sminrov coefficient; p - statistical significance of the Z; EQ - Empathy Quotient; SQ - Systemizing Quotient; D-score - difference score between systemizing and empathy; AQ - Autism Spectrum Quotient.

Results of Kolmogorov-Smirnov tests indicated empirical distributions on the EQ, SQ and AQ scales were not significantly different from the normal distribution ($p > .05$).

An Exploratory Factor Analysis with Principal Components Analysis and Varimax rotation revealed four factors on EQ and SQ, and five factors on AQ (results are shown in Supplementary Materials).

Table 2
Results of subsamples of male and female participants

		N	M	SD	t	df	p	d
EQ	Male	164	38.50	5.95	-2.07	349	.04	-.22
	Female	187	39.82	6.03				
SQ	Male	164	30.12	7.03	1.84	348	.07	.23
	Female	186	28.68	7.59				
D-score	Male	164	.01	.06	3.62	347.98	<.01	.39
	Female	186	-.01	.07				
C-score	Male	164	.00	.10	0.07	348	.94	.01
	Female	186	-.00	.10				
AQ	Male	163	41.58	10.22	2.12	344	.03	.23
	Female	182	39.06	11.72				

Note. N - number of respondents; M - mean; SD - standard deviation; t - t-test; df - degrees of freedom; p - statistical significance; d - Cohen's d; EQ - Empathy Quotient; SQ - Systemizing Quotient; D-score - difference score between systemizing and empathy; C-score - composite score of systemizing and empathy; AQ - Autism Spectrum Quotient.

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1 Outliers were identified by using Tukey's (1977) method. Three outliers were detected on EQ-C, two on SQ-C, five on D-score and six on AQ-C. Since that same or very similar results were observed when the outliers were removed or winsorized, we have decided to present results of analyses performed on raw data.

Student's t-test for independent samples was used to test for sex differences (Table 2). Results showed that girls had higher EQ than boys ($p = .04$). Sex differences in SQ were marginally significant ($p = .07$). Boys tended to have higher AQs than girls ($p = .03$). They also tended to have higher D-scores than girls ($p < .01$). In contrast, sex differences in the sum of standardized scores of empathy and systemizing (C-score) were not statistically significant. After comparing effect sizes (Cohen's d), sex generally had a small effect, while the effect on D-score was stronger than on EQ and AQ. These results partially confirmed our hypothesis (H1).

Table 3
Pearson's correlation coefficient (r)

	Age[a]	EQ	SQ	D
Age				
EQ	− .03			
SQ	− .02	.42*		
D-score	.00	− .43*	.64*	
AQ	.09	− .51*	− .08	.35*

Note. EQ - Empathy Quotient; SQ - Systemizing Quotient; D-score - difference score between systemizing and empathy; AQ - Autism Spectrum Quotient; [a] Spearman's correlation coefficient (used because age significantly deviated from normal distribution) showed very similar results: age was not significantly correlated with other variables; * $p < .001$.

As shown in Table 3, EQ was positively correlated with SQ ($r = .42$, $p < .01$) and negatively with AQ ($r = − .51$, $p < .01$). AQ and SQ were not related ($r = − .08$, $p = .15$), while D-score was positively correlated with AQ ($r = .35$, $p < .01$).

Table 4
Standardized regression coefficients

	Predictor	β	*p*
Model 1	D-score	.34	<.01
	Age	.09	.09
	Sex	− .05	.34
Model 2	EQ	− .57	<.01
	SQ	.16	.002
	Age	.07	.10
	Sex	-.04	.45

Note. β - Stastistical regression coefficient; *p* - stastistical significance of the standardized regression coefficient; EQ - Empathy Quotient; SQ - Systemizing Quotient; D-score - difference score between systemizing and empathy; AQ - Autism Spectrum Quotient.

Multiple regression analysis was conducted for the prediction of autistic traits. D-score, EQ and SQ could not be simultaneously entered as predictors because of multicollinearity. That was why we separately analyzed two prediction models (Table 4). D-score, sex and age (Model 1) together explained 12.4% of the AQ variance ($F (3, 336) = 17.05$, $p < .01$, adjusted $R^2 = .12$). Model 2, which contained EQ and SQ as separated predictors (instead of D-score), had even stronger predictive power: EQ, SQ, sex and age together explained

28.1% of AQ variance ($F(4, 335) = 34.11$, $p < .01$, adjusted $R^2 = .28$). Inspection of standardized regression coefficients revealed that EQ was the best predictor of AQ, followed by D-score and SQ, while sex and age were not significant predictors.

Pearson's correlation coefficients presented in Table 3 revealed that SQ and AQ were not significantly correlated ($r = -.08$, $p = .15$), while multiple regression analysis (presented in Table 4) revealed that SQ had significant partial effect on AQ ($\beta = .16$, $p = .002$). For this reason, we have used partial correlation for further detailed analysis. Results showed that after controlling for EQ, SQ was significantly correlated with AQ ($r_{parc} = .17$, $p < .01$), which might be an indication of a suppressing effect of EQ on this relationship (Figure 1).
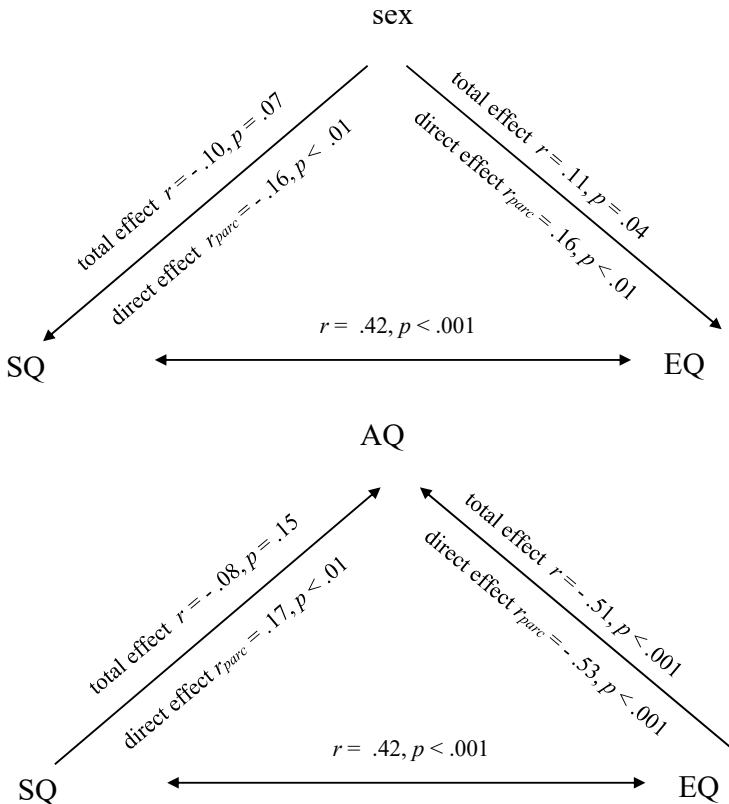

Figure 1
Scheme of suppressor variables

In further analysis we have examined if D-score, as well as its components, could be seen as a mediator of the effect of sex on AQ. As it has been also shown in Figure 2, regression of sex on AQ, ignoring the mediator, was significant (R^2 = .01, $F(1, 348)$ = 4.63, p <. 001; B = –0.054, SE_b = 0.025, β = – .10, $t(351)$ = 2.16, p = .03). Second step of mediation testing showed that the regression of the sex on the mediator variable D-score was also significant, i.e., R = .35, R^2 = .12, $F(2, 347)$ = 24.00, p <.001; B = –0.025, SE_b = 0.007, β = – .38, $t(351)$ = 3.59, p <.001. Third step indicated a significant effect of D-score on AQ, controlling for sex, R = .11, R^2 = .01, $F(1, 348)$ = 4.63, p <.001; B = 1.206, SE_b = 0.1884, β = .33, $t(351)$ = 6.54, p <.001. Finally, analyses revealed that, after controlling for D-score, sex was not a significant predictor of AQ anymore, R = .11, R^2 = .01, $F(1, 348)$ = 4.63, p <.001; B = –0.024, SE_b = 0.024, β = – .23, $t(351)$ = 1.00, p = .32. Results of Sobel's test also showed that D-score was a statistically significant mediator of the relationship between sex and AQ (z = 3.18, p = .001).

To examine which constituent of D-score has the more important mediator role, we repeated the same set of mediation analyses twice; first, using the EQ score as a potential mediator, and subsequently using the SQ score as a potential mediator. Results showed that the (a) regression of sex on EQ was significant (R = .11, R^2 = .01, $F(1, 351)$ = 4.35, p <.05; B = 0.049, SE_b = 0.024, β = .22, $t(351)$ = 2.08, p = .04); (b) regression of EQ on AQ, controlling for sex, was also significant (R =.51, R^2 = .26, $F(2, 350)$ = 61.21, p <.001; B = –0.532, SE_b = 0.049, β = – .50, $t(351)$ = 10.78, p <.001); and (c) after controlling for the mediator (EQ) sex stopped to be a significant predictor of AQ (R = .11, R^2 = .01, $F(1, 351)$ = 4.67, p <.05; B = –0.028, SE_b = 0.022, β = – .12, $t(351)$ = 1.28, p = .20). This pattern of results indicates that there is a significant mediating role of EQ in the relationship between sex and AQ, which was also confirmed by the results of Sobel's test (z = 2.04, p = .04).

On the other side, results of analyses that tested whether the SQ score could be a mediator of sex-AQ relationship revealed that (a) effect of sex on SQ was only marginally significant (R = .10, R^2 = .01, $F(1, 351)$ = 3.7, p> .05; B = –0.054, SE_b = 0.028, β = – .20, $t(351)$ = 1.92, p = .06); (b) effect of SQ on AQ, controlling for sex, was not significant (R = .15, R^2 = .02, $F(2, 350)$ = 3.81; p <.05; B = –0.082, SE_b = 0.048, β = –.09, $t(351)$ = 1.71, p = .09); and (c) sex was still a significant predictor of AQ after controlling for the SQ (R = .11; R^2 = .01, $F(1, 351)$ = 4.66, p <.05; B = –0.059, SE_b = 0.025, β = –.25, $t(351)$ = 2.33, p = .02) which is in line with results of Sobel's test that showed that SQ does not mediate significantly the relationship between sex and AQ (z = 1.19, p = .23).

To sum up, it seems that the observed difference between boys and girls in AQ could be at least partially explained by sex differences in D-score, especially by differences in EQ (see also Figure 2).
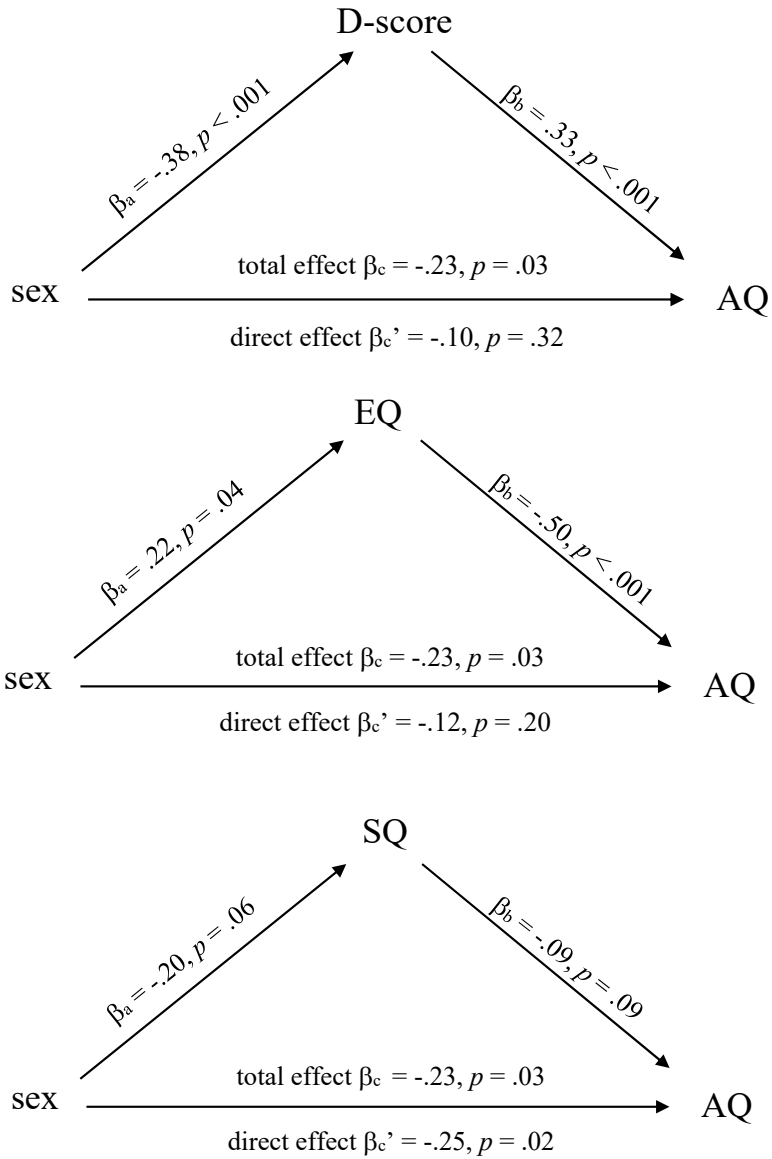
Figure 2
Standardized effects in mediation analyses

Discussion

The aim of this study was to examine the relationship between sex, empathy, systemizing and autistic traits in primary school children. As far as we know, this is the first study that used the Children's Version of Autism Spectrum Quotient - AQ-C scale (Auyeung et al., 2008) on a Serbian sample. The Children's Versions of the Empathy Quotient – EQ-C and Systemizing Quotient – SQ-C (Auyeung et al., 2009b) scales have been previously used in Serbia only with preschool children (Author, 2020).

An exploratory Factor Analysis with Principal Components Analysis and Varimax rotation revealed four factors on EQ and SQ, and five factors on AQ (see Supplementary material). Five factors we observed on AQ are similar[2] to theoretically proposed five subscales and empiricaly confirmed four factors reported by authors of the scale (Auyeung et al., 2008). Authors of the original version (Auyeung et al., 2009b) did not comment on the factorial structure of these questionnaires, so direct comparison could not be made. Considering that (and also the fact that all three scales had acceptable Cronbach's alpha coefficients for the internal consistency), we decided to use only composite scores for whole scales, with all items kept.

Sex differences observed in this study are in accordance with previously reported results (e.g., Auyeung et al., 2008, 2009a, 2009b; Escovar et al., 2016; Palomba et al., 2012; Tavassoli et al., 2018; Wakabayashi et al., 2007, 2013). In our study, all sex differences were in expected directions, statistically significant for empathy and autistic traits.

We found expected sex differences in D-score, which reflects that, on average, boys had higher systemizing than empathy, while girls showed an opposite pattern. In contrast, sex differences in sum of standardized scores of empathy and systemizing were not statistically significant, which means that boys and girls are not different in the total capacity (neither sex is superior), but only in its distribution. Similarly, Goldenfeld et al. (2005) found that TD adult males and females did not differ in sum of standardized scores of empathy and systemizing, while this composite was significantly lower in persons with high-functioning autism.

After comparing for effect sizes, we concluded that sex had a small effect in general, although its effect on D-score was higher than the effect on EQ and AQ scores. Authors often emphasize that gender differences are observed in average scores, while there is an overlap in score distribution in males and females (Auyeung et al., 2009b, 2012; Baron-Cohen et al., 2003, 2014; Greenberg et al., 2018; Wheelwright et al., 2006). For example, when randomly selected pairs of males and females were compared, males had higher SQ in 62% of pairs, and females in 36% of pairs. Similarly, higher EQ was observed in females in approximately two thirds of pairs, and in males in about 30% of pairs, in remaining cases scores were identical (Wright & Skagerberg, 2012).

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2   Detailed comparison of factors observed in our and previous studies is available on request from the first author.

Eisenberg et al. (1996), and also Sallquist et al. (2009) explain differences in observed association between gender and empathy by diferent information sources (other/report, vs. Selfreport and observation in experiment) and gender stereotipes. Gender ratio in ASD also varies depending on used methodology. While all data report higher prevalence of ASD in males than in females, this difference is smaller in population based studies (regardless of previous diagnosis), than in studies that analyzed people diagnosed with ASD (Loomes et al., 2017). Some authors claim that it is harder to recognize ASD in females, because they might express ASD symptoms differently and they are more prone to "camouflage" (see Allely, 2019 for review). While difficulties of diagnosing ASD in females might contribute to explaining the observed gender ratio in ASD, sex differences in brain structure and function indicate an impact of biological factors (Baron-Cohen et al., 2011). Causal mechanisms underlying those differences are considered in different theories, relying on impact of fetal testosterone (Auyeung et al., 2009a), X and Y chromosome, and the reduced autosomal penetrance (see Baron-Cohen et al., 2011 for review). Sex differences in brain structure and function are in accordance with E-S and Hypersystemizing theory.

We found a significant moderate positive correlation between empathy and systemizing quotients (r = .42). The intensity and direction of observed correlation are in contrast with the E-S theory (Baron-Cohen et al., 2003) and with previous studies conducted with children and adolescents (Auyeung et al., 2009b, 2012; Escovar et al, 2016), as well as on TD adults (Baron-Cohen et al., 2003; Greenberg et al., 2018; Wheelwright et al., 2006), which found a weak negative correlation between empathy and systemizing quotients. On the other hand, some research found low (Sindermann et al., 2019; Wakabayashi, 2013; Wright & Skagerberg, 2012) or moderate positive correlation (Author, 2020) between empathy and systemizing. Wright and Skagerberg (2012) considered that differences in sampling lead to different correlations in their study and in previous studies, while Sindermann et al. (2019) proposed the existence of a common cognitive factor in empathy and systemizing. Wakabayashi (2013) pointed out that both scales included some items related to the children's abilities, and that Japanese parents might be assessing their child based on the overall impression. Another possible explanation for the unexpected positive correlation between EQ and SQ is that factorial structure of the Serbian version of these questionnaires differs from those used in previous research (Auyeung et al., 2009b; Escovar et al., 2006; Saenz, 2014; Tavassoli et al., 2018; Wakabayashi, 2013). Comparison could not be made since authors of the original scales did not publish the factor structure of the questionnaires. Although back translation method was applied, it might not be sufficient for obtaining equivalent forms of questionnaires (Hedrih, 2018), e. g. Serbian version of EQ (Dimitrijević et al., 2012) did not replicate the unifactorial structure of the English version for adults (Baron-Cohen & Wheelwright, 2004).

Higher autistic traits were correlated with lower empathy and higher D-score (which indicated that systemizing is more developed than empathy),

which is in accordance with previous research (Greenberg et al., 2018; Rudra et al., 2016; Sindermann et al., 2019; Wheelwright et al., 2006; Wright & Skagerberg, 2012). Bivariate correlation between systemizing and autistic traits was not statistically significant, but after controlling for empathy, systemizing was significantly correlated with sex and autistic traits, so we concluded that empathy acts as a potential suppressor in these relations. It is interesting that systemizing can also be seen as a suppressor of the relationship between empathy and autistic traits. This effect is also observed when empathy and systemizing are combined in D-score, whereby systemizing minimizes the total effect of empathy on autistic traits. Based on these findings, we proposed a bidirectional relationship between empathy and systemizing, stressing that used analyses and the correlation-regression research design cannot provide conclusions about impact direction nor casual relations. Unexpected moderate positive association between empathy and systemizing probably lead to a smaller effect of D-score on autistic traits and masked the association between systemizing (on the one hand) and sex and autistic traits (on the other hand).

Multiple regression analysis showed that empathy and systemizing were significant predictors of autistic traits. When they were analyzed separately, they had stronger predictive power than when they were combined in D-score. D-score, sex and age together explained 12.4% of AQ variance, while EQ, SQ, sex and age together explained 28.1% of AQ variance. Examining of standardized regression coefficients revealed that EQ was the strongest partial predictor of AQ, followed by D-score and SQ, while sex and age were not significant predictors.

Because the main effect of sex was confirmed, but the partial effect was not, we further examined the assumption about the mediation effect of D-score and its components in the relationship between sex and autistic traits (Figure 2). Results of partial correlation and multiple regression analyses confirmed the mediation effect of D-score: after controlling for D-score, correlation between sex and autistic traits was not significant. When empathy and systemizing were analyzed separately, only empathy was a significant mediator, which means that the effect of D-score actually came from empathy. In other words, sex impacts empathy (thus impacting D-score and brain type), which than impacts AQ. We are not familiar with previous research that analyzed the mediation effect between sex and autistic traits.

Our results of multiple regression analysis are in accordance with results of an online study on around 670000 participants 16-89 years old (including 36648 persons with ASD). In that study, demographic variables (sex, age, education, occupation, hand dominance) explained 2.3% of AQ, while D-score explained an additional 41.4% of variance. Effects of sex and group (TD/ASD) were partially mediated by D-score. Lowest AQ was observed in persons with Extreme E type, while highest AQ was observed in persons with Extreme S type, i.e. "extreme male brain" (Greenberg et al., 2018). Small differences between the described online study and our study probably originate from the difference in correlation between EQ and SQ.

Similar to our results, EQ and SQ were good predictors of AQ in the study of Wheelwright et al. (2006). Prediction was performed separately for male (723) and female (1038) TD students, and also for a clinical group of 125 people with ASD. Factor analysis of EQ, SQ and AQ revealed a single factor that explained 54.7% of total variance, 76.1% variance of AQ, 58.3% of EQ and 30% of SQ. AQ and SQ were strongly positively correlated with this factor, while EQ was strongly negatively correlated.

Our findings partially support assumptions of the Hypersystemizing theory of autism (i.e., the Extreme male brain theory; Baron-Cohen et al., 2003). In accordance with this theory, stronger autistic traits were correlated with higher D-score (which indicated that systemizing is higher than empathy). Yet, empathy was a better predictor of autistic traits than systemizing or D-score (brain type). Advantage of Hypersystemizing theory of autism is that it fits with the concept of "neurodiversity", which sees ASD as the extreme of autistic traits present in the general population. In the context of "neurodiversity", different learning styles and information processing in persons with ASD do not have to reflect a deficit (but diversity present in milder form in general population), it can even be seen as a talent (Baron-Cohen & Lombardo, 2017). In contrast to theories focused on deficits in persons with ASD (e. g. Baron-Cohen, 2000; Ozonoff et al., 1991), the Hypersystemizing theory also explains talents in this population. It also offers an explanation for the higher prevalence of ASD in males (Baron-Cohen et al., 2003; Baron-Cohen & Lombardo, 2017; Greenberg et al., 2018). The mentioned hypersystemizing does not necessarily imply that systemizing is higher in all persons with ASD (compared to TD population), instead, it means that systemizing is much higher than empathy. In this respect, we can speak about hypersystemizing in people with intellectual disability. Still, this theory is empirically tested only in people with average or above average intellectual abilities. Since a significant number of people with ASD has intellectual disability, the question remains open whether this theory can be applied to all people with ASD, which is its biggest limitation.

The limitations of this study are: using correlation-regression cross-sectional study design, gathering information from only one source (the parents), not controlling for IQ, the fact that AQ-C is not a diagnostic instrument and that the presence of autistic traits is not equivalent to the diagnosis of ASD. Another limitation is possible differential functioning between the Serbian versions and the original questionnaires. EQ and SQ for adults show good cross-cultural stability in Western countries, with some differences in Asian countries (see Groen et al., 2015 for review). A study conducted in Japan found results similar to a UK sample, with small differences only in the percentage of extreme brain types (Wakabayashi et al., 2007).

Conclusion

Sex differences in autistic traits, empathy and systemizing (after controlling for empathy), and also the correlation between autistic traits and D-score (the brain type), support assumptions of the Empathizing-Systemizing theory and

Hypersystemizing theory. In contrast to expectations based on these theories, which view empathy and systemizing as independent dimensions, we found a moderate positive association between empathy and systemizing. Empathy and systemizing were good predictors of autistic traits in TD children, although they had stronger predictive power when viewed independently, than when combined in D-score (brain type). Sex effect on autistic traits was mediated by D-score (brain type) and empathy. Longitudinal research is recommended for exploring the impact direction and the possibility of long-term prediction (e. g. predicting later autistic traits based on previous empathy level). Future research should include clinical population (people with ASD) and check whether same relations between variables can also be found in this population. We also recommend gathering information from different sources, including direct ability assessment (e. g. theory of mind tests). If empathy and systemizing were good predictors in the clinical population, they should be integrated in risk assessment for ASD. Analyzing specific aspects of empathy, systemizing and autistic traits (selected based on factor analysis of appropriate scales) would contribute to deeper understanding of these phenomena.

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Odnos pola, empatije, sistematizovanja i autističnih crta kod dece osnovnoškolskog uzrasta

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Cilj ovog istraživanja bio je da ispita povezanost između pola, empatije, sistematizovanja i autističnih crta kod dece osnovnoškolskog uzrasta. Uzorak je činilo 353 učenika osnovne škole, starosti 7-11 godina. U istraživanju su korišćene dečije verzije Koefcijenta empatičnosti (eng. Empathy Quotient – EQ-C), Koeficijenta sistematizacije (eng. Systemizing Quotient – SQ-C), kao i dečija verzija Koeficijenta autističnog spektra (eng. Autism Spectrum Quotient – AQ-C), kao primarne mere ishoda. Devojčice su imale višu empatiju, dok su dečaci imali izraženije autistične crte. Empatija i sistematizacija su bili u umerenoj pozitivnoj korelaciji, ali su oba bili dobri prediktori autističnih crta. Uticaj pola na autistične crte posredovan je empatijom i razlikom između sistematizacije i empatije. Ovi rezultati delimično podržavaju postavke teorije empatičnosti-sistematizacije i hipersistematizacione teorije autizma, koje bi trebalo dalje proveriti i na populaciji osoba sa poremećajem iz spektra autizma.

Ključne reči: empatisanje, sistematizovanje, teorija hipersistematizacije, autizam