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The aim of the present study was to investigate associations between four highly used self-report measures assessing empathy (measured as both a unidimensional and multidimensional construct), autistic tendencies, and systemizing tendencies. Participants in this study completed the following self-report measures: The Interpersonal Reactivity Index (IRI) and the Empathy Quotient (EQ) to measure empathy, and the Autism Spectrum Quotient (AQ) and the Systemizing Quotient–Revised (SQ-R) to assess autistic and systemizing tendencies, respectively. The final sample consisted of \( N = 1,098 \) participants (304 males) without a diagnosed autism spectrum disorder, most of whom were university students. The IRI scale “Perspective Taking” and the EQ were negatively related to the AQ in male and female participants, while the IRI scale “Empathic Concern” was negatively related to the AQ in females only. Moreover, the AQ was positively related to the SQ-R in females only. Lastly, the SQ-R and a number of the empathy scales were significantly associated: For example and surprisingly, the EQ correlated weakly and positively with the SQ-R in both male and female participants. The results from this study illustrate how standard self-report measures of empathy, autistic tendencies, and systemizing tendencies are associated with each other in a large sample not diagnosed with an autism spectrum disorder. Additionally, some potential gender-specific effects are revealed.

Keywords: empathy, autism, systemizing, Interpersonal Reactivity Index, Empathy Quotient, Autism Spectrum Quotient, Systemizing Quotient–Revised

INTRODUCTION

Empathy can be understood as an important concept contributing greatly toward successful human social interaction (1–3). However, despite empathy being a widely used term in science, as well as in everyday life, a consensus definition of the concept remains somewhat elusive [see, for example, the review and discussion of this topic in Refs. (4, 5)]. Nevertheless, there is some agreement that empathy comprises both affective (i.e., feeling similar emotions to another person) and cognitive components (i.e., understanding the feelings of another person) [for a summary covering many definitions of empathy, please see Ref. (4), and for examples, please see Refs. (6, 7)].
In line with the various definitions of empathy, a range of self-report measures assessing individual differences in empathy exist [e.g., Refs. (6–9)]. These questionnaires assess the degree of empathy on a continuum from low to high empathy. Two widely used measures in this area of research are the Interpersonal Reactivity Index (IRI) and the Empathy Quotient (EQ) (6, 8). The IRI assesses empathy using four distinct scales/dimensions of empathy labeled “Perspective Taking” (PeT), “Empathic Concern” (EmC), “Personal Distress” (PeD), and “Fantasy” (Fan). The PeT scale assesses the ability/tendency to take another’s perspective. The EmC scale assesses the extent to which someone feels warmth, but also concern for others. The PeD scale assesses self-oriented feelings of tension and worry in difficult social situations, or when someone else is hurt or in danger. Lastly, the Fan scale asks participants about their tendency to relate to fictional characters (8, 10). In most studies, it is claimed that the PeT and Fan scales measure cognitive aspects of empathy, whereas the EmC and PeD scales assess affective aspects of empathy. However, there is some controversy about this putative structure. For example, not all researchers agree that the Fan scale actually measures a facet of empathy (2, 3, 11–15). Moreover, there has been a suggestion that the PeD scale strongly overlaps with facets of the personality dimension Neuroticism (3). In contrast to the IRI, the EQ was originally developed to measure empathy as a unidimensional construct. The authors justify this decision by arguing that cognitive and affective components of empathy cannot be easily separated (6). Studies across various countries that have examined the associations between the scores of both self-report measures show that the EQ has the strongest and most consistent positive associations with the PeT and EmC scales of the IRI (2, 14, 16, 17).

Different versions of the EQ are often used in studies investigating empathy in the context of the neurodevelopmental condition of an autism spectrum disorder (ASD; see results reported below). ASD is/will be classified (including diagnostic criteria) and divided into various subtypes in the International Classification of Diseases 11th Revision (ICD-11) and the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). It is—among other things—characterized by deficits in social functioning and communication (18, 19). According to the previous literature, samples of people diagnosed with an ASD show lower scores in empathy, as measured using different versions of the EQ, compared to control samples (20–24). However, autistic tendencies can also be studied on a continuum in the normal population. One instrument that assesses autistic tendencies using a dimensional approach is the Autism Spectrum Quotient (AQ) (21, 25, 26). As such, the AQ has been correlated with the EQ in previous studies (using a range of slightly different versions of the measures). Studies consistently report a negative association between the two measures in both control samples and samples of participants diagnosed with an ASD (6, 20, 21, 24, 27). To the best of our knowledge, however, there is only one study that has previously reported associations between the AQ and IRI scores. In this study, negative correlations between the AQ and the IRI scales PeT and EmC, and to a lesser extent Fan, were found. On the other hand, positive associations between the AQ score and the PeD scale were reported in these largely student samples from Germany and China (28).

Aside from reporting lower levels of empathy, samples of participants diagnosed with an ASD also show higher systemizing tendencies compared to control samples (20, 21, 24). These tendencies describe “the drive to analyze, understand, predict, control and construct rule-based systems” (p. 48) (21). Additionally, these tendencies might explain some of the characteristic symptoms of an ASD, such as repetitive behavioral patterns and problems with change (19, 29). A widely used self-report measure that assesses individual systemizing tendencies in the general population, as well as in people diagnosed with an ASD, is the systemizing quotient (SQ), and its revised version (SQ-R) (20, 21). Again, using a dimensional approach to measurement of this construct, correlations between autistic and systemizing tendencies have been shown to be positive for both control samples and those diagnosed with an ASD (20, 21, 24). This supports the idea that the key characteristics of an ASD can be observed in mild forms in participants sampled from the general population.

Although higher autistic tendencies are robustly associated with both lower empathy and higher systemizing tendencies, empathy and systemizing tendencies are not robustly correlated with each other. Correlations between scores in different EQ and SQ(-R) versions have been reported to lie between −0.06 and −0.21 in general population samples, and at around −0.29 in a sample of people diagnosed with an ASD (20, 21, 24, 30, 31). No study so far, however, seems to have reported associations between the IRI and the SQ-R.

Taken together, the aim of the present study was to investigate the relationships between empathy, autistic tendencies, and systemizing tendencies. Previous studies investigating these relationships typically used versions of the EQ, AQ, and SQ(-R). The findings previously shown with these scales should be replicated. In addition to this, the present study also sought to examine these relationships using the IRI, which, contrary to the EQ (which assesses empathy as unidimensional construct), assesses empathy as a multidimensional construct. In line with results from previous studies, we expected the following associations:

1. Positive correlations between the EQ and the IRI scales PeT and EmC
2. Negative correlations between the AQ and both the EQ and the IRI scales PeT and EmC
3. Positive correlations between the AQ and the SQ-R
4. Positive correlations between the AQ and the IRI PeD scale
5. No significant correlations between both the EQ and the IRI scales with the SQ-R

**MATERIALS AND METHODS**

**Registration**

This study is registered at https://osf.io/q2arp/. Data will be made available upon reasonable request.

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1No significant associations were expected, because especially in control samples (not diagnosed with an ASD) the associations found in previous literature were of rather low effect size.
Participants
Participants took part in an online study including various self-report questionnaire measures presented using the SurveyCoder-Tool (https://www.ckannen.com/). The data collection took place at Ulm University, Ulm, Germany. Therefore, most participants tended to be younger and were students. More specifically, 1,249 participants took part online in the present study, which is part of the Ulm Gene Brain Behavior Project (UGBBP). However, 11 participants were excluded due to missing data. Hence, 1,238 participants (373 males) were retained for subsequent analyses. One participant reported suffering from Asperger syndrome. This participant was excluded from further analyses, as he/she was identified as an outlier in terms of the AQ score.

More specifically, after calculating scores of all scales under investigation (see the paragraphs on Self-Report Measures), 140 participants were excluded due to their categorization as an outlier on at least one of the scales under investigation, or because of their reported age. All participants who scored lower than \([25^{\text{th}}\text{-Quantil} - (1.5\times(75^{\text{th}}\text{-Quantil} - 25^{\text{th}}\text{-Quantil}))]\) or higher than \([75^{\text{th}}\text{-Quantil} + (1.5\times(75^{\text{th}}\text{-Quantil} - 25^{\text{th}}\text{-Quantil}))]\) on at least one of the scales under investigation, or for age, were treated as outliers and excluded from further analyses (32). This is also the formula used in the Statistical Package for the Social Sciences (SPSS) statistics software of the International Business Machines Corporation (IBM) to detect outliers (unidimensionally) by means of the boxplot method. Results from the total sample, including those participants identified as outliers, are presented in the Supplementary Material. As can be seen there, the results of the analyses are similar whether the participants classified as outliers are included or not.

The mean age of the final sample of \(N = 1,098\) participants (304 males) was 21.94 years \((SD = 2.72\text{ years}; \text{median} = 21\text{ years})\). The age range was 18–30 years.

All subjects gave electronic informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the local ethics committee of Ulm University, Ulm, Germany.

It should be noted that as all participants are members of the UGBBP, the sample reported in this study partly overlaps with other samples derived from this project. For example, a previous study investigated a smaller subsample in relation to associations between oxytocin receptor genetics and the IRI and the AQ (28). Moreover, the IRI was also investigated in a recent experimental study on music perception in \(n = 160\) participants from the UGBBP (33).

Self-Report Measures

Interpersonal Reactivity Index
A German version of the Interpersonal Reactivity Index (IRI) was administered to measure empathy multidimensionally (8, 10). It consists of 28 items split into four scales. These are named “Perspective Taking” (PeT), “Empathic Concern” (EmC), “Personal Distress” (PeD), and “Fantasy” (Fan). Each scale consists of seven items. No total score across all items is calculated. All items are answered on a five-point Likert scale from “0” to “4.” The internal consistencies (using Cronbach’s alpha) of the four scales in the present sample were as follows: PeT: .78, EmC: .82, PeD: .76, Fan: .81.

Empathy Quotient
A German version of the 60-item Empathy Quotient (EQ) was used in the study to measure empathy unidimensionally (6). The items of this questionnaire are answered on a four-point Likert scale. The answer to each item is transformed into either “0” (for two of the four responses indicating nonempathic tendencies), “1,” or “2,” with higher values indicating higher empathy. The scores for 40 of the items are then summed to create a total scale score. It should be noted that it is also possible to calculate several subscales from the EQ. However, such subscales were not originally intended by the authors (6). Additionally, details about such subscales remain debatable (16, 17, 34–36). The present study therefore focused on the total scale. Its internal consistency (using Cronbach’s alpha) in the present sample was .88.

Autism Spectrum Quotient
A German version of the Autism Spectrum Quotient (AQ) was used to measure autistic tendencies in the current study (25, 26). It consists of 50 items answered on a four-point Likert scale. The answer to each item is transformed into a “1” for more autistic-type responses, and a “0” for nonautistic-type responses. From this, a total score, as well as scores for several subscales, can be calculated [see Refs. (26, 37) for different approaches to splitting the AQ into subscales]. The current study focused only on the total scale score. Its internal consistency (using Cronbach’s alpha) was .73 in the present sample.

Systemizing Quotient–Revised
The German version of the Systemizing Quotient–Revised (SQ-R) was used to measure systemizing tendencies (21) (German version available from: http://docs.autismresearchcentre.com/tests/SQ_German.pdf). It consists of 75 items, which are answered on a four-point Likert scale. The answer to each item is transformed into either “0” (for two of the four answer options indicating nonsystemizing tendencies), “1,” or “2,” with higher scores indicating stronger systemizing tendencies. From this, a total score is calculated by summing across the items. The internal consistency (using Cronbach’s alpha) of this scale was .85 in the present sample.

Statistical Analyses
All analyses were implemented using SPSS statistics version 24.

First, the distributions of the scales under investigation were checked for a normal distribution. The statistical tests (Kolmogorov–Smirnov and Shapiro–Wilk) indicated significant deviations from the normal distribution for all scales. This is most likely due to the large number of participants in the present study. Therefore, the skewness and kurtosis of all distributions were additionally checked. For all of the scales under investigation, as well as age, the skewness and kurtosis were smaller than +/−1. Hence, in line with the rules of thumb suggested by Miles and Shevlin, normality could be assumed.

For all of the scales under investigation, as well as age, the skewness and kurtosis of all distributions were additionally checked. For all of the scales under investigation, as well as age, the skewness and kurtosis were smaller than +/−1. Hence, in line with the rules of thumb suggested by Miles and Shevlin, normality could be assumed.

Following this, the associations between the scales of all of the self-report measures included in the study, along with age, were calculated using Pearson correlations. Next, differences across gender were investigated using t-tests (if necessary, Welch’s t-tests were used and reported).
Finally, associations between the scales were calculated using partial Pearson correlations, controlling for age (see significant associations with age). These analyses were performed in the total sample \((N = 1,098)\), as well as split by gender. This procedure was chosen given the unequal gender distribution and the differences in the mean scores of the self-report measures across males and females. The correlations were compared across males and females using Fisher's \(z\)-tests (http://www.markenkunde.de/korrelation_tool/markenkunde_corcomparer1_0.xls).

We present correlational analyses between the self-report measures instead of, for example, regression analyses in the main manuscript in order to report “unbiased” associations (i.e., not controlling for potential overlaps between the self-report measures). However, as an additional and exploratory analysis, a regression model to predict the AQ score is also presented in the Supplementary Material.

All results were evaluated for significance using two-tailed tests.

**RESULTS**

**Associations With Age and Gender**

Age correlated significantly with the IRI scales EmC \((r = −0.10, p < 0.001)\), PeD \((r = −0.12, p < 0.001)\), and Fan \((r = −0.17, p < 0.001)\), and with the EQ \((r = −0.11, p < 0.001)\). The \(p\)-values for all other correlations with age were >0.247. Age was therefore controlled for in further analyses.

Significant differences across gender were found for all of the scales under investigation. For descriptive statistics and results of the \(t\)-tests, please see Table 1. Females scored higher on all empathy-related scales, whereas males scored higher on the AQ and SQ-R.

**Correlations Between the Self-Report Measures**

Correlations between the self-report measures in the total sample are presented in Table 2 (without any correction for multiple testing). After manually applying a Bonferroni correction for multiple testing (\(alpha = 0.05/21 = 0.0024\); divided by 21 because 21 correlations were calculated), the following results with regard to the hypotheses remained significant: Partly in line with the first hypothesis, the EQ correlated significantly and positively with the IRI scales PeT, EmC, but also Fan. The EQ and the IRI scales PeT and EmC correlated significantly and negatively with the AQ. This is in line with the second hypothesis. The AQ correlated significantly and positively with the SQ-R and with the IRI scale PeD, which supports the third and fourth hypotheses. In relation to the fifth hypothesis, the SQ-R showed (mostly) weak correlations with the empathy measures. Only its negative correlation with PeD remained significant.

The correlations between the self-report measures for males and females separately are presented in Table 3 (without any correction for multiple testing). After manually applying a Bonferroni correction for multiple testing (\(alpha = 0.05/21 = 0.0024\)), the following significant correlations with regard to the hypotheses were found:

**TABLE 1** | Descriptive statistics for all scales under investigation and \(t\)-tests for gender differences.

<table>
<thead>
<tr>
<th></th>
<th>Total sample ((N = 1,098))</th>
<th>Males ((n = 304))</th>
<th>Females ((n = 794))</th>
<th>(t)-test (t(df)) ()</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI PeT</td>
<td>17.29 (4.29)</td>
<td>16.55 (4.38)</td>
<td>17.57 (4.23)</td>
<td>(t)(1096) = −3.53</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IRI EmC</td>
<td>19.07 (4.51)</td>
<td>16.38 (4.47)</td>
<td>20.09 (4.09)</td>
<td>(t)(507.47) = −12.61</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IRI PeD</td>
<td>13.50 (4.29)</td>
<td>11.24 (3.78)</td>
<td>14.37 (4.16)</td>
<td>(t)(599.19) = −11.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IRI Fan</td>
<td>18.67 (5.04)</td>
<td>16.38 (5.04)</td>
<td>19.55 (4.76)</td>
<td>(t)(1096) = −9.74</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EQ</td>
<td>42.18 (10.60)</td>
<td>36.34 (9.75)</td>
<td>44.42 (10.06)</td>
<td>(t)(1096) = −12.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AQ</td>
<td>16.47 (5.66)</td>
<td>18.01 (5.54)</td>
<td>15.89 (5.59)</td>
<td>(t)(1096) = 5.65</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SQ-R</td>
<td>51.20 (14.80)</td>
<td>56.59 (14.64)</td>
<td>49.13 (14.35)</td>
<td>(t)(1096) = 7.66</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**TABLE 2** | Partial correlations between all scales under investigation in the full sample.

<table>
<thead>
<tr>
<th></th>
<th>IRI PeT</th>
<th>IRI EmC</th>
<th>IRI PeD</th>
<th>IRI Fan</th>
<th>EQ</th>
<th>AQ</th>
<th>SQ-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI PeT</td>
<td>0.40***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRI EmC</td>
<td>−0.03</td>
<td>0.30***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRI PeD</td>
<td>0.20***</td>
<td>0.39***</td>
<td>0.22***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRI Fan</td>
<td>0.47***</td>
<td>0.61***</td>
<td>0.04</td>
<td>0.33***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQ</td>
<td>−0.23***</td>
<td>−0.22***</td>
<td>0.26***</td>
<td>−0.08**</td>
<td>−0.43**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AQ</td>
<td>0.09**</td>
<td>−0.01</td>
<td>−0.18**</td>
<td>0.09**</td>
<td>0.07**</td>
<td>0.18**</td>
<td></td>
</tr>
</tbody>
</table>

\(N = 1,098\). All correlations are corrected for age. ***\(p < 0.001\), **\(p < 0.01\), *\(p < 0.05\) (two-tailed). Of the significant \(\*p < 0.05\) correlations reported in this table, those between IRI PeT and SQ-R \((p = 0.003)\), between IRI Fan and AQ \((p = 0.005)\), between IRI Fan and SQ-R \((p = 0.003)\), and between EQ and SQ-R \((p = 0.028)\) would not remain significant after manually applying a Bonferroni correction for multiple testing \((alpha = 0.05/21 = 0.0024)\).
TABLE 3 | Partial correlations between all scales under investigation for males and females separately.

<table>
<thead>
<tr>
<th>IRI PeT</th>
<th>IRI EmC</th>
<th>IRI PeD</th>
<th>IRI Fan</th>
<th>EQ</th>
<th>AQ</th>
<th>SQ-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI PeT</td>
<td>0.41***</td>
<td>0.04</td>
<td>0.25***</td>
<td>0.51***</td>
<td>−0.20***</td>
<td>0.15**</td>
</tr>
<tr>
<td>IRI EmC</td>
<td>0.39***</td>
<td>0.32***</td>
<td>0.35***</td>
<td>0.55***</td>
<td>−0.07</td>
<td>0.14*</td>
</tr>
<tr>
<td>IRI PeD</td>
<td>−0.10***</td>
<td>0.17***</td>
<td>0.22***</td>
<td>−0.03</td>
<td>0.32***</td>
<td>−0.20***</td>
</tr>
<tr>
<td>IRI Fan</td>
<td>0.15***</td>
<td>0.32***</td>
<td>0.12***</td>
<td>0.30***</td>
<td>−0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>EQ</td>
<td>0.45***</td>
<td>0.57***</td>
<td>−0.09*</td>
<td>0.26***</td>
<td>−0.39***</td>
<td>0.23***</td>
</tr>
<tr>
<td>AQ</td>
<td>−0.22***</td>
<td>−0.29***</td>
<td>0.33***</td>
<td>−0.05</td>
<td>−0.41***</td>
<td>0.07</td>
</tr>
<tr>
<td>SQ-R</td>
<td>0.10**</td>
<td>0.05</td>
<td>−0.09*</td>
<td>0.19***</td>
<td>0.12***</td>
<td>0.18***</td>
</tr>
</tbody>
</table>

Results for the male participants (n = 304) are presented above the diagonal. Results for the female participants (n = 794) are presented below the diagonal. All correlations are corrected for age. **p < 0.001, *p < 0.01, “p < 0.05 (two-tailed). Of the significant (p < 0.05) correlations, the correlations between IRI PeT and SQ-R (p = 0.008) and between IRI EmC and SQ-R (p = 0.017) for males, and between IRI PeT and SQ-R (p = 0.004), between IRI PeD and SQ-R (p = 0.012), between IRI PeD and EQ (p = 0.013), and between IRI PeT and PeD (p = 0.004) for females would not remain significant after manually applying a Bonferroni correction for multiple testing (alpha = 0.05/21 = 0.0024).
The sample consisted of participants not diagnosed with an ASD. The results generally support the notion that autistic tendencies are negatively related to empathy, but positively related to systemizing tendencies, and systemizing tendencies using a dimensional approach to measurement. Newer measures also exist that assess empathy, autistic tendencies, or systemizing tendencies, we need to ask the individuals themselves. Additionally, we aimed to provide further insights into associations between self-reported empathy (using unidimensional and multidimensional measures), autistic tendencies, and systemizing tendencies using a dimensional approach to measurement. Newer measures also exist that assess empathy in relation to specific emotions. These measures should also be investigated in relation to the widely used measures covered in the present study.

In conclusion, the results from this study provide insights into the relationship between empathy, autistic tendencies, and systemizing tendencies in a large, mostly student, sample not diagnosed with an ASD. The results generally support the notion that autistic tendencies are negatively related to empathy, but positively related to systemizing tendencies, although in males the association between autistic and systemizing tendencies was weak and nonsignificant. Therefore, the results suggest that future studies should report findings with these measures separately.
for males and females, and also support the notion that future studies should focus on facets of autistic tendencies and empathy to examine these relations in more fine-grained detail.

ETHICS STATEMENT
All subjects gave electronic informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the local ethics committee of Ulm University, Ulm, Germany.

AUTHOR CONTRIBUTIONS
CS and CM planned and implemented the study and collected the data. CS implemented the statistical analyses and wrote the manuscript. CM worked over the manuscript to improve it. AC gave helpful advice and also worked over the manuscript to improve it.

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SUPPLEMENTARY MATERIAL
The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2019.00307/full#supplementary-material

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.