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## ORIGINAL ARTICLE

# Empathizing and systemizing are differentially related to dimensions of autistic traits in the general population



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### KEYWORDS

Autistic trait;  
Empathizing;  
Systemizing;  
Sub-clinical;  
Descriptive survey  
study

### Abstract

**Background/Objective:** Empathizing-Systemizing Theory suggests that low empathizing and high systemizing are linked to autistic traits in the general population. Evidence from autistic individuals is convincing, but more research in the normal population is needed. **Method:** We conducted two surveys ( $N=3,345$ ) investigating the relationships between empathizing, systemizing and autistic traits in the general population, using a large variety of self-report instruments and direct performance tests. **Results:** Strong connections between autistic symptoms, empathizing, and systemizing were found using commonly used measures (Autism Quotient, Systemizing Quotient and Empathizing Quotient). Other measures on empathizing and systemizing found the connections that E-S-theory predicts, but the correlations were a lot more modest. Weak empathizing was related to autism's social difficulties, while systemizing was linked to non-social aspects of autism. **Conclusions:** The present results support the main tenets of empathizing-systemizing theory, but suggest that earlier findings might be inflated due to overlapping items in the most common assessment instruments.

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### PALABRAS CLAVE

Rasgos autistas;  
empatía;  
sistematización;  
subclínico;

La empatía y la sistematización están relacionadas diferencialmente con las dimensiones de rasgos autistas en la población general

### Resumen

**Antecedentes/objetivo:** La Teoría de la Empatía-Sistematización (E-S) sugiere que la baja empatía y la alta sistematización se relacionan con rasgos autistas en la población general.

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estudio descriptivo  
mediante encuesta

La evidencia científica en sujetos autistas es consistente, pero es necesaria investigación en población normativa. **Método:** Se realizaron dos investigaciones basadas en encuesta ( $N = 3.345$ ) sobre la asociación entre empatía, sistematización y rasgos subclínicos autistas en población general haciendo uso de gran variedad de mediciones auto-informadas y pruebas de rendimiento. **Resultados:** Se hallaron fuertes relaciones consistentes con la teoría E-S entre rasgos autistas, empatía y sistematización de uso común, medidas con índices de uso común (Coeficiente del Espectro Autista, Coeficiente de Empatía y Coeficiente de Sistematización). En otros indicadores de empatía y sistematización se encontraron relaciones en concordancia con la teoría E-S, pero las correlaciones fueron mucho más modestas. Se obtuvo una relación entre baja empatía y las dificultades sociales propias del autismo, mientras que la sistematización se relacionó con aquellos aspectos no sociales del autismo. **Conclusiones:** Este trabajo corrobora los principios esenciales de la Teoría de la Empatía-Sistematización, pero sugiere a su vez que resultados previos pudieran estar sesgados debido al solapamiento de ítems en los instrumentos de medición más comúnmente usados.

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Autism spectrum disorder (ASD) is a developmental disorder, characterized by piecemeal processing of information, deficits in theory of mind, and impaired executive function (Hill, 2004; Romero et al., 2016). Baron-Cohen's empathizing-systemizing (E-S) theory suggests that two cognitive processes that develop universally in childhood help us to explain both the causes of autism spectrum disorders, and in general, autistic traits which are continuously distributed in the general population (Constantino & Todd, 2003). Empathizing is the ability and interest to identify other people's thoughts and emotions and to respond to them appropriately, whereas systemizing is the ability and interest in technical, motor, and abstract systems. While empathizing is a powerful way of understanding the social world, systemizing facilitates understanding inanimate phenomena. Normal variation exists, but according to the theory, if strong systemizing is combined with poor empathizing, it predicts healthy individuals' Asperger traits, and in extreme forms, autism spectrum disorders (Baron-Cohen, 2010).

The E-S theory has been influential and has received wide empirical support. Because the main focus of the theory is on ASD, the vast majority of the evidence rests on comparisons showing that individuals with ASD show higher systemizing and lower empathizing than people with neurotypical development (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003; Grove, Baillie, Allison, Baron-Cohen, & Hoekstra, 2015; Wilson et al., 2014). However, differences within the general population have received less research attention. As Ruzich et al. (2015) note, few studies include any characterization of the general population control groups or report any psychometric properties, even the shape of the distribution, of the measures used to assess autistic traits. Yet the power of the theory to explain the cognitive mechanism behind ASD depends on the assumption of interacting continua – finding that high systemizing and low empathizing are not related to autistic traits in the general population would imply that

the mechanisms giving rise to autistic traits are qualitatively different in the clinical population than in the general population.

Another aspect that needs attention when assessing the evidence for E-S theory is that most studies have examined empathizing, systemizing, and autistic traits as one-dimensional constructs, although recent studies have demonstrated their multidimensionality. The central and much-used Empathy Quotient (EQ; Baron-Cohen & Wheelwright, 2004), Systemizing Quotient (SQ; Baron-Cohen et al., 2003), and Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) all break into several dimensions (e.g., Hoekstra et al., 2011; Ling, Burton, Salt, & Muncer, 2009; Morales-Hidalgo, Hernández-Martínez, Voltas, & Canals, 2017; Muncer & Ling, 2006); EQ into cognitive empathy, social skills, and emotional reactivity; SQ into technicity, topography, and structure; and AQ into social skills, routine, switching, imagination, and fascination for numbers and patterns. We will examine whether these dimensions play different roles in the links between empathizing, systemizing, and ASD traits.

For example, E-S theory suggests that impaired empathizing is only related to autism's social difficulties, and systemizing only to its non-social aspects (Baron-Cohen, 2010), but we know of only one study so far that has found evidence for these predictions within the general population (Grove, Baillie, Allison, Baron-Cohen, & Hoekstra, 2013). Further, the E-S-theory suggests that both cognitive and emotional empathy are impaired in autism disorders (Baron-Cohen, 2010) but research evidence is mixed, with some studies finding impairments only in cognitive empathy (Rueda, Fernández-Berrocal, & Baron-Cohen, 2015) and others finding impairments in both (Grove, Baillie, Allison, Baron-Cohen, & Hoekstra, 2014).

Finally, a major limitation of the research record is that a vast majority of the studies have used the same assessment measures: Empathizing has typically been assessed only by the EQ and systemizing only by the SQ. Some evi-

dence indicates that EQ, SQ and AQ overlap heavily (Grove et al., 2013). Thus, any conclusions based solely on these measures need to be replicated using a different set of measures. Thus, we conducted two studies aiming to assess how the dimensions of autistic traits are associated with the dimensions of empathizing and systemizing in the general population. In Study 1, we used a large general population sample and the widely-used measures EQ and SQ, accompanied by performance measures of empathizing and systemizing. In Study 2, we included a wider range of measures, both self-rate and performance tasks, to conceptualize empathizing and systemizing.

## Study 1

### Method

#### Participants and Procedure

The participants were 3,043 Finnish individuals (for their characteristics, see Table 1). The participants were informed about the online study at several open internet discussion forums on topics of general interest (e.g., people, science) and by sending an email to several student mailing lists. No exclusion criteria for participation were applied. Participants were excluded from analyses involving measures on which they had more than 25% missing items.

Following Finnish law and the guidelines of the Finnish Advisory Board on Research Integrity (<http://www.tenk.fi/en/tenk-guidelines>), the Ethical Committee of the University of Helsinki approves studies that 1) do not fall within the category of medical research as defined in the Act on Medical Research, and 2) do fulfill specific requirements, without a separate ethical review. Psychological studies, which focus on the general adult population, include no intervention for the participants, obtain informed consent and impose no physical or mental harm or security risk for the participants, fulfill these requirements. Therefore approval for the study has been granted without review.

### Instruments

**Empathizing.** Self-reported empathizing was measured with the 15-item Empathy Quotient (EQ-Short; Muncer & Ling, 2006). The reliability (Cronbach's  $\alpha$ ) was .81. Average scores were calculated for the subscales Cognitive empathy ( $\alpha = .79$ ), Social skills ( $\alpha = .72$ ), and Emotional reactivity ( $\alpha = .67$ ). As in Baron-Cohen and Wheelwright (2004), the

response format (1 = *strongly disagree*, 2 = *slightly disagree*, 3 = *slightly agree*, 4 = *strongly agree*) was converted into scores of 0, 0, 1, and 2.

**Affective empathy** was measured by the Pictorial Empathy Test (PET;  $\alpha = .90$ , Lindeman, Koirikivi, & Lipsanen, 2016). It consists of 7 photographs of people experiencing negative emotions, and assesses the strength of the emotional reactions evoked by the photographs.

**Cognitive empathic ability** was measured with 13 items from the Reading the Mind in the Eyes Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The test consists of pictures of people's faces with different emotions and the participants' task is to identify the correct emotion among four options.

**Systemizing.** Self-reported systemizing was assessed with the 18-item Systemizing Quotient (SQ-Short; Ling et al., 2009). The scale ( $\alpha = .84$ ) has four subscales: Technicity ( $\alpha = .77$ ), Topography ( $\alpha = .67$ ), DIY ( $\alpha = .48$ ), and Structure ( $\alpha = .74$ ). The response format was the same as in the EQ scale.

**Systemizing skills** were assessed by using three different performance tests: mental rotation, map reading, and mechanics. The mental rotation test included 5 items asking participants to determine if two presented pictures represent the same object. Map reading ability was assessed using a task asking participants to match a map and 4 photographs to infer where each photograph was taken. Mechanical ability was assessed using 9 items from the Physical Prediction Questionnaire (PPQ; Lawson, Baron-Cohen, & Wheelwright, 2004), which asks the participants to infer how pressing a lever affects the movement of the other parts of a device. For details on the systemizing tasks, see Svedholm-Häkkinen and Lindeman (2016). A composite Systemizing Skill score was calculated by averaging the standardized scores of these three tasks.

**Brain type.** As the E-S theory argues that the crucial factor for autism is the relative balance between empathizing and systemizing, we calculated two variables expressing this relationship. First, we calculated the conventional "brain type" score, which is the difference between standardized self-rated systemizing and empathizing scores (Wakabayashi et al., 2006). Second, we calculated the "performance brain type" score, which was the difference between standardized scores on the performance tests of systemizing and empathizing ((map reading + mental rotation + mechanics)/3 - (PET + eyes)/2). These two brain type scores correlated highly with each other,  $r = .53$ . (All correlations in this article are Pearson correlations.)

**Table 1** Characteristics of the participants in Study 1 ( $N = 3,043$ ).

Age ( $M$ , $SD$ , range)	28.0, 8.8 (15-69)
Gender % (M/F)	35/65
Working / Studying / Other %	27/64/9
Autism Spectrum Quotient ( $M$ , $SD$ , range)	2.2 (0.3), 1.3-3.5
Empath Quotient (sum, $SD$ , range)	15.7(5.5), 0-29
Systemizing Quotient (sum, $SD$ , range)	12.8(6.7), 0-35
Brain type, self-reported ( $M$ , $SD$ , range)	0.0(15.1), -36.8 - 54.3
Brain type, performance ( $M$ , $SD$ , range)	0.2(1.0), -2.7-3.3

**Table 2** Correlations between systemizing, empathizing and autism spectrum traits in Study 1.

	AQ Total	Social	Routine	Switching	Imagination	Numbers
<i>Self-reported variables</i>						
EQ	-.66**	-.55**	-.26**	-.32**	-.52**	-.15**
Emotional reactivity	-.31**	-.27**	-.04*	-.10**	-.26**	-.16**
Cognitive empathy	-.50**	-.34**	-.17**	-.24**	-.52**	-.05*
Social skills	-.68**	-.63**	-.38**	-.38**	-.41**	-.15**
SQ	.11**	.09**	-.14**	.03	-.01	.39**
Technicity	.13**	.10**	-.10**	.06**	.05**	.28**
Topography	-.05**	-.02	-.19**	-.08**	-.07**	.23**
Structure	.12**	.09**	-.10**	.06**	-.07**	.41**
DIY	.09**	.07**	-.05**	-.02	.02	.23**
Brain type	.51**	.42**	.08**	.22**	.34**	.36**
<i>Performance measures</i>						
PET	-.31***	-.26**	-.11**	-.12**	-.27**	-.14**
EYES	-.11**	-.06**	-.03	-.08**	-.10**	-.09**
Systemizing skill	.16**	.11**	-.06	.13**	.10**	.19**
Map reading	.10**	.08**	-.04*	.08**	.06**	.14**
Mechanics	.19**	.12**	-.06**	.16**	.15**	.20**
Mental rotation	.07**	.04*	-.03	.06**	.03	.09**
Brain type (perf.)	.28**	.20**	.01	.18**	.22**	.23**

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$ .

Autistic traits. Traits associated with the autistic spectrum were assessed with the Autism Spectrum Quotient (AQ-short; [Hoekstra et al., 2011](#)). The scale ( $\alpha = .82$ ) includes 28 four-point items (1 = *definitely agree*; 4 = *definitely disagree*), which divide into subscales of Social skills (7 items,  $\alpha = .78$ ), Routine (4 items,  $\alpha = .54$ ), Switching (4 items,  $\alpha = .46$ ), Imagination (8 items,  $\alpha = .60$ ), and Fascination for numbers and patterns (5 items,  $\alpha = .57$ ). Scoring was done by averaging the 4-point response scale, rather than dichotomizing responses, as this improves validity in general population samples ([Murray, Booth, McKenzie, & Kuenssberg, 2016](#)).

## Results and Discussion

No marked gender differences in the correlations between the study variables emerged. Therefore, the correlations are reported for the whole sample in [Table 2](#).

As the table shows, the relationships between empathizing, systemizing, and autistic traits were different for different aspects of the constructs. While weak empathizing was related in particular to the social skill and imagination difficulties found in autism, systemizing was related to the non-social aspects (fascination for numbers and patterns). Regarding emotional and cognitive empathy, the results were different for self-ratings and performance measures. However, it is possible that the performance measures that we used were too narrow. In particular, the weak relationship of cognitive empathic ability with autistic traits should be interpreted with caution, as the evidence is mixed on how strongly the Eyes test measures empathy ([Allen-Walker & Beaton, 2014](#)).

As a whole, the relationships between empathizing, systemizing, and autistic traits appeared considerably stronger when using the EQ and SQ than when using any other measures. This finding leaves open the possibility that the results are due to overlap of these instruments, rather than to true links between empathy, systemizing, and autism. This possibility is alarming because the main evidence for the E-S theory so far has come from studies that use the EQ, SQ and AQ. Thus, a wider variety of measures is called for.

## Study 2

This study included a wider range of methods to assess both self-rated empathizing, and skills related to empathizing and systemizing. First, self-rated empathy was assessed using two well-validated instruments other than the EQ. Second, higher-level cognitive empathic ability was assessed using a novel task, the new Etiquette Scale. Third, we included a task assessing emotion recognition other than the Eyes test. Fourth, we added a validated and much-used instrument, the Intuitive Physics Test, to complement the systemizing measures used in Study 1.

## Methods

### Participants and Procedure

Three hundred and two people participated in the study (66% females, mean age 32, range 18–65). The participants were recruited by sending an e-mail to all individuals who had participated in Study 1 and who had given their consent to

participate in further studies ( $N = 1,537$ ). Of them, 237 could not be contacted because of outdated e-mail addresses and 887 did not take part in the present study. A further 44 were excluded because they responded to at least one attention check item. Finally, 67 participants were excluded because they indicated that they had a diagnosis or suspected they might have autism or an ASD. As in Study 1, participants were excluded from analyses involving scales with more than 25% missing answers. As for Study 1, ethical approval has been granted.

## Materials

**Empathizing.** To measure self-reported empathizing, we used the Interpersonal Reactivity Index (IRI;  $\alpha = .85$ , Davis, 1983), which includes 28 five-point items (0 = *does not describe me well*, 4 = *describes me very well*) and four 7-item subscales. Two of the subscales aim to assess cognitive empathy: Fantasy ( $\alpha = .77$ ) and Perspective taking ( $\alpha = .74$ ). Two subscales aim to assess affective empathy: Empathic concern ( $\alpha = .79$ ) and Personal distress ( $\alpha = .74$ ). In addition, we used the Basic Empathy Scale in Adults (BES-A;  $\alpha = .88$ , Carré, Stefaniak, D'Ambrosio, Bensalah, & Besche-Richard, 2013). BES-A includes 20 items rated on a five-point scale (1 = *strongly disagree*, 5 = *strongly agree*). We calculated the subscales of Affective empathy ( $\alpha = .88$ , 11 items) and Cognitive empathy ( $\alpha = .99$ , 9 items).

Cognitive empathic ability was assessed using a task asking participants to recognize basic emotions from facial expressions. The task used 14 images from the Averaged Karolinska Directed Emotional Faces (AKDEF) stimulus set (Lundqvist & Litton, 1998). The images depicted 7 female and 7 male faces in a frontal view expressing the six basic emotions fear, anger, disgust, happiness, sadness and surprise, and a neutral expression. For each image, participants chose which of these six emotions the image depicted.

To measure higher-level cognitive empathic ability, we created the Etiquette Scale (ES). By researching articles on etiquette mistakes we gathered a list of the most common ones. After piloting ( $N = 33$ ), the final scale consisted of 14 items, such as "I am late for appointments" and "I cut in line". The participants were told that we will ask them "about bad habits which we all have at least occasionally". The statements were presented twice, first with the question "How often do you behave like this?" (1 = *never*, or *almost never*, 5 = *very often*), and then with the question "Would you feel you were doing something wrong if you engaged in this behavior?" (1 = *no*, 5 = *with certainty*). We calculated subscales of Faux pas frequency ( $\alpha = .67$ ) and Guilt ( $\alpha = .86$ ) by averaging participants' responses to the items.

**Systemizing.** To assess systemizing ability and understanding of mechanistic principles, we used the Intuitive Physics Test (Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001). The test includes 20 multiple-choice items consisting of drawings and questions of how the depicted objects work, for example how a smaller wheel attached to a bigger wheel turns. Participants were given 10 minutes to complete the test.

## Results and discussion

The correlations between systemizing, empathizing and autistic traits are reported in Table 3. Because the results showed no systematic variation by age or gender, we only report results for the whole sample. As the table shows, weak self-perceived empathizing was related to autistic traits also when empathizing was measured with measures other than EQ. For example, empathic concern ( $r = -.33$ ) and personal distress ( $r = .35$ ) correlated with autistic traits. However, the correlations were again substantially smaller than those generally found when using EQ (Groen, Fuermaier, Den Heijer, Tucha, & Althaus, 2015).

On the performance tests of empathy, the strongest connection with autistic traits was found for the number of etiquette mistakes a person makes. Unsurprisingly, this was related to the social difficulties of autism, but not to the non-social aspects. Autistic traits were also weakly related to a lack of guilt over social blunders. The ability to recognize basic emotions from faces was also negatively, albeit weakly, related to the amount of autistic traits.

Systemizing skills, measured with the Intuitive Physics Test, were again correlated with autistic traits. The strength of the relationship was comparable to that of the tasks used in Study 1.

## General discussion

The present studies sought to investigate whether the interaction of low empathizing and high systemizing is linked to autistic traits in the general population, as it is in ASDs. Overall, the results were in line with the E-S theory, but with some important qualifications. We used several different assessment methods to tap into empathizing and systemizing, and we analyzed all the different dimensions of autistic traits separately: social skills, routine, switching, imagination, and fascination for numbers and patterns. Overall, autistic traits were more strongly related to reduced empathizing than to superior systemizing, replicating earlier findings (Carroll & Chiew, 2006; Groen et al., 2015).

Weak empathizing was related to autism's social difficulties, while systemizing was linked to non-social aspects of autism, all in line with E-S theory. This replicates the few studies that have investigated the relationships using all the AQ subscales (Grove et al., 2013, 2014), and may reflect the possibility that, like in ASDs (Happé, Ronald, & Plomin, 2006), deviations in social and non-social information processing related to autistic traits are dissociable even in the general population.

Out of the different subdomains of autistic traits the lack of imagination, along with weak social skills, showed the strongest associations with most measures of empathy, as well as with both brain type scores. This extends previous research with children, which shows that deficits in pretend play and other indices of imagination are among the core symptoms of autism (Ten Eycke & Müller, 2015). These results leave open for future studies what roles, if any, autistic-type routines and switching problems play for neurotypical people's psychological functioning.

**Table 3** Correlations between systemizing, empathizing, and autism spectrum traits in Study 2.

	AQ Total	Social	Routine	Switching	Imagination	Numbers
BES total	-.26**	-.22**	-.08	-.02	-.32**	-.08
BES affective	-.12*	-.13*	< .001	.04	-.17**	-.14*
BES cognitive	-.41**	-.30**	-.20**	-.15*	-.44**	-.01
IRI total	-.12	-.15*	-.02	.11	-.20**	-.07
Fantasy	-.17**	-.14*	-.02	.06	-.29**	-.12
Perspective taking	-.17**	-.24**	-.11	.01	-.23**	.05
Empathic concern	-.33**	-.30**	-.17**	-.06	-.30**	-.11
Personal distress	.35**	.24**	.23**	.31**	.27**	-.03
Basic emotion recog.	-.10	-.13*	.06	.04	-.04	-.13*
Faux pas frequency	.21**	.16**	.13*	.32**	.16**	-.06
Faux pas guilt	-.14*	-.11	-.05	-.03	-.12*	-.08
Intuitive Physics Test.	.16*	.09	.07	.03	.17**	.08

\*  $p < .05$ \*\*  $p < .01$ \*\*\*  $p < .001$ .

All connections were substantially more modest when empathizing and systemizing were assessed with other measures than EQ or SQ. This suggests that the evidence presented in support of E-S theory is highly dependent on the assessment measures used and raises the question whether some of the earlier findings reported might be due to artificial correlations. Inspection of the items in the EQ, SQ, and AQ reveals large overlaps. For example, the AQ item ‘‘I find social situations easy’’ is quite similar to the EQ item ‘‘I find it hard to know what to do in a social situation’’. Similarly, the AQ items assessing interests in numbers and patterns include statements such as ‘‘I notice patterns in things all the time’’, while the SQ Structure subscale contains a similar item: ‘‘In maths, I am intrigued by the rules and patterns governing numbers’’. This overlap can explain why [Grove et al. \(2013\)](#) found that the items in the AQ divide and load neatly onto factors with the EQ and SQ, indicating that the AQ construct is essentially a combination of the EQ and the SQ.

To better understand the relationship between empathizing and autistic traits, we analyzed the different dimensions of empathy separately, using both self-rating and performance tests. There is still debate on whether both cognitive and emotional empathy or only cognitive empathy are impaired in autism. Previous results with clinical populations have been mixed ([Fan, Chen, Chen, Decety, & Cheng, 2014](#); [Rueda et al., 2015](#)). The present study indicates that within the normal population, the relationship to autistic traits is more pronounced for self-rated cognitive empathy. These results were found when empathizing was assessed using the EQ or BES. When using IRI, the connection of cognitive empathy (the fantasy and the perspective taking subscales) to autistic traits was somewhat weaker than when using the other instruments.

The two other IRI subscales, empathic concern and personal distress, were also associated with autistic traits. These subscales are intended to assess emotional empathy, however, research indicates that both in fact measure other things. The empathic concern subscale assesses people’s own concerned reactions rather than compassion

([Baron-Cohen & Wheelwright, 2004](#)), while personal distress assesses feelings of anxiety in interpersonal settings ([Davis, 1983](#)), explaining why this subscale was positively rather than negatively related to autistic traits. Thus, in line with previous findings of heightened emotional processing in ASD ([Fan et al., 2014](#)), the present results show for the first time that even people with neurotypical development with autistic traits experience self-oriented unease in tense social situations. It has been proposed that suppressing such self-oriented anxiety is a cornerstone for well-functioning cognitive empathy ([Gilin, Maddux, Carpenter, & Galinsky, 2013](#)).

Out of the other measures of empathy, the PET had the strongest relationship with autistic traits. In particular, the social difficulties component of autistic traits was related to weaker emotional reactions to the pictures of suffering people. For all the other performance measures of empathy, the relationships with autistic traits were decidedly more modest. Still, the findings of even small relationships are interesting, and provide much-needed converging support for the link between autistic traits and empathizing abilities in the normal population.

In particular, we showed that the participants’ etiquette mistakes were related to autistic traits. Earlier research evidence on etiquette mistakes has concerned autistic individuals only ([Thiébaud et al., 2016](#)). Likewise, earlier research on basic emotion recognition accuracy has focused on comparing clinical ASD groups to people with neurotypical development. Individuals with ASD have been found to be slower at recognizing basic emotions from facial expressions, but findings regarding accuracy have been mixed ([Sucksmith, Allison, Baron-Cohen, Chakrabarti, & Hoekstra, 2013](#); [Wilson et al., 2014](#)). The present results indicate that in a general population, basic emotion recognition accuracy is related equally to both the social and non-social aspects of autistic traits.

On systemizing, the present results showed that ability at tasks such as map reading, mental rotation, and mechanical understanding were weakly but positively related to autistic traits among neurotypical people. Previous studies

have linked these tasks with self-rated systemizing (Cook & Saucier, 2010; Svedholm-Häkkinen & Lindeman, 2016), but few have looked at their connections with autistic traits, and we know of no previous studies distinguishing between the social and non-social aspects of autism in relation to systemizing. By the present data, systemizing skills were weakly related to both social and non-social autistic traits. These results are similar to those of previous general population studies, which have tended to find systemizing skills and autistic traits to be independent of each other (Carroll & Chiew, 2006).

If we compare the magnitudes of correlations, the performance measures painted a different picture from the self-rating measures regarding the question of how strongly empathy and systemizing are related to autistic traits. Although most of the scales have been validated in general population, the performance measures that we used varied widely in format, and their validity and psychometric properties have not been rigorously tested, impeding comparisons of their results. Thus, the status of the various performance tasks calls for replication studies with sufficient statistical power. Moreover, one important limitation is that the studied samples were not representative of general population. For now, we argue that the main implication of the current results is that systemizing, empathy and autistic traits are linked in the general population, even when assessed using measures other than the EQ and the SQ, but the associations may not be as strong as suggested by some studies relying exclusively on self-ratings.

## Conclusions

In all, the present study is in line with the main tenet of E-S theory, that the interaction of weak empathizing and strong systemizing are the cognitive mechanisms at the root of autistic traits. Because we used a wide variety of measures, including self-rate measures and skill tasks developed in research traditions other than the E-S theory, these findings bring much-needed converging evidence supporting the assumption that E-S theory can be a useful explanation of autistic traits in the general population. However, the present results also lead to the conclusion that the correlations between the AQ and the EQ and SQ are substantially inflated, and highlight the value of using multiple methods, because the results revealed that the associations between autistic traits, empathizing, and systemizing were driven by specific subscales, not the overall constructs. In particular, the relationship between empathy and autistic traits was largely driven by problems in social skills and imagination, while switching and routines played a minor role. Systemizing, in turn, was related mainly to the non-social aspects of autistic traits. What is more, clear differences emerged between self-report and performance measures, the reasons for which should be investigated in future studies.

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