Autism spectrum disorder traits are associated with empathic abilities in adults with anorexia nervosa

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Abstract

Background: Social and emotional difficulties have been identified as key factors in the development and maintenance of anorexia nervosa (AN). However, few studies have investigated the influence of comorbid psychopathology on social cognition. The aim of the current study was to examine perception of nonverbal communication and empathy in AN using ecologically valid, performance-based measures, and to explore associations with comorbid psychopathology (anxiety, depression, autism spectrum disorder (ASD) traits, alexithymia, and social anxiety). **Methods**: In this cross-sectional study, the Multifaceted Empathy Test (MET) and the Mini Profile of Nonverbal Sensitivity (MiniPONS) were administered to 51 adults with AN, 51 recovered AN (REC), and 51 healthy controls (HCs). Comorbid psychopathological traits were assessed using self-report questionnaires and the Autism Diagnostic Observation Schedule – 2nd edition (ADOS-2). **Results**: Individuals with AN showed reduced affective empathy to positive stimuli compared to HCs, and a trend towards lower vocal prosody recognition scores relative to REC. Around a quarter of AN and REC scored above the clinical cut-off for ASD on the ADOS-2, and high ASD symptoms predicted lower cognitive and affective empathy scores. **Limitations**: The study is cross-sectional, future research would benefit from examining social-cognition performance and comorbid psychopathology longitudinally. **Conclusions**: The findings highlight the importance of ASD symptoms in empathy dysfunction in those with a lifetime history of AN. Future research should explore whether treatment adaptations to accommodate for differences in social-cognitive abilities may be helpful in the treatment of AN.

Key words: anorexia nervosa, empathy, emotion recognition, ASD, comorbidity

Introduction

Contemporary models of eating disorders (EDs) such as anorexia nervosa (AN) suggest social and emotional difficulties are key factors in the development and maintenance of the disorder (Treasure & Schmidt, 2013). During the illness, a variety of social difficulties are seen, including social anxiety (Kerr-Gaffney et al., 2018), poorer social skills (Rhind et al., 2014; Winecoff et al., 2015), and less social support (Tiller et al., 1997). Given that interpersonal problems are associated with more severe ED psychopathology (Illing et al., 2010; Tasca et al., 2011) and poorer outcomes (Franko et al., 2013; Gillberg et al., 1994; Jones et al., 2015; Zipfel et al., 2000), it is important to understand possible underlying mechanisms. One area that has received considerable attention is emotion recognition, an aspect of theory of mind (ToM). Those with AN show difficulties in recognising emotions and inferring the mental states of others, compared to healthy controls (HCs) (Bora and Kose, 2016). Individuals with AN may also have difficulties in other aspects of ToM, such as understanding social interactions and implicit social attribution, however research in this area is lacking (Leppanen et al., 2018).

The majority of emotion recognition studies in AN have used static images restricted to the face or eye-region only (Leppanen et al., 2018). Consequently, much of the information that is inherent in everyday social interactions, such as tone of voice, body language, and context is missing from such stimuli. Research has therefore investigated emotion recognition using different modalities of nonverbal communication in order to better understand the mechanisms that may underlie social difficulties in AN. For example, a few studies have examined emotion recognition from body movements or voice only. Individuals with AN were less accurate at recognising sadness but better at recognising anger conveyed through body movements compared to weight-restored AN and HCs (Lang et al., 2015; Zucker et al., 2013). However group differences became non-significant after controlling for BMI in one

study (Zucker et al., 2013). AN were also less accurate than HCs at recognising emotions conveyed through voice (Kucharska-Pietura et al., 2004; Oldershaw et al., 2010). Again, group differences were not significant in one study when covariates (age, education, depression) were controlled for. Finally, a few studies have examined perception of nonverbal behaviour more holistically, using paradigms that include facial expression, posture, and vocal prosody together. For example, Gramaglia et al. (2016) used the Awareness of Social Inference Test (TASIT; McDonald et al., 2002), finding no significant differences between individuals with AN and HCs in identifying emotional states from video clips. However, the clips involved speech, therefore the task cannot be considered a pure measure of nonverbal communication only. Thus, the limited research available suggests there may be differences in perception of nonverbal communication in those with AN, however further exploration of the impact of various clinical factors, such as anxiety, depression, and BMI is required.

Relatedly, there is some evidence to suggest there are differences in empathy in AN. Empathy is considered a key component of prosocial behaviour and social cognition, as it allows us to make sense of and respond appropriately to others' behaviour (Decety et al., 2016; Eisenberg and Miller, 1987). It comprises two major facets: cognitive and affective empathy. While cognitive empathy refers to the ability to recognise and understand the mental states of others (overlapping with the concept of ToM); affective empathy is the ability to share the feelings of others, without any direct emotional stimulation to oneself (Blair, 2005). Based on longitudinal research in a community sample, Gillberg and colleagues reported on a subgroup of participants with AN with "empathy disorders." This group had severe problems in social understanding and communication, consistent with a diagnosis of autism spectrum disorder (ASD) (Gillberg et al., 1994). Poorer outcomes in terms of recovery and psychosocial functioning were found in this group (Anckarsäter et al.,

2012; Wentz et al., 2009). More recently, several studies have used self-report measures to investigate empathy in AN. A meta-analysis of these studies reported that while overall empathy and affective empathy did not differ between AN and HC, those with AN had significantly lower cognitive empathy scores (Kerr-Gaffney et al., 2019). However, self-reported measures of empathy are limited in that they measure how empathetic individuals perceive themselves to be, rather than providing an objective measure of performance.

In those with EDs, only two studies have used a performance-based or "online" measure of empathy. Both studies found no significant differences between ED and HC groups in empathic ratings to videos or in an empathy for pain paradigm (Cardi et al., 2015; Brewer et al., 2019). However, the latter study demonstrated that high levels of alexithymia were associated with increased empathic personal distress (Brewer et al., 2019). These studies both used mixed ED samples (AN and BN), limiting the generalisability of the results for either of the two disorders, and only affective empathy was assessed. Importantly, the study by Brewer et al. (2019) demonstrates that comorbid traits such as alexithymia may explain differences in emotion processing, rather than the ED itself. Indeed, other studies in EDs have shown that alexithymia rather than ED diagnosis predicts emotion recognition abilities (Brewer et al., 2015). Thus, it is possible that the mixed results in emotion processing studies in EDs are due to samples differing in their levels of alexithymia, such that when alexithymia is particularly high in the ED group (or low in the HC group) a group difference is found.

Several other comorbid traits may influence socio-emotional cognition in AN in this way. For example, between 4 and 50% of individuals with AN show high ASD traits – scoring above clinical thresholds on diagnostic interviews for ASD (Anckarsäter et al., 2012; Vagni et al., 2016; Westwood et al., 2018, 2017). Individuals with ASD show difficulties in ToM (Happé, 1994; Kleinman et al., 2001), emotion recognition (Bal et al., 2010; Harms et

al., 2010; Hubert et al., 2007), empathy (Baron-Cohen and Wheelwright, 2004; Kok et al., 2016), and social attention (Chita-Tegmark, 2016). Further, ASD traits in the general population are associated with more difficulties in these areas (Blain et al., 2017; Halliday et al., 2014; Luo et al., 2017; Zhao et al., 2018). Therefore, it is possible that high levels of ASD traits co-occur with socio-emotional processing difficulties in a proportion of those with AN. Although a few studies have found associations between high ASD traits and more severe socio-emotional difficulties, such as alexithymia (Westwood et al., 2017), social anhedonia (Adamson et al., 2018), and flattened facial affect (Lang et al., 2016), research exploring the effect of ASD traits on social cognition performance in AN is lacking. Anckarsäter et al. (2012) assessed ToM performance using the Happe cartoon task, comparing those with AN who also met criteria for ASD (AN+ASD) to those who did not (AN-ASD), as well as HCs. HCs were significantly more accurate on the mental cartoons task than AN+ASD, whereas performance in the AN-ASD group did not significantly differ from either of the other two groups, lying in the middle.

The aim of this experimental study was to examine cognitive and affective empathy and perception of nonverbal communication in AN, recovered AN (REC), and HCs. A secondary aim was to explore potential relationships between comorbid psychopathological traits and performance on social cognition tasks. As well as including measures of the aforementioned ASD traits and alexithymia, we included depression, anxiety, and social anxiety, due to their high co-occurrence with AN (Kerr-Gaffney et al., 2018; Pollice et al., 1997; Swinbourne and Touyz, 2007) and potential effects on social cognition (Attwood et al., 2017; Bourke et al., 2010; Demenescu et al., 2010; Hezel and McNally, 2014; Schreiter et al., 2013; Washburn et al., 2016).

Based on previous literature documenting difficulties in self-reported cognitive empathy (Kerr-Gaffney et al., 2019), we hypothesised that individuals with AN would show

poorer cognitive empathy performance compared to HCs, but no differences in affective empathy. We expected an intermediate cognitive empathy profile in REC (scores lying between that of AN and HC). Regarding perception of nonverbal communication, we hypothesised that AN would show lower overall performance compared to HCs. We did not make any prediction on the specific modalities affected, due to a lack of research in this area.

Methods

Participants

Ethical approval was obtained from the National Health Service Research Ethics Committee (Camberwell St Giles, 17/LO/1960). All participants were required to be between 18 and 55 years old and fluent in English. Exclusion criteria were a history of brain trauma or learning disability. HC participants were recruited through a King's College London email circular and posters around campuses. Before taking part, HC participants were screened using the Structured Clinical Interview for DSM-5 Disorders, research version (SCID-5-RV; First et al., 2015), to ensure they did not meet criteria for any psychiatric disorders. HCs were required to have a body mass index (BMI) between 19 and 27.

In addition to the university advertisements, participants with AN or REC were recruited through online advertisements (B-eat, call for participants, MQ mental health). Participants with AN were also recruited through two specialist NHS ED services in London. AN and REC were screened using the SCID-5-RV to confirm a current or past diagnosis of AN. Participants with AN were required to have a BMI $\leq$ 18.5, and REC participants a BMI between 19 and 27. Further, REC participants were required to have maintained a BMI within this range for at least 1 year prior to testing.

Materials

The Wechsler Abbreviated Scale of Intelligence - Second Edition (WASI-II; Wechsler, 2011) measures verbal intelligence and perceptual reasoning, as well as full-scale IQ. The two subtest version was used (vocabulary and matrix reasoning).

The Eating Disorder Examination Questionnaire (EDE-Q; Fairburn and Beglin, 1994) measures severity of ED psychopathology. Global scores are calculated by averaging responses across items, with higher scores indicating more severe symptoms (max 6). HCs with a score of >2.7 were excluded to ensure those with possible sub-threshold ED symptoms were not included (Lang et al., 2016). Cronbach's alpha was 0.98.

The Autism Diagnostic Observation Schedule – 2nd edition (ADOS-2), Module 4 (Lord et al., 2012) is a standardised semi-structured interview for the assessment of ASD. It includes a range of questions and activities designed to evoke behaviours and cognitions associated with ASD. The revised algorithm, which was designed to more closely reflect the DSM-5 criteria for ASD was used for scoring (Hus and Lord, 2014). The algorithm has two subscales: social affect and restrictive and repetitive behaviours, and total scores of 8 or more indicate possible ASD. The ADOS-2 was used in this study to provide an observational measure of ASD traits, which is recommended in the assessment of ASD (NICE, 2012). Interviews were administered and scored by the first author, who received ADOS-2 training and met requirements for research reliability.

The Social Responsiveness Scale-2nd Edition, adult self-report form (SRS-2; Constantino and Gruber, 2005) measures symptoms associated with ASD, with higher scores (max 195) indicating more autistic symptoms. There are 5 sub-scales: social awareness, social cognition, social communication, social motivation, and restrictive interests and repetitive behaviour. Cronbach's alpha was 0.97.

The Hospital Anxiety and Depression Scale (HADS; Zigmond and Snaith, 1983) is a 14 item scale with two subscales: anxiety and depression. Subscale scores are interpreted as: normal (0-7), mild (8-10), moderate (11-14), and severe (15-21). Cronbach's alpha was 0.94.

The Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) has two subscales: fear and avoidance of social situations. A score of 30 has been established as a cut-off indicative of SAD (Rytwinski et al., 2009). Cronbach's alpha was 0.97.

The twenty-item Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994) has three subscales: difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Total scores range from 0 to 100, and cut-offs are as follows: ≤51 = no alexithymia; 52-60 = borderline alexithymia; and ≥61 = alexithymia (Parker et al., 1993). Cronbach's alpha was 0.90.

The Work and Social Adjustment Scale (WSAS; Mundt et al., 2002) is a brief measure of functional impairment in five domains: work, home management, social leisure, private leisure, and ability to form and maintain close relationships. Scores range from 0 to 40, with a score of 20 or more indicating clinical significance. Cronbach's alpha was 0.93.

The Multifaceted Empathy Test (MET; Dziobek et al., 2008) is a performance-based measure of cognitive and affective empathy, using photo-realistic, context-embedded stimuli. Forty photographs of people in various emotional states (20 positive and 20 negative) are presented twice. In 40 trials participants are asked to identify which emotion the person is feeling out of a choice of four emotions (cognitive empathy), and in a further 40 trials they are asked to indicate how much they empathise with the person depicted on a scale of one (not at all) to nine (a lot) (affective empathy). The outcome measure for cognitive empathy is a total correct score out of 40 (although note that scores in normative samples do not reach ceiling, e.g., Drimalla et al., 2019; Kuypers et al., 2017), while affective empathy is a mean score out of 9.

Positive and negative empathy scores can be calculated for affective and cognitive empathy. The MET was presented on a 14" monitor using Psychopy (Pierce, 2009).

The Mini-Profile of Nonverbal Sensitivity (MiniPONS; Bänziger et al., 2011) measures the ability to recognise emotions, interpersonal attitudes, and intentions from different modes of nonverbal communication (face only, body only, voice only, face and voice together). The task consists of 64 clips (2s each), depicting the same actor in different interpersonal situations. Respondents are required to indicate the correct answer from a choice of two after each clip. The short version used here correlates highly with the full version, which has been validated in a number of populations (Rosenthal et al., 1979). A total score out of 64 is calculated, as well as scores out of 16 for each of the 4 channels. Accuracy in a normative sample in the original validation study was 80% for total scores (Bänziger et al., 2011).

Procedure

Participants attended a testing session at the Institute of Psychiatry, Psychology & Neuroscience, however where participants were inpatients (N = 11), testing took place at their place of treatment. Written informed consent was obtained. The first author administered the WASI-II, followed by the MET and the MiniPONS, and then conducted the ADOS-2. Finally the participant completed the questionnaires. At the end of the session, participants' heights and weights were taken to calculate BMI (weight/height^2). The session took around 2 hours, and all participants were reimbursed £20 for their time.

Data analysis

Histograms and Q-Q plots were inspected to check for normal distributions. Where variables were positively skewed, a logarithmic transformation was applied. Homogeneity was assessed using Levene's test. Group differences in social cognition, psychopathology, and demographic information were assessed using one-way ANOVAs and Tukey's post-hoc tests, or Welch's ANOVA with Games-Howell post-hoc tests where the assumption of homogeneity was violated. Independent samples t-tests were used when assessing group differences between AN and REC only. Chi-squared tests of homogeneity (or Fisher's exact test where the sample size assumption was not met) were conducted for dichotomous variables.

Pearson's correlations were run to explore potential relationships between psychopathology (EDE-Q, HADS anxiety, HADS depression, LSAS, SRS-2, TAS-20, WSAS, and ADOS-2 total scores), demographic variables (age, IQ, BMI, age at diagnosis, illness length), and performance on social cognition tasks. Where significant correlations were found, hierarchical linear regressions were run to examine whether dimensions of psychopathology predicted social cognition performance, after controlling for associated demographic variables and group membership.

Results

Demographic information

One hundred and fifty-three participants were recruited. Out of 51 HCs, 5 were excluded based on their EDE-Q scores, and 1 REC participant was excluded due to BMI >27. Thus, 46 HCs, 51 AN and 50 REC participants were included in analyses. Demographic information is presented in Table 1. Groups were of similar age, gender, and IQ. As expected, AN had a significantly lower BMI than both REC and HC (both $p<.001$). Age at diagnosis

was significantly older in individuals with AN compared to REC, and they were more likely to be taking a psychiatric medication. Seventy-eight percent of participants with AN had a diagnosis of AN restricting sub-type (AN-R), the rest had AN binge-purge subtype (AN-BP). AN-R and AN-BP did not differ on any demographic variable or performance on social-cognitive tasks, however AN-BP had significantly higher HADS depression scores, t(49)=-2.08, p=.043 and TAS-20 scores, t(31.55)=-2.16, p=.038.

TABLE 1 HERE

Psychopathology

Scores on self-report questionnaires assessing dimensions of psychopathology and functional impairment are presented in Table 2, as well as ADOS-2 total and subscale scores. On each self-report scale, all three groups significantly differed from one another, with AN showing the highest levels of psychopathology, REC an intermediate profile, and HC the lowest scores. Regarding the ADOS-2, AN had significantly higher total, SA, and RRB scores than HCs (all p<.01). A significantly higher proportion of AN and REC participants scored above the clinical cut-off for ASD compared to HC (both p<.05).

TABLE 2 HERE

Social cognition

Results from the MET and MiniPONS are presented in Table 3. Groups did not significantly differ in their total cognitive empathy scores or mean affective empathy. However, AN had significantly lower positive affective empathy scores compared to HC (p=.004). Groups did not differ on total MiniPONS scores, however an ANOVA revealed perception of nonverbal communication through voice significantly differed between groups. Post hoc tests indicated a trend towards AN scoring lower than REC, p=.057.

TABLE 3 HERE

Associations between psychopathology and social cognition

Cognitive empathy scores were significantly positively associated with IQ (r=.29, p<.001) and age (r=.22, p=.009), and negatively correlated with ADOS-2 (r=-.29, p<.001), SRS-2 (r=-.23, p=.005), and TAS-20 scores (r=-.20, p=.02). A hierarchical multiple regression was run to determine if the addition of ADOS-2 and TAS-20 scores would improve the prediction of cognitive empathy scores over group membership, age, and IQ.[1] The full model was significant, R^2=.20, F(6, 132)=5.37, p<.001, adjusted R^2=.16. Details of each regression model are displayed in Table 4. The addition of ADOS-2 scores to the prediction of cognitive empathy (Model 2) led to a significant increase in R^2 of .04, F(1,133)= 6.48, p=.012. The addition of TAS-20 scores (model 3) did not significantly add to the prediction.

TABLE 4 HERE

Mean affective empathy was significantly positively correlated with BMI (r=.17, p=.042), and negatively correlated with WSAS (r=-.23, p=.006), HADS anxiety (r=-.24, p=.004), HADS depression (r=-.26, p=.002), LSAS (r=-.22, p=.009), TAS-20 (r=-.35, p<.001), SRS-2 (r=-.37, p<.001), and ADOS-2 total scores (r=-.30, p<.001). A hierarchical multiple regression was run to determine if the addition of ASD symptoms, HADS anxiety and depression, LSAS, and TAS-20 scores would improve the prediction of affective empathy scores over group membership and BMI.[2] The full model was significant, R^2=.18, F(7, 132) = 4.03, p<.001, adjusted R^2=.13. Details of each regression model are displayed in Table 5. The addition of ADOS-2 scores to the prediction of cognitive empathy (Model 2) led

[1] SRS-2 scores were not included in the regression due to the correlation with ADOS-2 scores
[2] WSAS scores were not included in the regression due to the hypothesised direction of causality between variables

to a significant increase in R^2 of .08, F(1,135)=12.42, *p*=.012. The addition of HADS (model 3), TAS-20 (Model 4), and LSAS scores (Model 5) did not significantly add to the prediction.

TABLE 5 HERE

Total MiniPONS scores were positively correlated with BMI (r=.21, *p*=.01) and IQ (r=.27, *p*=.001), and negatively correlated with WSAS (r=-.19, *p*=.026), HADS depression (r=-.20, *p*=.019), SRS-2 (r=-.29, *p*=.001), and ADOS-2 (r=-.21, *p*=.011). A hierarchical multiple regression was run to determine if the addition of ADOS-2 scores and HADS depression would improve the prediction of MiniPONS scores over group membership, BMI, and IQ. The full model was significant, R^2=.12, F(6, 134)=2.90, *p*=.011, adjusted R^2=.08. See Table 6 for details of each regression model. The addition of ADOS-2 scores (model 2) and HADS depression (model 3) did not significantly add to the prediction of MiniPONS scores.

TABLE 6 HERE

Associations between ASD symptoms and cognitive and affective empathy were explored further by grouping individuals with lifetime AN (REC and current AN) based on whether they met the clinical cut-off for ASD on the ADOS-2, and comparing their scores with HCs. The two HCs who scored above cut-off on the ADOS-2 were excluded, due to their being too few cases to assess group differences. Thus, 44 HC, 26 lifetime AN scoring above ADOS-2 cut-off (AN+ASD), and 75 lifetime AN scoring below the ADOS-2 cut off (AN-ASD) were included in analyses. Results are displayed in Figure 1. One-way ANOVAs with Tukey's post-hoc tests indicated that AN+ASD had significantly lower total cognitive empathy and positive cognitive empathy scores compared to AN-ASD (*p*=.015 and *p*=.019 respectively). AN+ASD also had significantly lower mean affective empathy scores than AN-ASD (*p*=.011) and HC (*p*=.003), and lower positive affective empathy scores than AN-ASD

(p=.049) and HC (p<.001). AN-ASD and HC did not significantly differ on any of the MET outcome measures.

FIGURE 1 HERE

Discussion

The primary aim of the current study was to compare performance across socio-emotional cognition tasks in individuals with AN, recovered AN, and HCs. To our knowledge, this is the first study to use a performance-based measure of cognitive and affective empathy in AN. Contrary to our hypothesis, there were no differences in cognitive empathy across groups. Instead, those with AN showed significantly lower affective empathy performance when stimuli were positively valanced, compared to HC. Performance in the REC group reflected an intermediate profile and did not significantly differ from that of the other two groups. Regarding perception of nonverbal behaviour, no significant group differences in total MiniPONS scores were found. However, there was a trend towards lower vocal prosody perception scores in AN relative to REC. In addition, associations between social cognition performance, dimensions of psychopathology, and demographic variables were found. Each of these findings will be discussed in turn.

The lack of group differences in cognitive empathy contrasts with findings from a recent meta-analysis, which found that individuals with AN had lower self-reported cognitive empathy scores (small effect size) compared to HC (Kerr-Gaffney et al., 2019). Discrepancies between self-report and performance-based measures of empathy have been found in other psychiatric disorders, such as schizophrenia (Bonfils et al., 2016; Derntl et al., 2009). Self-reporting one's own empathic abilities may be particularly difficult in those with high levels of alexithymia, as was the case in our AN group. Our results also contrast with

previous studies showing emotion recognition difficulties in AN (Caglar-Nazali et al., 2014). There are a number of possible explanations for this. The MET, while showing relatively complex emotional states, also includes contextual information (e.g., a woman looking tired in a hospital bed). Thus, the cognitive empathy test in the MET does not measure pure emotion recognition ability from isolated facial expressions. A tentative conclusion may be that while individuals with AN have some difficulties in recognising emotions from faces alone, they are able to attend to other cues in the environment that facilitate understanding and empathising ability.

Another explanation for the lack of group differences in cognitive empathy (and overall affective empathy) scores concerns another of our findings: ASD symptoms predicted empathic abilities, rather than AN diagnosis. The correlation analysis showed that higher cognitive empathy scores were associated with higher IQ and older age, and lower levels of alexithymia and ASD symptoms (measured by both the ADOS-2 and SRS-2). When entered into regression models, IQ, age, and ADOS-2 scores remained as significant predictors of cognitive empathy scores. Higher affective empathy scores were correlated with higher BMI, and lower levels of anxiety, depression, social anxiety, alexithymia, ASD symptoms (measured by both the SRS-2 and ADOS-2) and work and social adjustment difficulties. However, when entered into the regression model, only ADOS-2 scores significantly predicted affective empathy scores. Further, individuals with lifetime AN who scored above the clinical cut-off on the ADOS-2 (AN+ASD) had lower overall and positive cognitive empathy scores, compared to those who scored below the cut-off (AN-ASD). AN+ASD also had lower overall affective empathy and positive affective empathy scores than both AN-ASD and HCs, who did not differ from one another on any empathy measure. Thus, it is possible that variations in ASD symptoms across study samples contribute to the mixed findings in emotion recognition and empathy studies in AN. It must be noted that R^2 was

rather small in our regression analyses, suggesting other unmeasured factors also contributed to empathic abilities.

Despite ASD symptoms being a better predictor of overall affective empathy, individuals with AN had lower positive affective empathy scores compared to HCs. This is in agreement with a few studies investigating facial expressivity – a component of empathy that has been termed "motor empathy" (Blair, 2005). Two studies found that those with AN produced fewer positive facial expressions in response to a positive film clip compared to HC, whereas there was no difference between groups while watching negatively valanced clips (Cardi et al., 2014; Lang et al., 2016). Although not included in our study, previous research using the MET has found that affective empathy scores are strongly associated with degree of facial expressivity during the task (Drimalla et al., 2019). Difficulties in empathising with positive emotions in others in AN may be related to higher levels of social anhedonia – a lack of pleasure and reward from social interaction (Tchanturia et al., 2012). If individuals with AN are less able to share the positive emotions of others, they may be less likely to seek out social interactions, leading to further isolation and difficulties with relationships. Further, a lack of expression of positive empathic responses during social interactions is likely to signal disinterest or rejection. This finding may be important in developing interventions that aim to increase positive emotions and develop social skills to improve social life in AN (Lyubomirsky and Layous, 2013).

In addition to intact cognitive empathy performance, the results from the MiniPONS generally do not support the hypothesis that individuals with AN have difficulties in understanding emotions and intentions through nonverbal communication. This is consistent with findings of a previous study, which did not find significant differences in performance on the TASIT in individuals with AN compared to HCs (Gramaglia et al., 2016). Considering predictors of MiniPONS performance, IQ was found to be the only significant predictor in

regression models. The association between IQ and interpersonal sensitivity has been reported in several studies previously (Murphy and Hall, 2011). This might be due to some common variable involved in both understanding others and performance on IQ tests, such as attention. However the results from the regression model in this study would suggest a causal relationship – higher intelligence may allow for a better understanding of meaning from nonverbal cues. This would also explain the association found between IQ and cognitive but not affective empathy performance.

In the current study 27.5% of AN and 24% of REC met the clinical cut-off for ASD on the ADOS-2, a significantly greater proportion than in the HC group (4.3%). Past research has reported similar findings, although few studies have included a REC group (Anckarsäter et al., 2012; Bentz et al., 2017; Vagni et al., 2016; Westwood et al., 2017). It has been argued that high levels of ASD traits seen in AN are a consequence of starvation, or some other factor associated with the ill state (Hiller and Pellicano, 2013). Given that almost the same proportion of individuals in our REC group scored above the clinical cut-off, starvation is unlikely to be the major contributor to elevated ASD traits in our study. Similarly, it could be that psychomotor agitation (e.g., tapping, restlessness, fidgeting) associated with high levels of anxiety and/or depression (Zbozinek et al., 2012) in AN and REC groups is being interpreted as sensory motivated autistic behaviours on the ADOS-2. However, a recent study using the new scoring algorithm found that anxiety, depression, and BMI were not associated with ADOS-2 scores in REC or AN (Sedgewick et al., 2019). Thus, our study supports the view that ASD symptoms are stable traits in a proportion in those with AN.

Limitations

A limitation of the current study is the cross-sectional design. It is possible that differences in social-cognitive functioning or psychological resources contributed to the

recovery of the REC group. Future research would benefit from following the same group of individuals with AN before and after recovery. Further, our study only examined a limited range of socio-emotional skills. Future studies could examine associations between comorbid psychopathology and other aspects of socio-emotional cognition in order to provide a more complete picture of the nature of social dysfunction in AN. Another limitation relates to the assessment of ASD symptoms. Although the ADOS-2 is considered a 'gold-standard' tool for assessing current ASD symptoms, it does not provide enough information to give a diagnosis of ASD. Research using developmental measures in addition to assessing current symptoms would be informative in further defining social cognition in the AN+ASD sub-group. Further, the interviewer administering the ADOS-2 was not blind to the diagnostic status of the groups, potentially introducing bias into the scoring. Finally, a history of psychiatric disorders was an exclusion criteria for HCs, therefore this group may not be representative of the broader population.

Conclusions

Our data show that the presence of AN alone does not lead to lower empathy performance overall, with the exception of positive affective empathy. Rather, those with a previous or current diagnosis of AN plus high ASD symptoms demonstrated lower cognitive and affective empathy compared to those with low ASD symptoms. Individuals with AN and high ASD traits may require different treatment approaches or adaptations. For example, previous research has shown that patients with ASD and AN and their clinicians report difficulties in communicating with one another and a lack of understanding of each other's perspective (Kinnaird et al., 2019, 2017). While a number of interventions have been developed to target facets of social cognition in adults with ASD, improvements tend to be specific to the cognitive task in question, rather than extending to wider aspects of social life

(Pallathra et al., 2019). Such interventions might be worth exploring in individuals with AN and high ASD traits who show difficulties in empathy and emotion recognition.

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Table 1. Mean (SD) demographic information

	AN (N = 51)	REC (N = 50)	HC (N = 46)	Test statistics	*p*-value	$\eta p^2/d$
Age (years)[†]	27.57 (8.52)	26.33 (8.04)	24.37 (4.43)	F(2, 92.29) = 2.50	.09	.03
% female	92.2	98.0	93.5	Fisher's exact test = 1.89	.44	
BMI	15.72 (1.41)[a]	21.20 (1.95)[b]	21.69 (1.88)[b]	F(2, 143) = 178.44	**<.001**	.71
Years of education	16.22 (3.15)	16.53 (2.59)	16.63 (2.45)	F(2, 143) = 0.42	.66	.01
IQ	109.69 (13.28)	109.66 (11.28)	113.78 (7.25)	F(2, 143) = 2.16	.12	.03
Age diagnosed[†]	19.64 (7.22)[a]	16.44 (3.53)[b]	-	t(83.56) = 2.70	**.01**	.56
Illness length (years)	7.19 (7.45)	5.31 (5.62)	-	t(90.92) = 1.63	.11	.28
% on psychiatric medication	54.9[a]	32.0[b]	-	$X^2 = 5.39$	**.02**	

AN, anorexia nervosa; BMI, body mass index; HC, healthy control; IQ, intelligence quotient; REC, recovered anorexia nervosa; SD, standard deviation;

Different superscripts indicate significant differences between groups, significant *p*-values are highlighted in bold.

[†]Variable was log transformed for analyses, original values are displayed.

Table 2. Mean (SD) scores on self-report questionnaires and ADOS-2

	AN (N = 51)	REC (N = 50)	HC (N = 46)	Test statistics	*p*-value	ηp²
EDE-Q	3.85 (1.37)[a]	1.82 (1.51)[b]	0.61 (0.58)[c]	F(2, 80.38) = 118.73	**<.001**	.54
HADS anxiety	13.92 (4.46)[a]	10.78 (5.07)[b]	5.02 (3.09)[c]	F(2, 93.61) = 71.10	**<.001**	.42
HADS depression	10.14 (4.31)[a]	5.00 (3.99)[b]	1.54 (1.68)[c]	F(2, 83.47) = 92.50	**<.001**	.50
LSAS	71.68 (31.41)[a]	56.60 (29.86)[b]	27.91 (18.32)[c]	F(2, 91.43) = 41.29	**<.001**	.31
SRS-2	85.29 (32.78)[a]	70.04 (31.97)[b]	39.23 (20.18)[c]	F(2, 138) = 30.44	**<.001**	.30
TAS-20	58.82 (13.28)[a]	49.80 (14.92)[b]	37.47 (11.26)[c]	F(2, 139) = 32.37	**<.001**	.30
WSAS	23.26 (8.70)[a]	11.10 (8.6)[b]	3.59 (6.23)[c]	F(2, 93.6) = 79.93	**<.001**	.51
ADOS						
Total	5.47 (4.44)[a]	4.18 (4.46)[ab]	2.70 (2.52)[b]	F(2, 91.23) = 7.86	**<.001**	.88
SA	4.71 (4.03)[a]	3.74 (3.93)[ab]	2.50 (2.38)[b]	F(2, 92.34) = 5.95	**.004**	.78
RRB	0.76 (1.07)[a]	0.44 (0.88)[ab]	0.20 (0.58)[b]	F(2, 92.35) = 5.65	**.005**	.82
% above cut-off	27.5[a]	24[a]	4.3[b]	$X^2 = 9.58$	**.008**	

ADOS-2, Autism Diagnostic Observation Schedule – 2nd edition; AN, anorexia nervosa; EDE-Q, eating disorder examination questionnaire; HADS, hospital anxiety and depression scale; HC, healthy control; LSAS, Liebowitz Social Anxiety Scale; REC, recovered anorexia nervosa; RRB, restrictive and repetitive behaviours; SA, social affect; SD, standard deviation; SRS-2, social responsiveness scale-2nd edition; TAS-20, Twenty-item Toronto Alexithymia Scale; WSAS, Work and Social Adjustment Scale

Different superscripts indicate significant differences between groups, significant *p*-values are highlighted in bold.

Table 3. Mean (SD) social cognition scores and analysis of group differences

	AN (N = 51)	REC (N = 50)	HC (N = 46)	Test statistics	*p*-value	ηp²
MET cognitive empathy (max 40)	27.22 (3.55)	28.42 (3.01)	27.72 (3.49)	F(2, 143) = 0.72	.49	.01
Positive (max 20)	15.00 (1.90)	15.15 (2.03)	15.20 (1.98)	F(2, 143) = 0.14	.87	.00
Negative (max 20)	12.72 (2.41)	13.22 (1.84)	12.52 (2.43)	F(2, 143) = 1.26	.28	.02
MET affective empathy (max 9)	4.74 (1.67)	4.90 (1.32)	5.30 (1.66)	F(2, 143) = 1.65	.20	.02
Positive (max 9)	3.84 (1.99)[a]	4.41 (1.68)[ab]	5.10 (1.99)[b]	F(2, 143) = 5.34	**.006**	.07
Negative (max 9)	5.63 (1.93)	5.40 (1.52)	5.50 (2.01)	F(2, 143) = 0.21	.81	.00
MiniPONS total (max 64)	48.27 (7.31)	50.43 (4.21)	49.61 (4.22)	F(2, 92.91) = 1.69	.19	.03
Face only (max 16)	11.53 (1.94)	11.80 (1.50)	11.61 (1.45)	F(2, 143) = 0.34	.71	.01
Body only (max 16)	12.04 (1.97)	12.10 (1.56)	11.72 (1.76)	F(2, 143) = 0.64	.53	.01
Voice only (max 16)	11.88 (2.62)	12.86 (1.49)	12.71 (2.03)	F(2, 143) = 3.13	**.047**	.04
Face & voice (max 16)	12.82 (2.46)	13.67 (2.01)	13.57 (1.46)	F(2, 92.99) = 1.08	.13	.04

AN, anorexia nervosa; HC, healthy control; MET, multifaceted empathy test; MiniPONS, Mini-Profile of Nonverbal Sensitivity; REC, recovered anorexia nervosa; SD, standard deviation

Different superscripts indicate significant differences between groups, significant *p*-values are highlighted in bold.

Table 4. Hierarchical regression analysis predicting cognitive empathy from associated demographic variables and psychopathology scores

	Model 1	Model 2	Model 3
IQ	.29***	.25**	.24**
Age†	.20*	.18*	.16*
ADOS-2		-.21*	-.18*
TAS-20			-.12
R^2	.15	.19	.20

Note: Figures shown are standardised coefficients. Group membership was entered in Model 1, but was not significant and not displayed here

†Variable was log transformed for analyses

*p <.05

** p <.01

*** p <.001

Table 5. Hierarchical regression analysis predicting affective empathy from associated demographic variables and psychopathology scores

	Model 1	Model 2	Model 3	Model 4	Model 5
BMI	.31*	.26	.23	.20	.19
ADOS-2		-.30***	-.26**	-.22*	-.23*
HADS			-.21	-.10	-.14
TAS-20				-.21	-.23
LSAS					.09
R^2	.05	.13	.15	.17	.18

Note: Figures shown are standardised coefficients. Group membership was entered in Model 1, but was not significant and not displayed here

*p <.05

** p <.01

*** p <.001

Table 6. Hierarchical regression analysis predicting MiniPONS scores from associated demographic variables and psychopathology scores

	Model 1	Model 2	Model 3
BMI	.26	.26	.25
IQ	.28***	.27**	.26**
ADOS-2		-.04	-.03
HADS depression			-.12
R^2	.11	.11	.12

Note: Figures shown are standardised coefficients. Group membership was entered in Model 1, but was not significant and not displayed here

*p <.05

** p <.01

*** p <.001

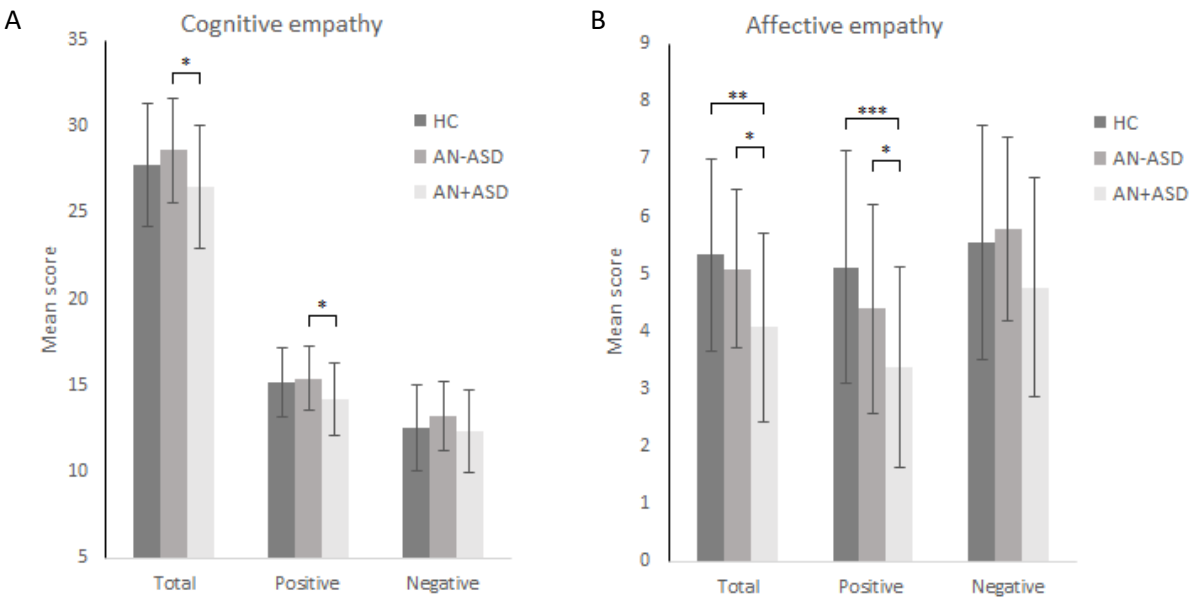

Figure 1. Mean scores for A) cognitive empathy and B) affective empathy. Error bars indicate standard deviation. HC = healthy controls; AN-ASD = lifetime AN, below cut-off on the ADOS-2; AN+ASD = lifetime AN, above cut-off on the ADOS-2. Significant *p*-values indicating group differences are marked with an asterisk; * <.05, ** <.01, *** <.001.