ARTICLE

Exploring emotion recognition in adults and adolescents with anorexia nervosa using a body motion paradigm

Katie Lang[1], MSc, Marcela Marin Dapelo[1]*, MSc, Mizanur Khondoker[2,3], PhD, Robin Morris[4] MA(Oxon), Msc, Phd (Cantab), Simon Surguladze[5] MD, PhD, Janet Treasure[1] MD, PhD, FRCP, FRCPsych, & Kate Tchanturia[1,5] PhD, ClinPsyD, FAED, FBPS.*
[1] Psychological Medicine, King's College London, IoPPN, UK
[2] Department of Biostatistics, King's College London., IoPPN, UK
[3] School of Life and Medical Sciences, University College London
[4] Department of Psychology, King's College London, IoPPN, UK
[5] Ilia State University Tbilisi
**Joint first authors*
Address for Correspondence: Dr Kate Tchanturia, PO59, King's College London, Psychological Medicine, London SE5 8AF, UK, Phone: +44 (0)20 7848 0134, Fax: +44 (0)20 7848 0182; E-mail: Kate.Tchanturia@kcl.ac.uk

Abstract
Objective: There is consistent evidence of difficulties in social cognition in adults with Anorexia Nervosa (AN), but less is known about adolescents. The aim of this study was to investigate the ability to recognise emotion expressed in body movement in adults and adolescents with AN. Method: 193 females participated in the study, (AN=97: 61 adults and 36 adolescents). The performance of participants with AN on a body emotion recognition task was compared to age matched healthy controls (HC=96). Results: The AN participants were significantly worse than HC in the ability to recognise sadness, with adolescent AN participants showing worse performance overall. There were no difficulties in the recognition of other emotions from body motion. Discussion: The results partially support previous studies and the literature on facial emotion recognition, showing poorer recognition of sadness in AN. The results also show greater difficulty in the recognition of sadness in adolescents with AN.

Keywords: Emotion recognition, anorexia nervosa, eating disorders, point-light, body motion.

Exploring emotion recognition in adults and adolescents with anorexia nervosa using a body motion paradigm

Adults with Eating Disorders (EDs), and particularly with Anorexia Nervosa (AN), demonstrate difficulties in social cognition (Caglar-Nazali et al., 2014; Oldershaw, Hambrook, et al., 2011), exhibiting problems in emotional intelligence (Hambrook,

Brown, & Tchanturia, 2012), high levels of social anhedonia (Tchanturia et al., 2012), reduced emotion expression (Claes et al., 2012; Davies, Schmidt, Stahl, & Tchanturia, 2011), and poor social functioning (Harrison, Mountford, & Tchanturia, 2014; Tchanturia, Hambrook, et al., 2013) compared to healthy controls (HC). Several theories have proposed that socio-emotional difficulties contribute to the development and/or maintenance of the ED (Arcelus, Haslam, Farrow, & Meyer, 2013; Fox & Power, 2009; Treasure & Schmidt, 2013; Wildes, Ringham, & Marcus, 2010), but further understanding of the mechanisms involved in these difficulties is needed in order to design effective interventions.

An important aspect of social and emotional processing is the visual perception of emotions, including the exchange of information through facial expression, eye gaze and body movement (Frith & Frith, 2007). Some of the mechanisms underlying the difficulties exhibited by people with AN may be related to the way in which individuals with AN interpret visually mediated social messages, intentions, and emotions. For example, research has shown attentional biases in individuals with AN towards angry, sad and rejecting faces (Aspen, Darcy, & Lock, 2013; Cardi, Di Matteo, Corfield, & Treasure, 2013; Cserjesi, Vermeulen, Lenard, & Luminet, 2011; Harrison, Sullivan, Tchanturia, & Treasure, 2010), hypervigilance to threat-related cues (McFillin et al., 2012), and avoidance of accepting faces (Cardi et al., 2013).

A majority of studies examining the ability to infer emotional states in others (i.e. emotional Theory of Mind) using the Reading the Mind in the Eyes task (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001) in individuals with EDs (13 in total), have demonstrated that participants with AN are less accurate at identifying emotional states compared to HC (Tchanturia, Marin Dapelo, Harrison, & Hambrook, 2015). However, findings from studies examining facial emotion recognition have been more inconsistent (Tchanturia et al., 2015).

Currently, there is a distinct lack of research investigating socio-emotional processing in adolescents with AN. As adolescence is a critical time for social-cognitive development (Blakemore, 2012), social emotional ability at this time period is of particular relevance in understanding the consequences of this disorder. Although limited, the available literature suggests that adolescents with AN may display similar socio-emotional difficulties as adults with AN. A series of studies by Zonnevylle-Bender and collaborators (2002, 2004), suggested that adolescents with AN showed higher levels of alexithymia, as well as performing significantly worse on experimental measures of facial emotion recognition, compared to matched HCs (Zonnevijlle-Bender, van Goozen, Cohen-Kettenis, van Elburg, & van Engeland, 2002), along with a comparable poor performance to adult AN participants (Zonnevylle-Bender et al., 2004). There is also preliminary evidence of reduced facial emotion expression in adolescents with AN (Rhind, Mandy, Treasure, & Tchanturia, 2014). Albeit limited, the available data suggests that further investigation of social cognition in adolescents with AN is warranted.

Facial emotion recognition and expression is only part of nonverbal communication, another important aspect being body language (App, McIntosh, Reed, & Hertenstein, 2011). In fact, it has been proposed that body language can communicate both the emotion and the action tendency associated with the emotion (e.g. fear, therefore escape) (de Gelder, 2006; Demeijer, 1989), and there is evidence that the same brain regions that are known to be involved in the perception of facial emotion expression and behaviour are also involved in the processing emotional body language (de Gelder,

2006). It has been demonstrated that specific emotional states can be inferred by observing particular body movements (Atkinson, Dittrich, Gemmell, & Young, 2004; Demeijer, 1989; Heberlein, Adolphs, Tranel, & Damasio, 2004), and there is evidence that certain patterns of body movements may be specific to certain emotions (Wallbott, 1998). However, in contrast to the large amount of studies looking at facial emotion recognition, emotion recognition from body motion has received little attention in ED.

Point light walker (PLW) procedures (Heberlein et al., 2004) have been used to assess recognition of emotion expressed through body movements in different clinical populations. For example, problems with emotion recognition have been consistently demonstrated in the schizophrenia literature when using the PLW (Brittain, Ffytche, & Surguladze, 2012; Couture et al., 2010), and similar results have also been described for individuals with autistic spectrum disorders (Hubert et al., 2007; Nackaerts et al., 2012). Given the evidence of the high prevalence of autistic traits in people with AN (Baron-Cohen et al., 2013; Gillberg, 1983; Tchanturia, Smith, et al., 2013; Treasure, 2013; Zucker et al., 2007), some difficulties in this ability are to be expected.

To our knowledge, only one study has explored the ability to recognise emotions from body motion in individuals with AN using PLW. Zucker and collegues (2013) found that, compared with HC and weight restored participants, individuals with current AN were less accurate at identifying sadness, and more consistent than HC in recognising anger. In this study, weight restored participants showed similar performance to that of the HC (Zucker et al., 2013).

The current study aims to further build on these findings by firstly, investigating emotion recognition through body motion in a large sample of participants with AN using the PLW procedure. Secondly, we aim to investigate developmental differences in emotion recognition abilities in AN by comparing the performance of both adults and adolescents.

Materials and methods

Participants

Participants were 193 females: 97 (61 adults; 36 adolescents) with AN and 96 HC, ranging in age from 11-55 years. The AN participants were recruited from Specialist Eating Disorder clinics, and the local community. AN participants received a DSM-5 diagnosis of AN by using the Eating Disorder module of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders (SCID-I) (First, Gibbon, Spitzer, & Williams, 2002). Measures of height and weight were also routinely collected. The inclusion criteria for participants older than 18 years of age, was a BMI of less than 18.5 For participants younger than 18 years of age percentage weight for height calculations were made. Weight for height measurements indicate the percentage of the individuals ideal body weight for their height and age. Participants with a percentage height for weight of less than 90% of their ideal body weight were included in this study.

Absence of ED symptoms in HCs was evaluated using the ED module of the SCID and the Eating Disorder Examination Questionnaire (EDE-Q), along with measures of height and weight. The same BMI threshold was applied, this time, BMI being higher than 18.5 for those over 18 years old (adults) and the percentage weight for height over 90 for those of under 18 years (adolescents). HC and AN sample were matched by age.

Measures

Structured Clinical Interview for DSM-IV-TR Axis I Disorders; SCID-I: (First et al., 2002) The SCID is a semi-structured clinical interview aimed to assess axis I disorders according to the DSM-IV (American Psychiatric Association, 2000). In this study, the ED module (i.e., module H) was used to assess the presence and history of ED. In order to update the interview to DSM-5 criteria, criterion D (i.e., amenorrhea) was not required for AN diagnosis, and the frequency for binges and purges was reduced to once a week to assess the presence of bulimia nervosa in HC.

Body Mass Index (BMI- kg / m^2) for adult and/ percentage weight for height (%W4H) for adolescents: were calculated based on measurements taken during the testing session.

Eating Disorder Examination Questionnaire; EDE-Q: (Fairburn & Beglin, 1994): The EDE-Q is a 36-item self-report measure that assesses cognitions and behavioural features of ED. In the current study, internal consistency for EDE-Q scales ranged from α=0.77 to α=0.97.

Hospital Anxiety and Depression Scale; HADS: (Zigmond & Snaith, 1983): The HADS is a 14-item self-report questionnaire developed to assess anxiety and depression among patients of non-psychiatric clinics and shown to have good validity and reliability (Bjelland, Dahl, Haug, & Neckelmann, 2002). Internal consistency for the anxiety scale was α=0.88, and for the depression scale was α=0.83.

Autism Quotient; AQ-10: (Allison, Auyeung, & Baron-Cohen, 2012): The AQ-10 is a shorter version of the original Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), and has been used in EDs (Tchanturia, Smith, et al., 2013). A cut-off of 6 has been established to indicate clinical severity of autistic features. In this study, internal consistency was α=0.64.

Emotion recognition from body movement. Point-light walkers task (PLW): Originally created by Johansson (1973) to investigate human motion. It was then adapted to explore human ability to infer emotional states expressed through bodily motion (Heberlein et al., 2004). The present study employed the same methodology developed in previous studies with video clips of 40 point-light walkers (Atkinson, Heberlein, & Adolphs, 2007). For the development of this task, actors were filmed walking from left to right, whilst portraying one of four emotions (anger, fear, happiness, or sadness) or an emotionally neutral state. The actors were filmed in the dark and had small lights attached to their wrists, ankles, knees, elbows, outer hips, waist, outer shoulders and head. Thus, the stimuli appeared as white dots on a dark background (Atkinson et al., 2004).

There were 40 trials (4 emotions * 8 clips + 8 neutral clips) and five different randomised running orders were used. Participants rated which emotion was being portrayed from the five alternative forced-choice words (angry, afraid, happy, sad, or neutral) presented on a card. Five practice clips were used to explain the task.

A proportional correct scoring method, previously used with stimulus of this type, was employed to score participant's answers (Heberlein et al., 2004). In a pilot study, 15 "reference" HC participants rated the emotional clips in the way described above, with the exception that there were no "neutral' clips, and no "neutral" answer choice (i.e. 32 clips). Percentages were calculated for the amount of times each stimulus was labelled

as a particular emotion by the reference group. These percentages then formed the basis of the partial correctness scoring for the main study. For example, if a clip was labelled as 'happy' by 70% of the reference group, 'angry' by 20% of the reference group and 'sad' by 10% of the reference group, then if a participant in the main study labelled the same clip as 'happy' they would achieve the highest score of 1.0 (0.7/0.7), if they labelled it as 'angry' they would score 0.28 (0.2/0.7), and if they labelled it as 'sad' they would score 0.14 (0.1/0.7). All other answers would receive a score of 0. In the main study, the total score for each emotion corresponds to the sum of the scores obtained by the participant on each of the 8 clips that represent the emotion (i.e., the maximum score is 8 for each emotion category). This scoring method accepts that a certain degree of variability in the interpretation of emotions from body movements is common, for example a body movement can be perceived as both sad and fearful (Heberlein et al., 2004).

Procedure

Participants attended one session for the study. After completion of BMI measures and the PLW task they filled self-report questionnaires. The study was approved by the NHS Research Ethics Committee, reference number 13/LO/0201 and 12/LO/2015. Informed consent was obtained from all participants.

Statistical Analysis

Data were analysed using the statistical software STATA 12.0 © (StataCorp LP). Visual inspection through the use of histograms revealed that the data for each of the emotion variables was negatively skewed. Standard transformations were not able to normalize the data, and further inspection revealed that the distributions differed between the AN group and the HC group in terms of shape and scale (variability), meaning that the data did not fulfil the assumptions of nonparametric tests (e.g, Mann Whitney U test). We therefore analysed the data using median regression (more generally known as quantile regression) (Cade & Noon, 2003; Koenker, 2005), which is a more robust alternative to linear regression and suitable for modelling skewed data. Standard linear regression estimates the relationship between mean of a response distribution and a set of independent or predictor variables; whereas the median regression models the relationship between median of a response distribution and a set of predictor variables. Similar to the standard linear regression, group comparison can be made in a median regression by including a binary group indicator (in this study, 0=HC, 1=AN) as independent variable in the regression model. The regression coefficient for group represents the differences in medians between groups (instead of the differences in means, for standard linear regression). Median regression is more appropriate for skewed data than the conventional linear regression as median is a more representative measure of location for such data. Median is also a more robust measure of location as it is less affected by outliers. Median regression is also better alternative to the commonly used non-parametric tests (e.g., Mann Whitney U test) for group comparison as it allows, like conventional regression, controlling for potential confounding variables while estimating the group difference.

For each emotion variable, a median regression was performed to estimate and test for differences in the medians between the AN and HC groups. The effects of group (i.e., the median differences) were adjusted for the effect of age, weight for height, BMI, anxiety, depression, and autistic traits by including them as covariates in the median regression models. Each of the potential confounding variables was tested individually in a separate median regression model. The variables that were found to be individually

associated with the outcome variable at a p-value level less than 0.05 were included in the adjusted model described above.

Differences between the total AN group and HC group were explored first, with a subsidiary analysis investigating the AN sample split into adults and adolescents.

Results

Table 1 shows the demographic information of the total AN and HC groups. As expected, there was a significant difference between the groups with regard to BMI and clinical characteristics, such as eating disorders symptoms, anxiety, depression and autistic traits.

----------INSERT TABLE 1 HERE----------

Group Comparisons For Each Emotion

Figure 1 shows the median for each emotion for both the AN and the HC groups. Median regressions are shown in Table 2.

----------INSERT FIG 1 HERE----------

Neutral

There were no significant differences between AN and HC groups on neutral clips (difference in medians=0.00, p=1.00)

Anger

Due to lack of between group data variability, it was not possible to compute median regression for the anger clips. Visual inspection of the medians for the AN group and HC group suggested that were no differences between groups (AN median=8.00, HC median=8.00). Further inspection of the shape of the distribution of this variable indicated that it was similar for both groups (AN and HC), therefore Mann Whitney U test was carried out. The test confirmed that there were no significant differences between AN and HC (U(191)=5,071.00, p=0.23).

----------INSERT TABLE 2 HERE----------

Fear

There were no differences between the AN and HC groups in recognising fear (difference in medians=0.00, p=1.00).

Happiness

There were no significant differences recognising happiness between AN and HC groups (difference in medians=0.00, p=1.00).

Sadness

There was a significant difference between the medians of AN and HC groups, with the AN group being less accurate at recognising sadness (difference in median= -0.64, p=0.012). Group, age, and weight for height were significant independent predictors of the outcome. However, when added to the model, weight for height lost significance. Group and age remained significant predictors, with younger participants exhibiting worse performance (difference in median=-0.58, p=0.028). Together they predicted 4.19% of the variance.

The AN participants who did not correctly recognise and label the sadness stimulus, most commonly misinterpreted the clips as neutral (mean percentage of participants for the 8 sad clips =17.5%), followed by anger (mean percentage of participants= 6.7%), happiness (mean percentage of participants=2.7%), and then fear (mean percentage of participants=2.1%).

Adult versus Adolescent Analysis

A further analysis of the sadness emotion, which had shown difficulties in the total AN group with age a significant factor, was carried out by splitting the sample into adults (≥ 18 years old) and adolescents (< 18 years old). Table 3 describes means and medians for each group. This new variable was included as a covariate in the median regression along with the interaction effect of the clinical group (i.e. AN or HC) and the age group (i.e. adult or adolescent). The interaction was statistically significant (difference in median= 0.089, p=0.001) meaning that AN vs. HC group difference varied between the adult and adolescent group. Adolescents with AN exhibited worse performance than the rest of the participants.

----------INSERT TABLE 3 HERE----------

Discussion

The aim of the study was to explore emotion recognition through body movements using group of adolescents and adults with AN. The findings demonstrated that overall, there was poorer performance in recognising sadness in the AN group compared to HC. There was no evidence of difficulties in the recognition of fear, anger, and happiness in body motion stimuli.

Our results are in agreement with previous findings from Zucker and collaborators (2013) who reported difficulties in the recognition of sadness in AN participants using point-light walkers (PLW). In addition, our findings are consistent with the previous literature evaluating facial emotion recognition in AN. For example, Kucharska-Pietura and collaborators (2004) reported poorer recognition of sadness in faces in AN, and the same results have been found by Pollatos (2008) and Castro (2010). Taken together, these findings may be suggestive of specific difficulties in the recognition of sadness in AN.

In our study there was a significant interaction between group (AN or HC) and age, whereby younger participants with AN appeared to show poorer recognition of sadness. Further exploration of this interaction indicated that adolescents with AN showed more difficulties in sadness recognition compared to adults. This is the first study to explore emotion recognition through body movement in adolescents with AN and our findings are consistent with studies on facial emotion recognition that have shown difficulties in adolescents with AN (Zonnevijlle-Bender et al., 2002; Zonnevylle-Bender et al., 2004). Our results are also consistent with studies on facial emotion recognition in non-clinical populations that have demonstrated a continuum in the process of learning to recognise emotion expression throughout development (Herba & Phillips, 2004). Poorer performance in adolescents with AN could be due to the effects of starvation at a critical period of brain maturation disturbing the normal developmental trajectory of emotion recognition skills. Further studies with children and adolescents with AN utilising fMRI to delineate the neural underpinnings of emotion recognition are needed to confirm this.

Our study findings indicate that AN participants who were poorer at recognising sad clips, often misinterpreted them as neutral. It can be speculated that having difficulties in correctly recognising sadness in others can have negative consequences for social interaction, as it makes it hard to recognise the needs of others and respond appropriately, for example, by showing empathy. The evidence from studies on decision making suggest that sadness elicits compassion and leads to cooperation among people (Polman & Kim, 2013). Thus, having difficulties recognising sadness could have a negative impact on social cooperation. Furthermore, the finding that adolescents with AN were the poorest at recognising sadness highlights the need to support adolescents with AN in their social development, especially because adolescence is a time of rapid social development, where social relationships are particularly salient.

Our findings suggest that difficulties in emotion recognition in AN differ from those described for people with schizophrenia (Brittain et al., 2012; Couture et al., 2010), and autism (Hubert et al., 2007; Nackaerts et al., 2012; Philip et al., 2010). Unlike these clinical groups, individuals with AN do not seem to exhibit a generalised problem with emotion recognition from body motion. Moreover, in our study, autistic features, as measured by the AQ-10, were not associated with emotion recognition performance in PWL task. One possible explanation for this lack of association could be that although individuals with AN and ASD have similarities in cognitive profiles, there may be distinct differences in the emotional difficulties shown by each group (Oldershaw, Treasure, Hambrook, Tchanturia, & Schmidt, 2011); therefore, although some individuals with AN show elevated levels of autistic traits, they may not meet the clinically defined cut-off for a diagnosis of autism, and this may not translate into the same emotion recognition difficulties that are observed in individuals with a diagnosis ASD. In addition, it is worth noting that the majority of the ASD literature is based on male participants, whereas experimental studies of emotions in ED field are conducted on female participants including current study.

The relative subtlety of our findings in comparison to stronger evidence of difficulties in other areas of emotion recognition for those with AN (Caglar-Nazali et al., 2014; Oldershaw, Hambrook, et al., 2011), could suggest that emotion recognition through body movement may be considered a comparative strength in AN. It has been suggested that since body language provides information about both emotional states and their associated intentions, it may be a less ambiguous signal compared to facial emotion expression, and therefore easier to recognise, label and respond to (de Gelder, 2006).

It should be noted that the study might be limited by the negative skewing of the emotional recognition data for both AN and HC participants, with a proportion of the participants achieving maximum scores. This may suggest a ceiling effect in the case of anger, and could explain why an enhanced ability to identify anger in AN was not found in this study. Additionally, as a majority of AN cases are female, the present study only included female participants. However, given the known gender differences in the recognition of emotions in facial expressions (Hall & Matsumoto, 2004; Thayer & Johnsen, 2000) differences in body emotion recognition between men and women may also be expected, and future studies could be conducted to address this issue.

In summary, this study explored emotion recognition in body motion in a large group of participants with AN, and it is the first to investigate this in adolescents with AN. Its results are important for the field as they replicate previous findings of difficulties in

sadness recognition in AN. As the AN groups difficulties were confined to sadness, the results also suggest that difficulties in emotion recognition through body movements may be fairly subtle in comparison to other socio-emotional difficulties observed in this population. This information could be used in the development of future treatments targeting emotional skills. In addition, the greater impairment exhibited by adolescents with AN in this study highlights the importance for future research to continue to focus on the adolescent AN population.

Acknowledgements

KT would like to thank the Swiss Anorexia Nervosa Foundation, Maudsley Charity, Psychiatry Research Trust, and CONICYT- Becas Chile PhD Scholarship abroad programme for M. Marin Dapelo*.* KL is funded by the National Institute for Health Research (NIHR) [Mental Health Biomedical Research Centre and/or Dementia Biomedical Research Unit] at South London and Maudsley NHS Foundation Trust and King's College.

References

Allison, C., Auyeung, B., & Baron-Cohen, S. (2012). Toward Brief "Red Flags" for Autism Screening: The Short Autism Spectrum Quotient and the Short Quantitative Checklist in 1,000 Cases and 3,000 Controls. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(2), 202-212. doi: Doi 10.1016/J.Jaac.2011.11.003

App, B., McIntosh, D. N., Reed, C. L., & Hertenstein, M. J. (2011). Nonverbal channel use in communication of emotion: how may depend on why. *Emotion, 11*(3), 603-617. doi: 10.1037/a0023164

Arcelus, J., Haslam, M., Farrow, C., & Meyer, C. (2013). The role of interpersonal functioning in the maintenance of eating psychopathology: a systematic review and testable model. *Clin Psychol Rev, 33*(1), 156-167. doi: 10.1016/j.cpr.2012.10.009

Aspen, V., Darcy, A. M., & Lock, J. (2013). A review of attention biases in women with eating disorders. *Cogn Emot, 27*(5), 820-838. doi: 10.1080/02699931.2012.749777

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders: DSM-IV-TR*: American Psychiatric Publishing, Inc.

Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception, 33*(6), 717-746. doi: Doi 10.1068/P5096

Atkinson, A. P., Heberlein, A. S., & Adolphs, R. (2007). Spared ability to recognise fear from static and moving whole-body cues following bilateral amygdala damage. *Neuropsychologia, 45*(12), 2772-2782. doi: 10.1016/j.neuropsychologia.2007.04.019

Baron-Cohen, S., Jaffa, T., Davies, S., Auyeung, B., Allison, C., & Wheelwright, S. (2013). Do girls with anorexia nervosa have elevated autistic traits? *Mol Autism, 4*(1), 24. doi: 10.1186/2040-2392-4-24

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" Test revised version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *J Child Psychol Psychiatry, 42*(2), 241-251.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger syndrome/high-

functioning autism, males and females, scientists and mathematicians. *J Autism Dev Disord, 31*(1), 5-17. doi: Doi 10.1023/A:1005653411471

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale. An updated literature review. *J Psychosom Res, 52*(2), 69-77.

Blakemore, S. J. (2012). Development of the social brain in adolescence. *J R Soc Med, 105*(3), 111-116. doi: 10.1258/jrsm.2011.110221

Brittain, P. J., Ffytche, D. H., & Surguladze, S. A. (2012). Emotion perception and functional outcome in schizophrenia: the importance of negative valence and fear. *Psychiatry Res, 200*(2-3), 208-213. doi: 10.1016/j.psychres.2012.07.027

Cade, B.S., & Noon, B.R. (2003). A gentle introduction to quantile regression for ecologists. *Frontiers in Ecology and the Environment, 1*(8), 412-420.

Caglar-Nazali, H. P., Corfield, F., Cardi, V., Ambwani, S., Leppanen, J., Olabintan, O., . . . Treasure, J. (2014). A systematic review and meta-analysis of 'Systems for Social Processes' in eating disorders. *Neurosci Biobehav Rev, 42*, 55-92. doi: 10.1016/j.neubiorev.2013.12.002

Cardi, V., Di Matteo, R., Corfield, F., & Treasure, J. (2013). Social reward and rejection sensitivity in eating disorders: an investigation of attentional bias and early experiences. *World J Biol Psychiatry, 14*(8), 622-633. doi: 10.3109/15622975.2012.665479

Castro, L., Davies, H., Hale, L., Surguladze, S., & Tchanturia, K. (2010). Facial affect recognition in anorexia nervosa: is obsessionality a missing piece of the puzzle? *Aust N Z J Psychiatry, 44*(12), 1118-1125. doi: 10.3109/00048674.2010.524625

Claes, L., Jimenez-Murcia, S., Santamaria, J. J., Moussa, M. B., Sanchez, I., Forcano, L., . . . Fernandez-Aranda, F. (2012). The facial and subjective emotional reaction in response to a video game designed to train emotional regulation (Playmancer). *Eur Eat Disord Rev, 20*(6), 484-489. doi: 10.1002/erv.2212

Couture, S. M., Penn, D. L., Losh, M., Adolphs, R., Hurley, R., & Piven, J. (2010). Comparison of social cognitive functioning in schizophrenia and high functioning autism: more convergence than divergence. *Psychol Med, 40*(4), 569-579. doi: 10.1017/S003329170999078X

Cserjesi, R., Vermeulen, N., Lenard, L., & Luminet, O. (2011). Reduced capacity in automatic processing of facial expression in restrictive anorexia nervosa and obesity. *Psychiatry Res, 188*(2), 253-257. doi: 10.1016/j.psychres.2010.12.008

Davies, H., Schmidt, U., Stahl, D., & Tchanturia, K. (2011). Evoked facial emotional expression and emotional experience in people with anorexia nervosa. *Int J Eat Disord, 44*(6), 531-539. doi: 10.1002/eat.20852

de Gelder, B. (2006). Towards the neurobiology of emotional body language. *Nat Rev Neurosci, 7*(3), 242-249. doi: 10.1038/nrn1872

Demeijer, M. (1989). The Contribution of General Features of Body Movement to the Attribution of Emotions. *Journal of Nonverbal Behavior, 13*(4), 247-268.

Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: interview or self-report questionnaire? *Int J Eat Disord, 16*(4), 363-370.

First, M.B., Gibbon, M., Spitzer, R.L., & Williams, J.B.W. . (2002). *User's Guide for the Structured Clinical Interview for DSM-IV-TR Axis I Disorders - Research Version - (SCID-I for DSM-IV-TR, November 2002 Revision).*

Fox, J. R., & Power, M. J. (2009). Eating disorders and multi-level models of emotion: an integrated model. *Clin Psychol Psychother, 16*(4), 240-267. doi: 10.1002/cpp.626

Frith, C. D., & Frith, U. (2007). Social cognition in humans. *Curr Biol, 17*(16), R724-732. doi: 10.1016/j.cub.2007.05.068

Gillberg, C. (1983). Are autism and anorexia nervosa related? *Br J Psychiatry, 142*, 428.

Hall, J. A., & Matsumoto, D. (2004). Gender differences in judgments of multiple emotions from facial expressions. *Emotion, 4*(2), 201-206. doi: 10.1037/1528-3542.4.2.201

Hambrook, D., Brown, G., & Tchanturia, K. (2012). Emotional intelligence in anorexia nervosa: is anxiety a missing piece of the puzzle? *Psychiatry Res, 200*(1), 12-19. doi: 10.1016/j.psychres.2012.05.017

Harrison, A., Mountford, V. A., & Tchanturia, K. (2014). Social anhedonia and work and social functioning in the acute and recovered phases of eating disorders. *Psychiatry Res, 218*(1-2), 187-194. doi: 10.1016/j.psychres.2014.04.007

Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2010). Emotional functioning in eating disorders: attentional bias, emotion recognition and emotion regulation. *Psychol Med, 40*(11), 1887-1897. doi: 10.1017/S0033291710000036

Heberlein, A. S., Adolphs, R., Tranel, D., & Damasio, H. (2004). Cortical regions for judgments of emotions and personality traits from point-light walkers. *J Cogn Neurosci, 16*(7), 1143-1158. doi: 10.1162/0898929041920423

Herba, C., & Phillips, M. (2004). Annotation: Development of facial expression recognition from childhood to adolescence: behavioural and neurological perspectives. *J Child Psychol Psychiatry, 45*(7), 1185-1198. doi: 10.1111/j.1469-7610.2004.00316.x

Hubert, B., Wicker, B., Moore, D. G., Monfardini, E., Duverger, H., Da Fonseca, D., & Deruelle, C. (2007). Brief report: recognition of emotional and non-emotional biological motion in individuals with autistic spectrum disorders. *J Autism Dev Disord, 37*(7), 1386-1392. doi: 10.1007/s10803-006-0275-y

Johansson, G. (1973). Visual-Perception of Biological Motion and a Model for Its Analysis. *Perception & Psychophysics, 14*(2), 201-211. doi: Doi 10.3758/Bf03212378

Koenker, R. (2005). *Quantile regression*: Cambridge University Press.

Kucharska-Pietura, K., Nikolaou, V., Masiak, M., & Treasure, J. (2004). The recognition of emotion in the faces and voice of anorexia nervosa. *Int J Eat Disord, 35*(1), 42-47. doi: 10.1002/eat.10219

McFillin, R. K., Cahn, S. C., Burks, V. S., Levine, M. P., Loney, S. L., & Levine, R. L. (2012). Social information-processing and coping in adolescent females diagnosed with an eating disorder: toward a greater understanding of control. *Eat Disord, 20*(1), 42-59. doi: 10.1080/10640266.2012.635565

Nackaerts, E., Wagemans, J., Helsen, W., Swinnen, S. P., Wenderoth, N., & Alaerts, K. (2012). Recognizing biological motion and emotions from point-light displays in autism spectrum disorders. *PLoS One, 7*(9), e44473. doi: 10.1371/journal.pone.0044473

Oldershaw, A., Hambrook, D., Stahl, D., Tchanturia, K., Treasure, J., & Schmidt, U. (2011). The socio-emotional processing stream in Anorexia Nervosa. *Neurosci Biobehav Rev, 35*(3), 970-988. doi: 10.1016/j.neubiorev.2010.11.001

Oldershaw, A., Treasure, J., Hambrook, D., Tchanturia, K., & Schmidt, U. (2011). Is anorexia nervosa a version of autism spectrum disorders? *Eur Eat Disord Rev, 19*(6), 462-474. doi: 10.1002/erv.1069

Philip, R. C., Whalley, H. C., Stanfield, A. C., Sprengelmeyer, R., Santos, I. M., Young, A. W., . . . Hall, J. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychol Med, 40*(11), 1919-1929. doi: 10.1017/S0033291709992364

Pollatos, O., Herbert, B. M., Schandry, R., & Gramann, K. (2008). Impaired central processing of emotional faces in anorexia nervosa. *Psychosom Med, 70*(6), 701-708. doi: 10.1097/PSY.0b013e31817e41e6

Polman, E., & Kim, S. H. (2013). Effects of anger, disgust, and sadness on sharing with others. *Pers Soc Psychol Bull, 39*(12), 1683-1692. doi: 10.1177/0146167213500998

Rhind, C., Mandy, W., Treasure, J., & Tchanturia, K. (2014). An exploratory study of evoked facial affect in adolescent females with anorexia nervosa. *Psychiatry Res*. doi: http://dx.doi.org/10.1016/j.psy-chres.2014.07.057

Tchanturia, K., Davies, H., Harrison, A., Fox, J. R., Treasure, J., & Schmidt, U. (2012). Altered social hedonic processing in eating disorders. *Int J Eat Disord, 45*(8), 962-969. doi: 10.1002/eat.22032

Tchanturia, K., Hambrook, D., Curtis, H., Jones, T., Lounes, N., Fenn, K., . . . Davies, H. (2013). Work and social adjustment in patients with anorexia nervosa. *Compr Psychiatry, 54*(1), 41-45. doi: 10.1016/j.comppsych.2012.03.014

Tchanturia, K., Marin Dapelo, M., Harrison, A., & Hambrook, D. (2015). Why study positive emotions in the context of eating disorders? *Curr Psychiatry Rep, 17*(537). doi: 10.1007/s11920-014-0537-x

Tchanturia, K., Smith, E., Weineck, F., Fidanboylu, E., Kern, N., Treasure, J., & Baron Cohen, S. (2013). Exploring autistic traits in anorexia: a clinical study. *Mol Autism, 4*(1), 44. doi: 10.1186/2040-2392-4-44

Thayer, J. F., & Johnsen, B. H. (2000). Sex differences in judgement of facial affect: a multivariate analysis of recognition errors. *Scand J Psychol, 41*(3), 243-246.

Treasure, J. (2013). Coherence and other autistic spectrum traits and eating disorders: building from mechanism to treatment. The Birgit Olsson lecture. *Nord J Psychiatry, 67*(1), 38-42. doi: 10.3109/08039488.2012.674554

Treasure, J., & Schmidt, U. (2013). The cognitive-interpersonal maintenance model of anorexia nervosa revisited: a summary of the evidence for cognitive, socio-emotional and interpersonal predisposing and perpetuating factors. *J Eat Disord, 1*, 13. doi: 10.1186/2050-2974-1-13

Wallbott, H. G. (1998). Bodily expression of emotion. *European Journal of Social Psychology, 28*(6), 879-896. doi: Doi 10.1002/(Sici)1099-0992(1998110)28:6<879::Aid-Ejsp901>3.0.Co;2-W

Wildes, J. E., Ringham, R. M., & Marcus, M. D. (2010). Emotion avoidance in patients with anorexia nervosa: initial test of a functional model. *Int J Eat Disord, 43*(5), 398-404. doi: 10.1002/eat.20730

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatr Scand, 67*(6), 361-370.

Zonnevijlle-Bender, M. J., van Goozen, S. H., Cohen-Kettenis, P. T., van Elburg, A., & van Engeland, H. (2002). Do adolescent anorexia nervosa patients have deficits in emotional functioning? *Eur Child Adolesc Psychiatry, 11*(1), 38-42.

Zonnevylle-Bender, M. J., van Goozen, S. H., Cohen-Kettenis, P. T., van Elburg, A., de Wildt, M., Stevelmans, E., & van Engeland, H. (2004). Emotional functioning in anorexia nervosa patients: adolescents compared to adults. *Depress Anxiety, 19*(1), 35-42. doi: 10.1002/da.10145

Zucker, N. L., Losh, M., Bulik, C. M., LaBar, K. S., Piven, J., & Pelphrey, K. A. (2007). Anorexia nervosa and autism spectrum disorders: guided investigation of social cognitive endophenotypes. *Psychol Bull, 133*(6), 976-1006. doi: 10.1037/0033-2909.133.6.976

Zucker, N., Moskovich, A., Bulik, C. M., Merwin, R., Gaddis, K., Losh, M., . . . LaBar, K. S. (2013). Perception of affect in biological motion cues in anorexia nervosa. *Int J Eat Disord, 46*(1), 12-22. doi: 10.1002/eat.22062

Table 1: Participant demographics and clinical measures

	AN				HC				Cohen's d
	N	Min	Max	Mean (SD)	N	Min	Max	Mean (SD)	
Age	97	11.00	47.00	22.40 (8.32)	96	11.00	53.00	23.72 (9.80)	0.15
BMI * (adults only)	61	11.60	18.40	15.44 (1.68)	69	18.74	28.40	22.34 (2.42)	3.30
W4H * (adolescents only)	36	61.07	89.65	80.65 (6.69)	27	90.18	128.82	100.62 (9.95)	2.46
EDE-Q Rest *	97	0.00	6.00	3.56 (1.80)	96	0.00	4.40	0.81 (0.94)	1.92
EDE-Q Eat C *	97	0.00	6.00	3.40 (1.46)	96	0.00	2.40	0.31 (0.47)	2.86
EDE-Q Sh C *	97	0.13	6.00	4.45 (1.56)	96	0.00	5.13	1.33 (1.06)	2.35
EDE-Q Wt C *	97	0.20	6.00	3.74 (1.62)	96	0.00	4.20	0.96 (0.94)	2.11
EDE-Q Global *	97	0.19	6.00	3.79 (1.44)	96	0.00	3.83	0.85 (0.76)	2.56
Age of Onset	97	8.00	37.00	16.40 (5.51)					
Length of Illness (years)	97	0.00	37.00	6.20 (7.22)					
HADS-A *	97	0.00	21.00	11.20 (5.08)	96	0.00	9.00	4.05 (2.60)	1.78
HADS-D *	97	0.00	21.00	11.67 (4.90)	96	0.00	9.00	3.63 (2.04)	2.15
AQ-10 *	97	0.00	9.00	3.92 (2.13)	96	0.00	5.00	1.87 (1.34)	1.16

BMI= Body Mass Index; W4H= Percentage weight for height, EDE-Q Rest= Eating Disorder Examination Questionnaire Restraint; EDE-Q Eat C= Eating Disorder Examination Questionnaire Eating Concerns; EDE-Q Sh C= Eating Disorder Examination Questionnaire Shape concerns; EDE-Q Wt C= Eating Disorder Examination Questionnaire Weight Concerns; EDE-Q Global= Eating Disorder Examination Questionnaire Global Score; HADS-A= Hospital Anxiety and Depression Scale Anxiety subscale; HADS-D= Hospital Anxiety and Depression Scale Depression subscale; AQ-10= Autism Quotient 10.

(*) Mean difference is statistically significant ($p<0.01$)

Table 2: Median regression for each emotion

Emotion	Regression coef. for group (AN vs. HC)	SE (Coef.)	p-value	95% CI
Neutral	0.00	0.21	1.00	(-0.42, 0.42)
Fear	0.00	0.14	1.00	(-0.27, 0.27)
Happiness	0.00	0.20	1.00	(-0.40, 0.40)
Sadness*	-0.64	0.25	0.01	(-1.14, -0.14)

Regression coef.= Coefficients represent the estimated differences in medians between AN and HC groups; AN= Anorexia Nervosa; HC= Healthy Controls; SE= Standard Error; CI= Confidence interval

(*) Regression is statistically significant ($p < 0.05$)

Table 3: Mean and medians for sadness recognition for AN adults, AN adolescents, HC adults, and HC adolescents.

	N	Mean	S D.	Median
AN Adolescents	36	5.45	1.45	5.68
AN Adults	61	6.45	1.53	7.00
HC Adolescents	27	6.47	1.40	7.00
HC Adults	69	6.48	1.42	7.00

N=Number of participants in the group; SD.= Standard Deviation; AN=Anorexia Nervosa; HC= Healthy Control