

Introduction

Eating disorders (EDs) including anorexia and bulimia nervosa (AN, BN) are serious mental health difficulties with a biopsychosocial aetiology (Schmidt et al., 2016). Contemporary models suggest interpersonal difficulties contribute to perpetuating EDs (Fairburn, Cooper & Shafran, 2003; Schmidt & Treasure, 2013) and the social difficulties reported by patients (Harrison, Mountford & Tchanturia, 2014) are treatment targets in evidence-based interventions (Fairburn et al., 2009; Schmidt, Wade & Treasure, 2014). As people with AN experience comparable levels of social disability to those with schizophrenia (Arnell & Robinson, 2008), research has sought to understand which possible differences in specific interpersonal skills may underlie this. To date, conclusions can be drawn from three key areas:

The first relates to facial emotional expression, a vital communication tool (Frith, 2009). A meta-analysis of six studies including adolescent and adult patients found medium-sized reductions in the expression of positive ($d=0.59$) and negative ($d=0.58$) emotions in EDs compared to non-ED controls (Davies et al., 2016). This suggests that people with EDs do not communicate what they are thinking and feeling as efficiently as others and this might explain some of the social difficulties reported by patients (Harrison et al., 2014). One limitation of this work is that findings are limited to facially-evoked emotional expressions in response to static social stimuli, such as faces, or films and, as such, do not reflect real-time social interactions. Further, the studies in this review relied largely on using well-known video stimuli from films like “Four Weddings and a Funeral” to assess facially-evoked emotional expressions (e.g. Davies, Schmidt, Stahl & Tchanturia, 2011). Because participants may have been familiar with this film (a

possible confound that was not measured), the data may have been affected by participants' memories of this stimulus. The other approach was to explore facially-evoked emotional expressions in response to videos of infants (e.g. Cardi et al., 2014) which does not provide data on how people with AN respond to interactions with adults.

The second area reflects an extensive body of experimental work around heightened social anxiety, social sensitivity and social rejection. These data include reports of increased social anxiety (Kerr-Gaffney, Harrison & Tchanturia, 2018), greater sensitivity to social interactions (Steiger, Gauvin, Jabalpurwala Séquin & Stotland, 1999) and more unfavourable social comparisons (Cardi, Di Matteo, Gilbert, & Treasure, 2014; Troop & Baker, 2008) in people with EDs compared to non-ED controls. Other experimental data find reduced perceptions of warmth offered by others (Ambwani et al., 2016), attentional biases for rejecting faces (Cardi, Di Matteo, Corfield, & Treasure, 2013; Maier et al., 2014), with attention directed towards faces expressing rejection and submissiveness, and away from accepting faces (Cardi et al., 2013; 2014; 2015) in those with EDs compared to non-ED controls. This greater social sensitivity may underline differences in the use of eye-gaze identified in a systematic review and meta-analysis (Kerr-Gaffney, Harrison & Tchanturia, 2018) which found that people with EDs use their eye-gaze differently to non-ED controls. The data suggest that those with EDs avoid eye-contact during social interactions and in response to static and moving social stimuli like faces (Cipolli et al., 1989; Harrison, Watterson & Bennett, 2019; Watson, Werling, Zucker & Platt, 2010). This suggests that people with EDs might use another key social skill, eye-contact (Hamilton, 2008), differently to controls which may underpin the friendship difficulties reported by people with EDs (Patel, Harrison & Tchanturia, 2016; Westwood, Lawrence, Fleming & Tchanturia, 2016).

Alongside differences in social behaviours, individuals with EDs may also experience differences in their level of arousal during social situations. This can be measured using objective measures of autonomic arousal like electro-dermal activity. This established biomarker of sympathetic nervous system arousal (Boucsein, 2012) has previously been found to be lower in people with EDs, with reduced variance and this profile is thought to reflect difficulties relaxing and adapting to environmental changes (Crifaci et al., 2013). While previous studies have shown reduced electro-dermal activity during decision making tasks in ED participants (Tchanturia et al., 2007), electro-dermal activity has not been measured during a naturalistic, social interaction in EDs.

The third area is the ability to understand, generate and use non-verbal communication, including gestures and bodily cues. This vital interpersonal skill (App, McIntosh, Reed, & Hertenstein, 2011) allows humans to communicate thoughts, feelings and intentions and to infer important social information including others' emotional states from bodily movements (Atkinson, Dittrich, Gemmell, & Young, 2004). Emerging evidence suggests that adults and adolescents with AN find this more challenging than non-AN controls (Lang et al., 2015; Zucker et al., 2013), although this difference may not present in BN (Dapelo, Surguladze, Morris & Tchanturia, 2017). What is not known is whether people with EDs exhibit fewer non-verbal communication behaviors themselves during social interactions. Non-verbal behaviours are key components of efficient social interactions (Chartrand & Bargh, 1999) and signal social affiliation (Lakin & Chartrand, 2003). Observational methodologies might offer a useful means of improving these knowledge gaps and although this methodological approach has been widely used to understand academic (Maag, Reid, & DiGangi, 1993) and social/recreational behaviours

(Leff & Larkin, 2005), it has been underutilised in the ED field. The advantage of direct, systematic observation is that it helps to build on the inherent problems associated with self-report measures of interpersonal skills through collecting high fidelity behavioural data from more naturalistic environments in which target behaviours are operationally defined so that they can be readily observed and recorded using standardised coding procedures (Volpe & McConaughy, 2005).

Other unanswered questions at present around social communication in EDs relate to whether some of these social differences might be accounted for by autism spectrum disorder (ASD) traits thought to be present at elevated levels in the ED population (Westwood & Tchanturia, 2017) and reductions in the use of gestures are observed in those with autism spectrum disorder (Mundy, Sigman & Kasari, 1990). This important confounder has not been consistently measured in previous work. Another potential confounder and important comorbidity in EDs which has been poorly considered in previous research is mood (Keski-Rahkonen & Mustelin, 2016). Improving on this limitation is particularly important given that research on major depressive disorder demonstrates differences in the use of key non-verbal communication in the context of low mood (Balsters, Krahmer, Swerts & Vingerhoets, 2012) and depression is also commonly experienced by those with ASD (van Heijst, Deserno, Rhebergen & Guerts, 2020).

Therefore, this observational study, which adopted a trans-diagnostic approach to ED inclusion criteria (Fairburn, 2008), aimed to be the first to experimentally measure non-verbal communication in EDs during a naturalistic social interaction, relative to non-ED controls. The first hypothesis was that during a real-life, face-to-face social interaction, women with EDs

would show significantly reduced facially-expressed basic emotions, measured by observing the duration of facially-expressed basic emotions (happiness, sadness, anger, disgust, surprise and fear) in seconds during the social interaction. The second hypothesis was that individuals with EDs would also show significant differences in their use of non-verbal communication behaviours. Specifically, relative to non-ED controls, measured using an observational coding system designed to record the duration of these communication behaviors in seconds, those with EDs would show differences in the orientation of their body (facing or angled, to some degree away) and placement of their legs (crossed, uncrossed) in relation to their conversational partner; their trunk lean (upright, forwards or backwards), the positioning of their head, (whether their gaze was on the experimenter, away, or focused downwards) and the use of hand gestures to support their communication during the real-life social interaction. An additional exploratory hypothesis was that those with EDs may demonstrate less physiological arousal, measured using electro-dermal responses in micro-Siemens (μS) during the social interaction than controls.

2.0 Method

2.1 Design

This quantitative, overt, structured, observational study employed a mixed design with a quasi-experimental between-participants independent variable (ED and non-ED control participants) and an experimental, within-participants variable (emotional valence of conversational topic: positive, negative and neutral) to investigate the dependent variable of non-verbal communication.

2.2 Participants

A voluntary, convenience sample of female participants aged 16-55 with an ED diagnosis confirmed using the Eating Disorder Examination (Fairburn, 2008) were eligible for inclusion in the ED group and recruited via advertising on community notice boards, social media platforms and at support groups for individuals with EDs in the London area.

Inclusion criteria for non-ED controls were female participants aged 16-55 without an ED, confirmed using the Eating Disorder Examination Questionnaire (Fairburn & Beglin, 1994). Non-ED participants were recruited via advertising on community notice boards and social media.

2.3 Measures

2.3.1 Self-Report Measures: Key Psychopathology and Comorbid Symptoms

ED symptoms were measured using the EDE-Q (Fairburn & Beglin, 1994), a self-report tool measuring eating behaviours and attitudes over the past 28 days on a 7-point scale. Higher scores indicate greater symptoms. Cronbach's α is .93 for community samples (Peterson et al., 2007) and was .97 in this study.

Body mass index (BMI; $\text{mass}/\text{height}^2$) was calculated by measuring participants' weight and height on the day of testing.

The Depression, Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 1995), a 21-item scale measured depression/anxiety/stress comorbidities across a 4-point likert scale ranging from 0-3,

with higher scores indicating greater psychopathology. Cronbach's α is .88 (Henry & Crawford, 2005) and was .98 for this study.

The Social Phobia Inventory (SPIN; Connor et al., 2000), a 17-item self-report scale measured comorbid social anxiety on a 0-4 scale. Scores over 19 indicate clinical levels of social anxiety. Cronbach's α is .94 (Connor et al., 2000) and .97 in this study.

The 10-item Autism Quotient (AQ; Allison, Auyeung & Baron-Cohen, 2012) measured comorbid ASD traits across a 4-point scale ranging from definitely disagree to definitely agree. Cronbach's α is .85 (Allison et al., 2012) and .78 for this study. A cut-off of ≥ 6 indicates the possible presence of ASD.

2.3.2 Self-Report Measures of Social Skills

Difficulties experienced around work and social functioning were obtained using the Work and Social Adjustment Scale (WSAS; Mundt, Marks, Shear & Greist, 2002), a 5-item measure scored on a 0-8 Likert scale across five domains: ability to manage work, home management, personal and social leisure and social interactions. Higher scores indicate greater difficulties. Cronbach's α is .95 (Mundt et al., 2002) and was .94 in this study.

The Communicative Adaptability Scale (CAS; Duran, 1983), a 30-item self-report measure measured social skills across six subscales: Social composure (the extent to which one can manage social situations without feeling nervous; e.g. "I am relaxed when talking to others"), social confirmation (the ability to see a situation from another's perspective; e.g. "I try to make the other person feel good"), social experience (the variety of different social experiences a

person has; e.g. “I like to be active in different social groups”), appropriate disclosure (awareness and adherence to social norms regarding disclosure; e.g. “I know how appropriate my self-disclosures are”), articulation (fluency and abilities related to vocal organization of ideas; e.g. “when speaking I sometimes use words incorrectly”) and wit (the ability to use humor when appropriate to diffuse uncomfortable feelings and tension; e.g. “when I am anxious, I often make jokes”). Cronbach’s α is .89 (Duran, 1983) and .89 in this study.

Participants were asked to disclose whether they had a best friend, the number of friends in their close circle, their age, ethnicity, highest educational qualification and employment status.

2.4 Experimental Materials

2.4.1 *Non-Verbal Behaviour*

Non-verbal behaviour was recorded using a 4k camera (Panasonic HC-X1) overtly positioned in the room and was quantified using an event-based coding system informed by Dael, Mortillaro and Scherer (2012) and Harrigan, Oxman and Rosenthal (1985). The coding system was piloted on a sample of six individuals from the target population. Codes, explained in table 1, were assigned to the following non-verbal behaviours by an independent rater who was a Masters level psychology student blind to the hypotheses of the study and trained in the coding system:

INSERT TABLE 1 ABOUT HERE

Within the five categories, codes were assigned in a mutually exclusive way, such that within each category, only one code could be assigned at any given time. Codes were designed to

capture the positioning of the body during the social interaction, the use of hands as body manipulators (e.g. actions involving touching or playing with one's body or clothing) and the use of hand gestures as emblematic tools to illustrate and emphasize points. To estimate inter-rater reliability of the codes, 25% of videos were coded by a second independent rater, who was also a Masters level student in psychology trained in the coding system, yielding an overall percentage agreement of 92%.

2.4.2 Facially-Expressed Emotion Expression

Participants' videos were amplified to focus on the face area only and entered into Noldus FaceReader software which detects and analyses the valence of facial expressions across six basic emotions, happiness, sadness, anger, fear, surprise, and disgust alongside neutral states on a scale of 0-1 where 0=no emotion and 1=maximum intensity. Videos were analysed individually, frame by frame and sequentially using the batch analysis mode as per Leppanen et al (2017).

2.4.3 Psychophysiology

Electro-dermal activity, an objective measure of response to physically arousing external/internal stimuli was measured throughout the social interaction through two sensors attached to the forefinger and middle finger of the participant's non-dominant hand. These two channels relayed data on electro-dermal activity to a MindWare Mobile Recorder, model 50-2303-01. MWX files were extracted using EcigDA Analysis 3.1.5 software and converted into text files readable by The Observer using BioLab 3.3.1. The outcome variable was the mean value for each participant within each condition (positive, negative, neutral) measured in micro-Siemens (μS), controlling

for baseline activity. Variance (average of the squared differences from the mean) was also computed following Crifaci et al., (2013).

2.5 Procedure

The study received ethical approval from the University College London Research Ethics Committee (Ref 17.647) and was conducted in accordance with the World Medical Association's Declaration of Helsinki. Having received detailed information about the study, written, informed consent was obtained and participants were invited to attend a research appointment at University College London. Data collection took place in a small room at University College London which was originally the drawing room of a townhouse built between 1829 and 1847 and features armchairs, a carpeted floor, high ceiling and fireplace, with windows out onto the street. This location was selected to provide a more naturalistic environment akin to an individual's living room/lounge (as opposed to a laboratory) for the social interaction.

On arrival, participants completed digitised versions of the self-report measures on the Qualtrics platform. The researcher and participant then sat in armchairs 1.5 meters apart to engage in the videoed 15-minute face-to-face social interaction. Participants were guided by the researcher through the interaction in stages shown in figure 1 (in this example, the conditions were ordered positive, neutral, negative). These conditions reflecting positive, negative and neutral emotionally valenced topics were randomly allocated and counter-balanced across participants. The topic content was validated in a pilot study in which participants were asked to discuss these common topics with a researcher and afterwards, rated the emotional valence of the topic. The positive conversation involved the experimenter sharing a recent anecdote where they observed a

someone buy a coffee for a stranger in a coffee shop; the negative conversation involved the experimenter sharing a recent anecdote where they had missed the last train home; and the neutral topic was a discussion about the weather. Participants were instructed to communicate in the way they normally would with a friend or acquaintance.

INSERT FIGURE 1 ABOUT HERE

The three-minute periods were adhered to by a timer visible only to the researcher during the conversation. Finally, participants received a verbal and written debrief and thanked for their time with a cash payment of £10.

2.6 Data Analysis

A power analysis, using previous data from Leppanen et al's (2017) mega-analysis which pooled data from 297 participants from five published and one unpublished study was conducted using GPower with alpha set at .05, power set at 80% and aiming for a medium effect size ($d > .05$). This suggested a minimum sample size of 23 participants per group.

Self-report measures were assessed for assumptions of normality using box-plots, measures of skewness and kurtosis, histograms and the Kolmogorov-Smirnoff test and parametric tests were selected. These data were analysed using chi square for categorical data and independent t-tests for continuous data.

Data measuring facially expressed emotions for each participant were extracted from the Noldus FaceReader software as ODX files. For each participant, their ODX FaceReader data, electro-dermal activity text file and video recording of the social interaction were entered simultaneously into The Observer XT. The coding system was then applied to the video data with time stamps placed to designate the start and end of the pre-baseline, condition 1, 2 and 3 and post-baseline conditions. Data profiles in the Observer XT were used to derive dependent variables reflecting the duration of emotion expression (happy, sad, angry, scared, surprised, disgusted and neutral), measured in seconds, non-verbal behavior (behaviors exhibited within the five behavioral categories of orientation, legs, trunk, gaze and hands described in detail in table 1), measured in seconds/milliseconds, and electro-dermal activity, measured in μS during the positive, negative and neutral conditions for the ED and non-ED control groups, controlling for mean baseline σ^2 . Variance in electro-dermal activity (σ^2) was produced by computing the mean of the squared differences from the mean.

Data from the Observer XT were exported to SPSS Version 24 and assessed for assumptions of normality using boxplots, histograms, skewness and kurtosis. Generally these analyses indicated the use of parametric tests with some caveats. For the emotion expression data ($W(2)=.76$, $p=.026$, $\epsilon=.81$), the non-verbal behavior code of body orientation ($W(5)=.001$, $p\leq.001$, $\epsilon=.51$), and the non-verbal behavior codes reflecting the use of hands ($W(152)=.001$, $p\leq.001$, $\epsilon=.23$), Mauchly's Test of Sphericity was significant, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. When conducting post-hoc tests for the use of gaze, Levine's test for equality of variances was significant for the behavioural code of looking down and therefore the corrected t value and degrees of freedom were used. The use of parametric tests

was also informed by the need to control for depression/anxiety, using the DASS total score, and ASD traits, measured using the AQ, given that the groups differed significantly on these measures (see Table 3) and, as discussed, previous research has not consistently controlled for this potential confound. BMI was also entered as a covariate in all models, as this may negatively impact social functioning (Harrison, Tchanturia, Naumann & Treasure, 2012) and electro-dermal activity (Crifaci et al., 2013).

A related, factorial ANCOVA was used to explore main effects of group and condition and possible interactions. This meant that the group and condition were predictor variables and BMI, the DASS total score and AQ score were covariates in the model. The Variance Inflation Factor and Tolerance Statistic did not suggest multicollinearity because the maximum value for Tolerance was 1 and the maximum value for the Variance Inflation Factor was 2. Planned post-hoc t-tests tested the specificity and direction of significant effects. Bonferroni's correction for multiple testing was used to reduce Type 1 error (.05/number of comparisons). Cohen's *D* was used as an effect size estimation with .2 considered small, .5 medium and .8 large (Cohen, 1988).

3.0 Results

The final sample consisted of 50 women; 25 with EDs and 25 non-ED controls. Table 2 provides demographic information.

INSERT TABLE 2 ABOUT HERE

Groups were similar regarding age, educational background, ethnicity, occupational and relationship status and the number of close friends reported. More non-ED controls reported

having a best friend compared to those with EDs ($d=.60$). Within the ED group, 80% ($n=20$) participants had a diagnosis of AN and 20% ($n=5$) had a DSM 5 (American Psychiatric Association, 2013) diagnosis of Other Specified Feeding or Eating Disorder (OSFED) AN subtype. The mean EDE-Q global score for the ED group was 4.33 ($SD=1.59$) and BMI ranged from 15.27 to 23.96. Those with EDs had been unwell for 7.6 years on average ($SD=3.9$).

Table 3 provides data on comorbidity and self-reported social skills.

INSERT TABLE 3 ABOUT HERE

The ED group reported large-sized increases in stress ($d=1.23$), anxiety ($d=1.29$) and depression ($d=1.48$) and greater overall comorbidity, with a large-sized difference in the total DASS score ($d=1.41$), relative to non-ED controls. Those with EDs reported large-sized increases in social phobia (SPIN; $d=1.51$), ASD traits (AQ; $d=1.19$) and work and social adjustment difficulties (total WSAS; $d=.98$) compared to non-ED controls. Although the groups did not report differences in overall self-reported communicative adaptability, those with EDs felt they had a greater ability to manage social situations without feeling nervous (CAS Social Composure subscale; $d=1.07$), to see situations from others' perspectives (CAS Social Confirmation; $d=.94$) and to use jokes when feeling anxious ($d=.73$) than non-ED controls.

3.1 Observational Data: Emotion Expression

There was no significant main effect of condition ($F(1.62, 45.29)=.25, p=.782, d=.14$), suggesting no differences in emotional expression between the neutral, positive and negative conditions.

There was also no significant main effect of group ($F(1, 48)=.49, p=.782, d=.21$), suggesting the groups did not differ with regard to their overall emotion expression. There was no group by condition interaction ($F(1.62, 45.29)=.58, p=.529, d=.22$), suggesting that the two groups do not differ regarding their expression of emotions across positive, negative or neutrally valanced topics. Table 4 provides descriptive statistics for emotion expression in each of the three conditions (neutral, positive, negative) for the ED and non-ED control groups.

INSERT TABLE 4 ABOUT HERE

3.2 Observational Data: Non-Verbal Communication - Body Orientation,

There was a main effect of condition ($F(1.02, 47.89)=6.49, p=.014, d=1.75$), suggesting that the valence of the conversational topic affected the positioning of the body. Participants were significantly more likely to be directly facing their conversational partner in the negative condition ($M=02:03:43, SD=01:08:54$) than the neutral condition ($M=01:28:59, SD=00:38:42; t(49)=3.61, p=.001, d=1.77$). They were also significantly more likely to position their body facing their conversational partner in the positive condition ($M=02:16:35, SD=01:43:03$) than in the neutral condition ($M=01:28:59, SD=00:38:42; t(49)=-3.42, p=.001, d=1.68$). There was no difference between the positive and negative conditions ($t(49)=.80, p=.428, d=.23$). There was no main effect of group for body orientation ($F(1,47)=.28, p=.597, d=.15$), such that those with EDs

did not position their body in relation to their conversational partner any differently to non-ED controls. There was no group by condition interaction effect ($F(1.02, 47.89)=.52, p=.485, d=.20$).

3.3 Observational Data: Non-Verbal Communication - Placement of Legs

Conversational emotional valence did not affect whether participants' legs were crossed/uncrossed ($F(2,94)=.18, p=.837, d=.12$). There was no main effect of group with regards to the placement of participants' legs ($F(2,94)=.56, p=.22, d=.21$), nor was there a condition by group interaction ($F(2,94)=.22, p=.8, d=.13$). This suggests that neither the valence of the discussion, nor the presence of an ED changed the way people placed their legs during the real-life social interaction.

3.4 Observational Data: Non-Verbal Communication - Placement of Trunk

There was no main effect of condition on trunk lean (whether the trunk was positioned upright, angled forwards towards the conversational partner, angled backwards, or positioned in another configuration, such as significantly to the left or right); ($F(2,96)=1.18, p=.311, d=.31$). There was no main effect of group on trunk lean ($F(1,48)=.44, p=.51, d=.19$). However, there was a significant group by condition interaction ($F(2,96)=4.42, p=.015, d=.59$). Figure 2 illustrates how when discussing a negatively valenced topic, adopting a corrected p value of $\leq .0125$, the ED group were significantly less likely than non-ED controls to be leaning forwards towards their conversational partner ($t(48)=2.81, p=.007, d=.81$). Further, when discussing a positively valenced topic, those with EDs were significantly less likely to be positioned upright than non-ED controls ($t(48)=-3.86, p\leq .001, d=.56$). This suggests that individuals with EDs interact differently with their conversational partner in the context of negatively or positively-valenced

discussions, perhaps showing less interest through being less upright and forward in relation to their conversational partner.

INSERT FIGURE 2 ABOUT HERE

3.5 Observational Data: Non-Verbal Communication - Use of Gaze

There was a main effect of condition for the use of gaze (the position of the head: whether the participant's head was angled towards, down or away from their conversational partner; ($F(2,96)=21.81, p \leq .001, d=.57$). Using a corrected p value of $\leq .006$, post-hoc paired samples t -tests showed that in the negatively valenced condition ($M=02:40:45, SD=01:49:88$), participants' gaze was significantly more likely to be on the experimenter than in the neutral condition ($M=02:04:24, SD=01:26:43; t(49)=3.31, p=.002, d=.35$). Participants' gaze was also significantly less likely to be turned away from the experimenter in the positive condition ($M=00:40:24, SD=01:03:21$) compared with the negative condition ($M=01:10:55, SD=01:34:05; t(49)=-3.13, p=.003, d=.89$). Participants' gaze was also significantly more likely to be turned away from the experimenter in the neutral condition ($M=01:05:36, SD=01:20:25$) compared with the positive condition ($M=00:40:24, SD=01:03:21; t(48)=2.85, p=.006, d=.81$).

There was a main effect of group regarding the use of gaze during the social interaction ($F(1,48)=3.99, p=.052, d=.56$). Figure 3 illustrates how the ED group spent significantly less time with their gaze focused on the experimenter across all conditions ($M=130.96, SD=64.51$) than non-ED controls ($M=152.44; SD=85.41; t(48)=-1.02, p=.03, d=.29$). Those with EDs ($M=47.63, SD=48.94$) were significantly more likely to look down than non-ED controls

($M=47.63$, $SD=86.11$; $t(38.04)=1.92$, $p=.003$, $d=.54$) and those with EDs ($M=61.14$, $SD=79.48$) were also significantly more likely to look away than non-ED controls ($M=56.29$, $SD=62.06$; $t(48)=2.24$, $p=.008$; $d=.63$) throughout the duration of the real-life social interaction than controls. There was no significant group by condition interaction ($F(2, 96)=.14$, $p=.87$, $d=.11$).

INSERT FIGURE 3 ABOUT HERE

3.6 Observational Data: Non-Verbal Communication - Use of Hands

There was no significant main effect of condition ($F(1.89, 88.67)=2.44$, $p=.096$, $d=.24$), suggesting that conversation valence did not affect the use of hands as a non-verbal communication tool. There was a significant main effect of group ($F(1,47)=15.61$, $p\leq 0.001$, $d=1.12$). As illustrated in Figure 4, independent post-hoc t-tests with a corrected p value of .003 showed that significantly fewer beats (where hands move along with speech) were observed in the ED group ($M=19.02$, $SD=9.89$) compared to non-ED controls ($M=44.38$, $SD=24.37$; $t(48)=-2.21$, $p=.003$, $d=.63$). Significantly fewer iconics and metaphors (gesturing a real (iconics) or hypothetical/imagined (metaphors) spatial image, action or object) were observed in the ED group ($M=31.86$, $SD=9.89$) compared to non-ED controls ($M=70.78$, $SD=34.37$; $t(48)=-2.02$, $p=.003$, $d=.57$). The ED group ($M=34.52$, $SD=6.76$) was significantly more likely than non ED controls ($M=4.95$, $SD=3.54$) to touch their head during the social interaction ($t(48)=1.91$, $p=.003$, $d=.54$). The ED group ($M=8.96$, $SD=5.59$) was significantly more likely than non-ED controls ($M=.75$, $SD=.22$) to touch their mouth during the social interaction ($t(48)=-2.61$, $p=.001$, $d=.74$). The ED group ($M=5.71$, $SD=2.04$) were significantly less likely than non-ED controls ($M=17.47$, $SD=5.83$) to touch or play with their hair during the social interaction ($t(48)=-2.19$,

$p=.003$, $d=.62$). The ED group ($M=59.07$, $SD=18.31$) were significantly more likely than non-ED controls ($M=26.79$, $SD=13.45$) to have their hands in contact with their arms during the social interaction ($t(48)=1.81$, $p=.001$, $d=.51$) and were significantly more likely ($M=21.11$, $SD=4.15$) than non-ED controls ($M=2.25$, $SD=2.33$) to have their hands in contact with their trunk during the social interaction ($t(48)=2.32$, $p=.002$, $d=.66$). This suggests that regardless of a conversation's emotional valence, people with EDs use their hands less to support the conveying of their message (fewer beats, iconics and metaphors) and instead are more likely to be observed with their hands touching their body (particularly their head, mouth, arms and trunk) than non-ED controls. There was no significant group by condition interaction effect ($F(2,94)=.36$, $p=.701$).

INSERT FIGURE 4 ABOUT HERE

3.7 Psychophysiological Data: Electro-dermal Activity

Controlling for baseline electro-dermal response and the covariates (BMI, total DASS and AQ scores), there was no significant main effect of condition for electro-dermal response ($F(2,94)=1.97$, $p=.146$, $d=.40$). There was a main effect of group for electro-dermal response ($F(1, 47)=4.53$, $p=.03$, $d=.60$), shown in Figure 5. There was no condition by group interaction ($F(2,94)=.24$, $p=.787$, $d=.14$). This suggests that regardless of the emotional valence of the conversation, people with EDs are less physiologically aroused than unaffected peers during a real-life social interaction.

INSERT FIGURE 5 ABOUT HERE

4.0 Discussion

This study aimed to be the first to experimentally measure non-verbal communication in people with ED relative to non-ED controls. The first hypothesis, that during a real-life, face-to-face social interaction, women with EDs would show significantly reduced basic facial emotional expression than non-ED controls, was not supported by the data, with a small-sized ($d=.21$), non-significant difference between the ED and non-ED groups.

The second hypothesis, that individuals with EDs would also show significant differences in their use of non-verbal communication behaviour, was partially supported by the data. Those with EDs did not differ significantly from non-ED controls with regards to the orientation of their body (whether they were facing their conversational partner or angled away from them to any degree; $d=.15$) or whether they sat with their legs crossed or uncrossed during the social interaction ($d=.21$). The ED-group were significantly less likely than non-ED controls to be leaning forwards towards their conversational partner when discussing a positively valenced topic ($d=.81$), and those with EDs were significantly less likely than non-ED controls to be positioned upright, compared to non-ED controls when discussing a negatively valenced topic ($d=.56$), perhaps indicating lowered interest in their conversational partner. The ED group was significantly less likely than non-ED controls to focus their gaze on the experimenter, irrespective of the emotional valence of the discussion ($d=.29$) and spent significantly more time looking down than non-ED controls ($d=.54$) and were significantly more likely to look away during the social interaction than controls ($d=.63$).

There were notable differences in the use of hand gestures as non-verbal communication tools. Regardless of the conversation's emotional valence, those with EDs moved their hands along with their speech (beats) significantly less than non-ED controls ($d=.63$) and used significantly fewer iconics and metaphors (gesturing a real (iconics) or hypothetical/imagined (metaphors) spatial image, action or object) than non-ED controls ($d=.57$). The ED group touched their head ($d=.54$) and mouth ($d=.74$) significantly more often than non-ED controls and those with EDs were significantly less likely than non-ED controls to touch or play with their hair during the social interaction ($d=.62$). Instead, the ED group were more likely to be resting their hands on their arms ($d=.51$) or trunk ($d=.66$). The additional exploratory hypothesis of reduced physiological arousal, measured using electro-dermal responses, in the ED group compared with controls was supported by the data. Those with EDs showed significantly reduced electro-dermal activity ($d=.60$) than controls, regardless of the conversation's emotional valence, suggesting that the ED group are less physiologically aroused than unaffected peers during a real-life social interaction.

Taken together, these findings further elucidate the interpersonal difficulties posited to maintain EDs (Fairburn, Cooper & Shafran, 2003; Schmidt & Treasure, 2013), providing the first observational data to suggest medium to large-sized differences in the use of certain aspects of non-verbal communication during a real-life social interaction in those with EDs compared to non-ED controls. In particular, in addition to being significantly less aroused during a social interaction, people with EDs lean in less frequently towards their conversational partner, and when discussing both positive, negative and neutral topics, their hands remain somewhat still,

more frequently in contact with their arms or trunk, rather than being used to support their verbal communication through the use of hand gestures.

The data on facially expressed basic emotions, which are the first in the field to be derived from a real-life social interaction, differ from previous findings of reduced facial emotional expression in people with EDs relative to controls (Davies et al., 2016). This may be due to methodological differences because previous studies assessed facial emotional expression when participants interacted with static images or emotive videos, whereas this study attempted to quantify emotional expression during a real-life social interaction. Perhaps simply videoing and measuring basic emotions misses some of the complexity of this form of social communication. In future work, we hope to utilise eye-tracking glasses to measure and record eye-gaze and emotional expression in vivo to further explore this important facet of social communication in EDs.

Supporting Cipolli et al., (1989), Harrison, Watterson and Bennett (2019) and Watson, Werling, Zucker and Platt (2010), people with EDs used their gaze differently to controls, spending more time looking down or away. This finding contributes to growing empirical evidence that individuals with EDs look less at the face, and in particular, the eyes of interlocutors, which might explain some of the friendship difficulties experienced by those with EDs (Westwood, Lawrence, Fleming & Tchanturia, 2016). Looking away from the face can indicate a lack of interest in a conversational partner and thus this finding may explain why those with EDs say their friends reject them (Patel, Harrison & Tchanturia, 2016) and why this population experience high adversity (Arnell & Robinson, 2008),

These data offer significant new knowledge on some of the inefficiencies present when people with EDs use non-verbal communication skills when conversing with others. As non-verbal behaviour supports effective communication and signals social affiliation (Lakin & Chartrand, 2003), clinicians could support patients to develop effective social skills using role-play and in vivo experiments to increase awareness of how to use the body to effectively convey their message and interest in others. The use of video feedback, well used in social phobia treatment (Rapee & Hayman, 1996) and coaching for public speaking (Grice, Skinner & Mansson, 2004) could be a valuable means of helping people with EDs to be more aware of their use of non-verbal behaviors and what they are (or are not) signalling to others during social interactions. Another way to develop this work would be to look at mimicry between the participant and their conversational partner and this is what we will code in the next stage of this project.

The reduced electro-dermal response mirrors findings in previous work (Tchanturia et al., 2007) and suggests the physical experience of social situations may be different for those with EDs compared to unaffected peers. This work supports the conceptualisation of EDs (particularly those with nutritional restriction as core symptoms) as disorders of overcontrol, as outlined by Lynch, Hempel and Dunkley (2015). Treating overcontrol through Lynch's (2008) Radically-Open Dialectical Behaviour Therapy might provide patients with skills to use non-verbal communication more efficiently in social situations.

This study is limited in its female-only population and more diverse gender groups should be included in future research. The sample size was modest and could be increased in future studies

to enable, for example, regression analysis around how the observed social skills might predict the presence of self-reported social difficulties. The volunteer sampling approach attracted mostly individuals with AN, forming 80% of the ED group, and future work could explore whether these findings extend to other forms of eating psychopathology. The study is cross-sectional and does not inform us about the social skills of participants before illness onset. It would have been interesting to explore whether native English speaking might be a possible confounder, and while this was not recorded in this study, it might be a factor to consider in future research, particularly as clinicians work with individuals from a diverse range of backgrounds and who bring many different languages to the social setting of treatment. As this was an overt observational study, people knew they were being filmed which may have affected their social skills. This approach was selected with ethical considerations around covert filming of a vulnerable group in mind, but it may be possible to further develop the naturalistic aspect of data collection by covertly filming people in places where they might expect to be observed, such as in public settings perhaps.

In conclusion, in addition to being significantly less aroused during a social interaction, people with EDs lean in towards their conversational partner less frequently, and when discussing both positive, negative and neutral topics, their hands remain somewhat still, touching their arms or trunk rather than being used to support their verbal communication through the use of gestures. This difference in the use of non-verbal communication skills could be targeted in treatment using role-play, behavioural experiments, the use of video feedback to equip patients with the social tools needed to support them to make best use of social support in their recovery.

Funding**Statement of data availability**

The authors confirm that the data supporting the findings of this study are available upon request (not including the videos which contain identifying data).

CRedit authorship contribution statement

AH: Conceptualisation, Methodology, Formal analysis, Investigation and Writing.

Declaration of Competing Interest

The author declares no conflict of interest.

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