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Facial emotion recognition performance influences executive control impairment in Anorexia Nervosa: an exploratory study

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Abstract

Objectives. Since evidence on executive control among women with Anorexia or Bulimia Nervosa (AN/BN) are somehow inconclusive, we aimed to explore whether performance in set-shifting in AN/BN might be influenced by Facial Emotion Recognition (FER).

Methods. We randomly recruited women with a diagnosis of AN or BN, from an Eating Disorders Outpatient Clinic in Italy, as well as healthy controls (HCs). We evaluated with established tools: diagnosis (Eating Disorder Examination- EDE-17.0), executive control (Intra-Extra Dimensional Set Shift-IED) and FER (Ekman 60 Faces Test-EK-60F). Univariate distributions by diagnostic subgroups were assessed on sociodemographic and clinical variables, which were selected for subsequent multiple linear regression analyses.

Results. Women with AN performed significantly worse than HCs on IED adjusted total errors. HCs scored significantly better than AN and BN on EK-60F fear subscale. Although IED set shifting was associated (p = 0.008) with AN, after controlling for age, EK-60F fear subscale, alexithymia and depression (i.e., clinically relevant covariates identified a priori from the literature, or associated with AN/BN at univariate level), this association could not be confirmed.

Conclusions. Impaired executive control may not be a distinctive feature in women with AN, since several clinical characteristics, including fear recognition ability, are likely to have an important role. This has significant implications for relevant interventions in AN, which should aim at also improving socio-emotional processing.

Keywords

Executive control, facial emotion recognition, eating disorders.

INTRODUCTION

Executive control encompasses a set of mechanisms that allow individuals to plan complex goal-directed behaviours, flexibly adjusting their performance and adapting to changing environmental and internal states (Alvarez & Emory, 2006).
Various deficits in executive control have been identified in the Eating Disorders (EDs) literature, in particular, as regards difficulties in set-shifting (e.g., Kittel, Brauhardt, & Hilbert, 2015). Deficits in executive control – including inhibitory control, cognitive flexibility, decision-making, and working memory – may be risk or maintenance factors for EDs (Manasse et al., 2015). Nonetheless, evidence is somehow mixed in several aspects (Wu et al., 2014), considering various socio-demographic and clinical confounders. Significant methodological weaknesses (e.g., use of a single executive control measure, omission of relevant covariates) in the current literature represent one reason for lack of consensus. For example, considering Anorexia Nervosa (AN), children and adolescents populations show little, if any, impairment in set-shifting ability (Lang et al., 2014). This might be due to the cognitive disturbances derived from alterations in the brain structure detectable in the adulthood among people with AN, and possibly exacerbated by starvation, which contribute to the maintenance of AN after recovery (Fonville et al., 2014). Similarly, evidence on impairments underlying poor executive control in Bulimia Nervosa (BN) is not conclusive (Van den Eynde et al., 2011). In addition, individual differences in clinical characteristics in ED samples provide further interpretative challenges, as these could distinctively affect each individual's cognitive performance. For example, age of onset might influence inefficiencies in set-shifting that are apparent in the adult, since they do not appear to be as pronounced in children. This may suggest that

set shifting difficulties in adult AN are the result of starvation or indicative of longer duration of illness (Lang et al., 2014).

In particular, Facial Emotion Recognition (FER), that is, the ability to accurately identify and name emotions of other people, has been shown compromised in women with AN (Caglar-Nazali et al., 2014). The facets of social-cognition that appear to be compromised in this patient group include difficulties identifying basic and complex emotions, with large to moderate effects found for poor FER (Cardi et al., 2015), particularly in women with AN. Although evidence remains not entirely convincing and definitive, difficulties in interpreting emotions may contribute to, and exacerbate, AN clinical symptoms (Treasure, Corfield, & Cardi, 2012). Also, for BN, the limited literature has found some difficulties in recognizing specific emotions (e.g., Kuhnpast, Gramann, & Pollatos, 2012; Aloi et al., 2017). In particular, authors using pooled subjects with BN and AN have reported contradictory findings, showing global difficulties recognising emotions in adolescents (Zonnevijlle-Bender, van Goozen, Cohen-Kettenis, van Elburg, & van Engeland, 2002), but not in adults (Cardi et al., 2015). However, considering BN only, some investigations have found slight difficulties recognising surprise (Kessler, Schwarze, Filipic, Traue, & von Wietersheim, 2006; Legenbauer, Vocks, & Ruddel, 2008), and anger, often misinterpreted as fear (Kuhnpast, Gramann, & Pollatos, 2012), but no problems recognising other emotions.

However, an association between impaired FER and executive control has been found in several other serious mental disorders, including alcohol dependence (Trick et al., 2014), schizophrenia (Bortolon, Capdevielle, & Raffard, 2015), and bipolar disorders (David et al., 2014). Prefrontal dysfunction may lead to impairments in executive control and FER (Adolphs, 2002). Emotion face perception is a complex process that cannot be related to a single neural event taking place in a single brain region, but rather implicates an interactive network with distributed activity in time and space. Traditional models have often assumed that facial expression and executive control are processed along separate pathways. However, evidence from fMRI suggests that emotional processing can strongly affect brain systems responsible for both face recognition and memory, with fear-related modulations of face processing driven by amygdala signals implicating not only fusiform cortex, but also earlier visual areas in occipital cortex involved in cognitive responses (Vuilleumier & Pourtois, 2007). Deficits in FER and executive control could thus be associated also in EDs. Consistently, determining whether the impairment in EDs is cognitive-affective may have key therapeutic implications, as these require different intervention strategies (Legenbauer, Vocks, & Rüddel, 2008). It might well be that, also in people with EDs, set-shifting and FER are jointly compromised, at least as regards the impairment of certain emotions. Nonetheless, to our knowledge, no empirical research exists, explicitly addressing this issue. We thus tested the hypothesis that difficulties in set-shifting experienced by people with AN or BN may be influenced by impaired FER. We used a real world sample of women with EDs, rigorously assessing diagnostic and clinical features, but also executive control and emotional recognition abilities. It was hypothesized that, after adjusting for important sociodemographic and clinical characteristics, impaired FER would influence executive control performance in people with AN or BN.

MATERIAL AND METHODS

Design and sample

We conducted a cross-sectional study and, between October 2015 and May 2016, recruited, using a simple random procedure, women with a diagnosis of AN or BN from the Eating Disorders outpatient clinic of San Gerardo Mental Health Trust (Monza, Italy). This covers a 300,000 inhabitants catchment area in a mixed urban/rural region and provides specialized treatments for women suffering from EDs of any level of severity. In addition, we conveniently identified female healthy controls (HCs), easily accessible and geographically concentrated clients attending local shops, within the same age range. Power calculations to establish the required sample size were based on the data from similar clinical populations, which assessed IED total trials (adjusted) (Galimberti et al., 2012). Considering a Cohen's d of 0.80 and 80% power, a sample size of 58 (39 cases and 19 HC) was needed to detect this effect size at the conventional significance level of 0.05, according to a 2:1 cases-controls ratio to account for both AN and BN subgroups. All hypothesis testing was two-tailed.

Inclusion and exclusion criteria

Eligible participants were women suffering from AN or BN and aged 18–50 years at the time of enrolment in the study. We excluded people with current drug or alcohol misuse, mental retardation, and any major psychiatric illness apart from depressive disorders (which are commonly comorbid among women with EDs) as well as those unable to provide consent.

Measures and procedures

Socio-demographic and clinical variables.

Along with socio-demographic information (i.e., age, living and family conditions, employment status, education), several clinical variables, including body mass index (BMI), were collected. According to previous evidence from the literature, we selected clinically relevant variables that provide a broad picture of impairments related to psychological problems and emotional experience in EDs and that may influence specific domains we studied, that is, executive control and FER.

The Italian versions of the Eating Disorder Examination (EDE-17.0) (Calugi et al., 2017) and of the Eating Disorder Examination Questionnaire (EDE-Q 6.0) (Calugi et al., 2017), were used to generate DSM-5 ED diagnoses and to rule out (mean global score > 2.0) any possible EDs from HCs, respectively. Information on current symptom profile was collected on several domains. We used the Italian versions of Symptom Check List-SCL-90-R (Prunas et al., 2012) in order to get a broad picture of psychological problems and symptoms of psychopathology; the Beck Depression Inventory-BDI-II (Sica, Ghisi, & Lange, 2007) for measuring the severity of depression; the Eating Disorder Inventory-3 with subscales, a self-report tool, measuring constructs shown to be clinically relevant in individuals with EDs symptoms (i.e., drive for thinness-DT, bulimia-B and body dissatisfaction-BD) (Giannini et al., 2008); and the 20-item Toronto Alexithymia Scale-TAS-20 (Bressi et al., 1996), exploring difficulties in identifying and describing emotions and tendency to minimise emotional experience and focus attention externally. In addition, the Structured Clinical Interview AXIS II Personality Disorders (SCID-II) (First et al., 1997) for DSM-IV was administered to identify the relevant comorbid disorders.

Neuropsychological assessment

As far as cognition assessment, we distinguished two different domains.

First, in order to assess executive functions, we used the Intra-Extra Dimensional Set Shift (IED), a test of rule acquisition and reversal, sensitive to cognitive changes and widely adopted to assess executive control. IED is implemented on a computer-controlled touch screen, taking 7/10 min to be administered, assessing visual discrimination and attentional set formation maintenance, shifting, and flexibility of attention, using both simple stimuli for visual perceptual-dimensions, and compound ones, shown in nine different stages (Computerized Cambridge Cognition, 2013). Participants progress through the test completing the intra-dimensional shift stages and providing six consecutive correct responses. If at any stage the subject fails to reach this criterion after 50 trials, the test terminates. We used the adjusted number of errors as a measure of the participants' ability in completing the overall task. Since the participants who do not complete one or more stages are less likely to make errors, the total errors were adjusted considering the non-completed stages. Thus, we chose the IED adjusted total errors as the main outcome measure, as recommended to study the impaired set-shifting.

Secondly, as regards emotion and social cognition, we used the Ekman 60 Faces Test-EK-60F for emotion recognition assessment (Dodich et al., 2014). This contains the grayscale photographs of 10 individuals, each displaying one of the six high-intensity prototypical basic emotions. Faces are presented in a random order for 5 seconds each, and participants choose which emotion term (anger, disgust, fear, happiness, sadness, and surprise) best describes the facial expression shown. Based on the number of correct responses, the overall score can range from 0 to 60. Each basic emotion has a maximum sub-score of 10.

Data analyses

Checking the data distribution for IED adjusted total errors and EK-60F scores, we identified outliers based on the interquartile range (iqr) rule. In particular, we calculated (value - upper quartile)/iqr for any value at or above the upper quartile as well as (value - lower quartile)/iqr for any value at or below the lower quartile, considering a threshold ratio of 3 (Tukey, 1977; Dawson, 2011). Thus, the participants bringing values whose ratio exceeded 3 ('severe outliers') were excluded from the analyses. In order to explore the potential differences between the diagnostic subgroups and HCs, univariate distributions were assessed. Univariate comparisons were made using Pearson's chi-square test or Fisher's exact test, where appropriate, for categorical data, and ANOVA or Kruskal-Wallis test, according to assumptions on distribution, for continuous variables. These analyses involved sociodemographic (i.e., age, living and family conditions, employment status, and education) and clinical variables, known as potential confounders among women suffering from EDs. Clinical variables included: DSM-IV personality disorders; history of childhood abuse; BMI; length of illness; IED adjusted total errors and scores of EK-60F; BDI-II (rated on a 4-point scale ranging from 0 to 3);

TAS-20 (whose 20 items are rated using a 5-point Likert scale whereby 1 = strongly disagree and 5 = strongly agree); SCL-90 Global Severity Index (based on the average rating given to all 90 items); and EDI-3, whose 91 items – scoring from 0 to 4 – map into drive for thinness (DT), bulimia (B) and body dissatisfaction (BD) subscales. Adjustments for multiple comparisons, based on Bonferroni correction, were applied considering specific AN/BN diagnosis and different subscales of adopted instruments. Where appropriate, a mathematically equivalent adjustment was employed, multiplying the observed p-value by the number of comparisons made to obtain the Bonferroni-adjusted p-value.

In order to take into account the confounding effect, clinically relevant factors identified a priori from the literature and those covariates that were associated with specific EDs diagnostic subgroups (AN/BN) at univariate level were selected for multiple linear regression analyses. We compared the performances of the different models (i.e., including the different subsets of covariates as control variables) using Akaike Information Criterion (AIC), based on the maximized log-likelihood of the model and the number of parameters estimated (Akaike, 1973). Models with lower AIC values have better empirical support than those with higher values, still considering overall significance of the model. Statistical significance was set at $p < 0.05$. We analysed the data using the Stata statistical software package (version 14; Stata Corp, College Station, Texas).

RESULTS

Checking the data distribution for IED adjusted total errors and EK-60F scores, we could detect two outliers based on interquartile range (iqr) rule (Tukey, 1977; Dawson, 2011), bringing values whose ratio exceeded 3 ('severe outliers'). These participants were excluded from analyses, resulting in an overall sample of 58 women (AN = 19; BN = 20; HCs = 19). Consistent with our study hypothesis, we first explored the attributes of EDs, also in terms of performance in executive control and FER. Thus, **Table 1** shows the univariate comparisons for sociodemographic and clinical characteristics across AN, BN and HCs subgroups. Mean age was comparable with participants usually in their late twenties, and not different in terms of living and family conditions, education and employment status. History of childhood abuse was rare, and BMI was obviously uneven between AN and BN. Women with AN performed significantly worse than HCs in terms of IED adjusted total errors. As regards EK-60F total and subscales scores, HCs scored significantly better than AN and BN only on fear subscale (subscale range 0–10). In addition, for measures describing current symptoms dimensions, that is, means of BDI-II, TAS-20, SCL-90 GSI, and EDI-3 subscales, women with AN and BN scored significantly worse than HCs.

Then, in order to explore the role of other factors, including FER performance and ED diagnostic subgroup, associated with IED adjusted total errors, we fitted several models that included significant attributes from the univariate analyses, and known to be relevant from the literature (**Table 2**). The first model considering the EDs diagnostic subgroups compared with HCs showed that IED set shifting performance was associated with AN ($p = 0.008$). However, in the second model, also taking into account age, EK-60F fear subscale, depression as measured by BDI-II, and alexithymia as measured by TAS-20, this association could not be confirmed. In addition, the performances of the two models in terms of AIC were comparable.

DISCUSSION

This study aimed to investigate the influence of FER abilities on impaired executive control in women with EDs. As a measure of executive control, we used the IED, a standardized and validated test that is not timed and so may be less affected by potential deficits in speed of processing, and that was previously successfully used among women with EDs (e.g., Galimberti et al., 2012). This is critical, since the effect sizes for different measures of set-shifting among women with EDs across the studies differ significantly from each other (Wu et al., 2014). We could initially uncover an association between IED set-shifting adjusted total errors and just AN, that was not found in the previous studies. We possibly sampled a slightly older clinical population that might have had sufficient time to develop cognitive disturbances. However, taking into account different correlates, including fear recognition ability, this association was no longer significant. Fear recognition ability is likely to have a role on impairment in executive control in women with AN as much as alexithymia (Brewer et al., 2015) and other clinical variables (Wu et al., 2014) may have. As a whole, our findings are consistent with the cognitive-interpersonal maintenance model of AN (Treasure & Schmidt, 2013), as far as executive control is shown to be compromised in women with AN. Nonetheless, they provide incremental knowledge jointly exploring, for the first time, the influence of impaired interpretation of facial emotions and weak set shifting, an important measure of executive control. In sum, further research should pay closer attention to the evaluation of several potential confounders on executive control (Abbate-Daga et al., 2015).

Table 1. Sociodemographic and clinical characteristics by diagnostic subgroups.

	Anorexia Nervosa N = 19	Bulimia Nervosa N = 20	Healthy Controls N = 19	P
Age, yrs. mean (SD) median (IQR)	27.26 (10.07) 23 (20-38)	27.65 (9.48) 23.5 (20.5-33.5)	26.79 (4.18) 26 (25-30)	0.378
In a relationship	3 (15.8%)	3 (15.0%)	5 (26.3%)	0.701
Employed	3 (15.8%)	8 (40.0%)	10 (52.6%)	0.054
Living condition Alone With family With partner Other	 1 (5.3%) 16 (84.2%) 2 (10.5%) 0	 3 (15.0%) 13 (65.0%) 3 (15.0%) 1 (5.0%)	 2 (10.5%) 12 (63.2%) 5 (26.3%) 0	0.596
DSM-IV Personality disorders None Borderline Obsessive-compulsive Depressive NAS	 11 (57.9%) 2 (10.5%) 3 (15.8%) 1 (5.3%) 2 (10.5%)	 9 (45.0%) 5 (25.0%) 0 1 (5.0%) 5 (25.0%)	 19 (100%)	0.001
Lifetime major childhood abuse Physical Sexual	 1 (5.3%) 0	 1 (5%) 2 (10.0%)	 0 0	-
BMI mean (SD) Median (IQR)	16.07 (1.09) 16.10 (15.23-17.22)	21.91 (4.63) 20.04 (19.48-21.55)	21.40 (2.50) 21.20 (19.31-22.32)	0.0001
Length of illness, yrs. mean (SD) Median (IQR)	7.95 (11.54) 3 (1-7)	8.30 (7.86) 5 (3-12.5)	-	-
IED Set shifting, mean (SD) adjusted total errors	40.32 (23.15)	30.80 (20.51)	21.74 (17.98)	0.044
EK-60F, Total mean (SD) Surprise Happiness Fear Disgust Anger Sadness	48.89 (4.66) 9.37 (0.83) 10.00 (0) 6.58 (2.63) 9.00 (1.45) 6.74 (1.66) 7.21 (2.15)	48.75 (3.54) 9.75 (0.55) 9.65 (0.75) 6.05 (2.37) 8.55 (1.15) 6.45 (1.64) 8.15 (1.46)	50.84 (4.19) 9.10 (1.29) 9.74 (0.45) 9.26 (1.15) 8.63 (1.46) 7.00 (1.73) 8.42 (1.17)	0.316 0.153 0.289 0.0001 0.328 0.666 0.196
BDI-II, mean (SD)	24.21 (13.80)	21.65 (12.55)	2.68 (3.87)	0.0001
TAS-20, mean (SD)	57.00 (10.59)	49.15 (14.38)	32.42 (6.14)	0.0001
SCL-90 GSI, mean (SD)	1.42 (0.74)	1.26 (0.54)	0.29 (0.28)	0.0001
EDI-3, mean (SD) DT B BD	 79.26 (18.09) 67.42 (21.48) 77.21 (15.03)	 72.55 (25.62) 63.80 (21.16) 71.40 (20.58)	 9.58 (18.77) 15.37 (18.87) 11.79 (17.72)	 0.0001 0.0001 0.0001

IQR = Interquartile range. Fisher's exact test for categorical, ANOVA and Kruskal-Wallis test for continuous variables.
BMI: Body Mass Index; IED: Intra-Extra Dimensional Set Shift; EK-60F: Ekman 60 Faces; BDI-II: Beck Depression Inventory; TAS-20: Toronto Alexithymia Scale; SCL-90 GSI: Symptom Check List Global Severity Index; EDI-3: Eating Disorder Inventory 3rd version subscales: drive for thinness (DT), bulimia (B) and body dissatisfaction (BD).

Limitations

Studies of this type, relatively small in sample size, are inevitably exploratory in nature. Thus, our findings need to be interpreted with caution until replicated in studies that can be more accurately powered, based on our results. We acknowledge several further methodological limitations. First, we focused on a specific FER measure (EK-60F) arising from the extant literature to avoid confusing comparisons with different tools. Nonetheless, because the role of possible confounders has been addressed at the stage of design (random sampling) and of analysis (adjusting for a selected

Table 2. Characteristics associated with IED adjusted total errors in different regression models.

	IED adjusted total errors					
	Model 1			Model 2		
	Regression coefficient	95% CI	P	Regression coefficient	95% CI	P
AN[a] **BN**[a]	18.58 9.06	5.15; 32.01 -4.20; 22.32	0.008 0.176	12.56 1.39	-9.25; 34.38 -18.56; 21.33	0.253 0.890
Age				0.54	-0.24; 1.32	0.171
EK-60F Fear				-1.92	-4.86; 1.02	0.195
BDI-II				0.15	-0.53; 0.82	0.665
TAS-20				-0.10	-0.83; 0.62	0.775
Model n^2	0.12			0.19		
AIC	518.74			522.28		

IED = Intra-Extra Dimensional Set Shift; AN = Anorexia Nervosa; BN = Bulimia Nervosa; EK-60F = Ekman 60 Faces; BDI-II = Beck Depression Inventory; TAS-20 = Toronto Alexithymia Scale.
CI = confidence Interval; AIC = Akaike Information Criterion.
[a] Reference category Healthy controls.

set of variables), we consider it unlikely that our results are driven by between-group differences in further unknown variables. However, we acknowledge that having treated age as a continuous variable, this might imply a multiplicative function that might distort the correlation studied. Also, we should acknowledge that arbitrary limits, based on the interquartile range rule (Tukey, 1977; Dawson, 2011), in order to identify the study outliers, might imply that important information is thrown out. In addition, we acknowledge the lack of a wider neuropsychological examination, including other, different, cognitive aspects, such as memory and attention, that would provide a more detailed picture of the affected domains.

CONCLUSIONS

These limitations notwithstanding, our study provides preliminary insight about the influence of FER abilities on impaired executive control in women with AN. They may not be able to recognize complex emotional states, and this may provide clues on their executive control abilities, affecting the maintenance of severe EDs symptoms. This may have important implications that can be included in specialized treatment programmes and interventions aimed at improving socio-emotional processing in AN and updating the current programs dealing with emotion functioning (Tchanturia et al., 2015).

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CONFLICTS OF INTEREST

The authors report no conflict of interest.

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ETHICAL APPROVAL

Ethical approval was received from the local ethic committee (The SCARED-Social Cognition and Recognition of emotions in Eating Disorders- study 2015).

INFORMED CONSENT

All subjects provided written informed consent after being fully informed about the study content and procedures.

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