Cognitive and emotional regulation in adolescents and young women with eating disorders

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Abstract

Background: Eating disorders (EDs) are associated with a reduced ability to regulate emotion and impulses during the lifespan. Working memory (WM) and executive functions (EF) are cognitive regulatory systems supported by networks involving the pre-frontal cortex. Studies in EDs found impaired functioning in these domains, showing an association between EDs and the reduced ability to control emotions and impulses.

Objective: Investigate EF in adolescents and young women with eating disorders (ED) using a quasi-experimental design, focusing on cognitive efficiency, emotional regulation (ER) and behavioural outcomes also taking into account pharmacological treatment and duration of illness.

Methods: A sample of 151 females belonging to two groups took part in this study. Twenty-six girls and young women (M_{age} 22;8 years) with ED and 125 typically developed girls and young women (M_{age} 17;4 years) completed a battery of cognitive tasks (Go-No-Go, Stop-Signal task, Symmetry span, Reading Span) and the Youth Self-Report and the Difficulties in Emotional Regulation Scale Performance. A series of ANOVA with the Brown-Forsythe test was used to compare the groups

Results: Participants with ED and controls did not show significant differences in EF tasks, whereas differences between younger and older participants with ED emerged. Moreover, ER difficulties seem to be associated with mainly internalizing problems in EDs. Further analysis on the full ED sample did not reveal any significant differences associated with the disorder

persistence. Considering pharmacological treatment effects over cognitive, emotional and behavioural measures emerged.

Conclusions: The present study documented no specific differences in EF between control and participants with EDs. Whereas important differences emerged in ER and behavioural outcomes perception in the clinical sample, together with a partial influence of pharmacological treatment.

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Keywords: Eating disorders, cognitive processes, emotional regulation, behavioural outcomes, adolescence

Level of evidence: No level of evidence

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Eating disorders (EDs) are associated with a reduced ability to regulate emotion and impulses during the lifespan [1]. Food assumption and appetite, defined as the motivational drive to obtain food, are subordinated by the basal regulation of hunger and fullness. It has been demonstrated how the interaction between the regulatory functions operated by the pre-frontal cortex together with sub-cortical activity in the brain has an important role in the aetiology and persistence of EDs, by analogy with what is documented in addictive behaviors.

Literature, in fact, documents how in patients diagnosed with EDs it was possible to find specific difficulties connected to cognitive processes supported by pre-frontal cortex, e.g. [2; 3].

Working memory (WM) and executive functions (EF) are cognitive regulatory systems supported by networks involving the pre-frontal cortex. Most studies on adults with EDs found impaired functioning in these cognitive domains, showing an association between EDs and the reduced ability to control emotions and impulses [4; 5]. Despite these documented results in the existing literature, there is still a lack of a broader investigation concerning these possible fragility factors in adolescents and young adults. Due to the high sensitivity of these processes to both individual differences and environmental stimulation, a deeper knowledge of these topics would allow a better understanding of ED aetiology and contribute to clinical advancement, opening up a concrete possibility for individualized early treatment.

During adolescence, EF continues to develop in parallel with changes in synaptic density in the pre-frontal brain regions [6]. In particular, inhibition and updating of WM, as core abilities of EF, e.g., [7], are shown to evolve throughout middle and late adolescence [8] and follow a protracted development into young-adulthood [9]. These processes significantly influence individual abilities to adapt to the context and manage environmental complexity. Individual differences in WM capacity are associated with a variety of cognitive and social outcomes, e.g., [10]. Dysfunctions in

EF correlate with risky behaviours and maladaptive outcomes already in pre-adolescence [11]. In particular, impulsiveness has been associated with non-adaptive behaviours: e.g. increased substance abuse, gambling [12], and self-injuries [13]. With regard to literature concerning individuals diagnosed with EDs, recent research has documented EF impairments [2] and particularly poor inhibitory control in binge eating, e.g. [14]. Adolescents who have a shorter experience of EDs also show deficits in EF [15] that persist after symptom remission [16, 17], suggesting that EF impairments are causal rather than consequential to EDs [18]. EDs are also characterized by difficulties in emotion regulation (ER), suggesting that emotion dysregulation may be a factor underlying their co-occurrence, e.g. [19]. EF and ER are complex cognitive features that interact to support one's ability to self-regulate in many aspects of every-day life [20]. Literature documents how difficulties in ER occur in a variety of conditions, as a consequence of trauma [21] or in association with severe clinical disorders [22]. Recent research has documented abnormalities in emotion generation/regulation in individuals with EDs [23; 24; 26; 27].

The affect regulation model of EDs proposes that disordered eating behaviours are the result of the attempt to decrease negative emotions [28]. Emotion dysregulation seems to be an important predictor of binge eating and a core factor that may predict the onset of EDs (e.g. dietary restriction [29]). Individuals with EDs tend to rely on maladaptive strategies (e.g. emotion suppression/ avoidance [30]) and these strategies often translate into maladaptive behaviours (e.g., loss of control over eating [31]). Externalizing tendencies are also documented in EDs [32].

WM was recently found negatively associated with difficulties in two separate ER dimensions labeled ER knowledge and ER responses, referring to cognitive reappraisal and emotion-generative process respectively, but no significant and direct relationship with internalizing and externalizing self-reported difficulties emerged [33]. One explanation may be the absence of a clinical sample in which maladaptive outcomes, such as extreme externalizing and internalizing tendencies, are more strongly related to the aforementioned cognitive features. Even though some important research in

the field has been conducted, an investigation into inhibition and WM in adolescence, which also considers difficulties in ER and behavioural tendencies in EDs, particularly investigating specific aspects of inhibition and WM and taking also into account the variable time, in terms of duration of illness and pharmacological treatment when present, is still lacking, as a great part of the literature is more focused on profiling EF in adulthood.

The present study

This study focuses on inhibition, WM, and emotional difficulties in adolescents and young women with EDs compared to a typically developing (TD) control group, using a quasi-experimental design. In the literature, whether these processes may be characterized by a different pattern of functioning compared to TD is still an open question. We expect the ED group to function differently in terms of inhibitory and WM efficiency in comparison to the TD group, and in terms of ER and behavioural outcomes as well. Also, we hypothesize that age influences performance in EF tasks, as a time effect in the development of these abilities is documented. The effects due to the duration of illness and effects of the eventual pharmacological treatment were also taken into account investigating inhibition, WM, ER and behavioural outcomes in the ED group.

Method

Participants

A final sample of 151 females belonging to two groups took part in this study. Twenty-six girls and young women (M_{age} 22;8 years, S.D. 7;3, range 15;0 - 44;5) with ED were included in two groups formed on the basis of the age range: a younger group (Adolescents; ED1) of 13 girls (M_{age} 17;9 years, S.D. 0;1, range 15;0 - 20;0) and an older group (Young Adults; ED2) of 13 women (M_{age} 28;5 years, S.D. 6;9, range 21;8 - 44;5). One-hundred-twenty-five TD girls and young women (M_{age}

17;4 years, S.D. 1;2, range 15;3 - 19;9) were included in the control group. Individuals in the clinical sample received a diagnosis of EDs (anorexia, bulimic syndromes, Other Specified Feeding or Eating Disorder - OSFED) according to DSM 5 and were recruited from two treatment centers in the north of Italy. All participants included in the clinical sample (for a complete description see Figure 1) received diagnosis throughout the diagnostic assessment and the administration of clinical questionnaires. TD participants were recruited from different high schools in the same area. None of them had a history of neurological impairment/developmental disabilities. Besides psychotherapeutic and medical support, participants with EDs attended a dedicated "module" of mindfulness practice in a weekly meeting of two hours during two months of intensive care hospitalization.

Materials and Procedure

We administered two 45-minute sessions in a quiet room provided by the school and the centers. The self-reports were filled autonomously by the participants.

Cognitive tasks (for an extensive description see [8, 33]).

Stop Signal task [34]. This task measures response inhibition and consists of two phases: a practice phase of 32 trials and an experimental phase of three blocks of 64 trials. In both phases, each trial starts with the presentation of the fixation sign, which is replaced by the primary-task stimulus after 250 msec. The stimulus remains on the screen until subjects respond or 1250 ms have elapsed. The interval between stimuli is 2000 ms and is independent of RT. During "stop" trials, a signal is presented after a variable Stop Signal Delay that is initially set at 250 ms and adjusted continuously with the staircase procedure. The dependent measure was the stop-signal reaction time SSRT index [35]. A split-half reliability with the Spearman-Brown formula was calculated (.84).

Go-No-Go task [36]. The Go-No-Go assesses the ability to stop an automatic response and required participants to press the spacebar when a given figure target was displayed and not to press

if any other figure was displayed (20% of the stimuli). The task consisted of a practice phase of 20

trials and a test phase of 100 trials. The stimulus duration time was 1500 ms. The dependent

variable was accuracy at the No-Go trials. The Cronbach's alpha calculated on the TD group was

.70.

Emotional Go-No-Go task [4; 37]. This type of Go-No Go measures the inhibition of an

automatic response in a more emotional condition, using faces that express a particular emotion.

The set of stimuli consisted of grey scale images of 10 adults (five males) posing three different

expressions (happy, fearful and neutral). Visual angle was approximately 12°. Face stimuli were

presented singly in the center of the screen. Subjects were instructed to press the space bar as fast as

they could when a named expression was presented and to withhold pressing the space bar in case

of a "no-go" condition (30% of the trials). In each block, an emotional expression was always

paired with a neutral expression. The test was composed of 6 randomized blocks with 50

randomized trials for each condition. Stimulus duration was 500 ms with 1000. The dependent

variable was accuracy at the No-Go trials. The Cronbach's alpha calculated on the TD group was

.65.

Symmetry Span task (SymmSpan [38]). This is a complex measure of WM capacity composed

of two different tasks performed at the same time. The first one consists of recalling a sequence of

squares that appear on the screen while the second one consists of judging if some figures are

symmetrical or not. Participants are then instructed to recall the whole sequence of squares in the

correct order and to maintain at least 85% accuracy in the symmetry task. The dependent variable

was the absolute span score (SSPAN score): the sum of all perfectly recalled sets. A split-half

reliability procedure was performed for this task. The Spearman-Brown coefficient for the TD

sample was .91.

Reading Span task (RSPAN [39]). This span is structurally identical to the previous one but

presents different stimuli. In fact, the tasks consist of recalling a sequence of letters that appear on

the screen while judging if some phrases make logical sense or not. The two tasks are clustered in sets (range two to seven). As mentioned in the previous task we used the sum of all perfectly recalled sets (RSPAN score). Participants were instructed to maintain at least 85% accuracy at the phrase problem task. A split-half reliability procedure was performed for this task. The Spearman-Brown coefficient was .91.

Self-report measures

Difficulties in Emotion Regulation Scale (DERS Italian version [40]). The DERS is a 36-item self-report measure developed to assess clinically relevant difficulties in ER. Items provide scores on six scales: Non-acceptance of Emotional Responses, Difficulties Engaging in Goal-Directed Behaviour, Impulse Control Difficulties, Lack of Emotional Awareness, Limited Access to Emotion Regulation Strategies, and Lack of Emotional Clarity. Participants have to indicate how often each item applies to them on a 5-point Likert-type frequency scale. Cronbach's alphas for each subscale range from .76 to .89.

Youth Self-Report (YSR, 11-18 years [41]). It provides an assessment of the respondent's social/emotional functioning. The YSR comprises 112 items scored using a three-point frequency scale and provide scores on eight subscales clustered to identify the individual's externalizing (Rule-Breaking Behaviour and Aggressive Behaviour) or internalizing (Anxious/ Depressed, Withdrawn/Depressed, and Somatic Complaints) tendencies. Cronbach's alphas ranged from .70 to .78. The YSR was not administered to the ED2 group because these women were over the age indicated in the questionnaire regulations.

Statistical Analyses

Descriptive statistics and ANOVA with the Brown-Forsythe test was used to compare the groups, and the Tamhane test was performed as a post-hoc test. The Brown-Forsythe is a robust test based on the absolute differences within each group from the group median. A larger control group was enrolled to control individual variability factors using robust statistics [42]. Cohen's d for

groups with different sample sizes was used to compute the effect size of significant pairwise comparisons between groups. To summarize the information about ER obtained with the DERS scales, an exploratory factor analysis (EFA) using principal axis factoring with varimax rotation of the factor structure was executed.

Results

The ANOVA revealed a main effect of age, $F(2,150) = 30.981$ $p < .001$ $\eta_2 = .648$. The post-hoc analysis showed that the ED2 were significantly older than both the control ($p < .001$, $d = 4.704$ [95% CI =3.907 – 5.5]) and the ED1 ($p < .001$, $d = 2.097$ [95% CI =0.744 – 3.451]) groups, which did not differ from each other. The three groups obtained similar results in all the cognitive tasks, excepting for the emotional go-no go, in which the participants of the ED2 group were more accurate than the control group ($p = .005$, $d = 0.766$ [95% CI = 0.188 – 1.344]). Conversely, the ED1 group did not differ from either the ED2 or control groups (Table 1).

The EFA on DERS subscales extracted two factors that account for about 58% of the total variance. The DERS subscales load mainly on factor 1 (48.25% of the total variance): Non-acceptance (.787), Goals (.668), Impulse (.735), and Strategies (.814). Awareness and Clarity subscales load on factor 2 (9.39%; .667 and .670, respectively). The two factors are labeled difficulties in emotion response (DERS-R) and difficulties in emotion knowledge (DERS-K), respectively. Indeed, factor 1 (DERS-R) consisted of subscales measuring difficulties in emitting a response following an emotional state. Factor 2 (DERS-K) included two subscales measuring the difficulties in knowing/understanding an emotional state [33]. A composite score with the means of the DERS scales loading each factor was calculated.

Considering the self-reports scores, the pairwise comparisons show several differences among the groups. The ED1 group indicated more difficulties than the control group in four of the DERS subscales (all ps < .05 or less): in the Non-acceptance of Emotional Responses scale ($d = 1.341$ [95% CI = 0.72 – 1.961]), in the Lack of Emotional Awareness scale ($d = 1.433$ [95% CI = 0.809 –

2.057]), in the Limited Access to ER Strategies scale (d = 1.476 [95% CI = 0.851 – 2.101]), and Lack of Emotional Clarity scale (d = 0.951 [95% CI = 0.342 – 1.56]). Also the ED2 group reported more difficulties than the control group in four DERS subscales (all ps < .05): in the Non-acceptance of Emotional Responses scale (d = 2.158 [95% CI = 1.521 – 2.795]), in the Difficulties Engaging in Goal-Directed Behaviour scale (d = 0.956 [95% CI = 0.368 – 1.544]), in the Impulse Control Difficulties scale (d = 1.644 [95% CI = 1.032 – 2.256]), and in the Limited Access to ER Strategies scale (d = 1.839 [95% CI = 1.218 – 2.46]). Moreover, the ED1 group reported fewer difficulties than the ED2 group in the Difficulties Engaging in Goal-Directed Behaviour scale (d = 1.022 [95% CI = 0.188 – 1.857]) and more problems in the Lack of Emotional Awareness scale (d = 1.027 [95% CI = 0.193 – 1.862]). Considering the DERS composite scores, the control group participants showed fewer problems than both the ED1 (p < .01, d = 1.093 [95% CI = 0.48 – 1.705]) and the ED2 group (p < .001, d = 2.078 [95% CI = 1.446 – 2.711]) in the DERS-R, whereas they showed fewer difficulties than the single ED1 group in the DERS-K factor (p < .01, d = 1.39 [95% CI = 0.768 – 2.012]). Furthermore the two ED groups differ in the DERS-R, with the ED2 group showing more problems than the ED1 group (p < .05, d = 1.075 [95% CI = 0.236 – 1.914]). A series of t tests comparing the two composite scores along each group revealed that only in the ED2 group did the difficulties in the DERS-R prevail, rather than in the DERS-K [t (df 12) = 3.480, p < .01, d = 1.288].

Considering behavioural problems, the ED1 group indicated more difficulties than the control group in five Youth subscales (all ps < .05): in the Anxious/Depressed scale (d = 1.234 [95% CI = 0.617 – 1.85]), in the Withdrawn/Depressed scale (d = 1.264 [95% CI = 0.646 – 1.881]), in the Social Problems scale (d = 1.234 [95% CI = 0.617 – 1.85]), in the Thought Problems scale (d = 1.406 [95% CI = 0.784 – 2.027]). Finally, as expected, the control group showed significantly less internalizing problems than the ED1 group (d = 2.035 [95% CI = 1.285 – 2.2.685]).

Further analysis on the full ED sample taking into account the effects due to the lasting of the disorder (time) and to the different pharmacological treatments, if present, did not reveal any significant differences associate with the disorder persistence (see Figure 1). Considering pharmachological treatment participants that received a combination of antidepressants and antipsychotics showed a significantly lower performance score at Symm_Span [$F(3, 20) = 3.800$, p =.026, $\eta_2 = .363$]. and RSPAN [$F(3, 20) = 3.895$, p =.024 , $\eta_2 = .369$] whereas participants treated with antidepressants seem to report less YSR_Somatic Complaints [$F(3,19) = 4.353$, p = .017, $\eta_2 = .407$], YSR_Social Problems [$F(3,19) = .3.888$, p = .025, $\eta_2 = .380$] and less difficulties in emotional recognition DERS-R [$F(3,19) = 4.303$, p = .018 , $\eta_2 = .405$].

Discussion

This study investigates the relationships between inhibition and WM, difficulties in ER and behavioural outcomes in adolescents and young women diagnosed with EDs compared to a TD group. In particular, it examines if inhibition and WM, as components of self-regulation, can be associated with difficulties in ER and specific non-adaptive behavioural outcomes. Results concerning the performance in EF tasks do not point to significant differences between the participants with ED and controls. The lack of significant differences between the clinical samples and the controls, was a non-expected result, which needs to be interpreted carefully, as the small samples may have undermined the results, but it is also possible that these specific tasks, focused on accuracy/ precision, may elicit perfectionism and attention to detail which are characteristic features of the spectrum [43]. This attitude may influence the performance in cognitive tasks producing a sort of paradox, as found with the emotional go-no-go task. The documented attention to detail /perfectionism in individuals with EDs e.g. [43] can also explain the higher accuracy shown by the older clinical sample group (ED2), that may be more inclined to pay attention to key body details and detect emotions in the pictures faster than other people and by so doing they manage to be more precise in this specific task.

Regarding self-reported difficulties in ER, adolescents and young women with ED referred more ER difficulties than controls. These results confirm what the existing literature says about self-reported difficulties in ER in adolescence and young adulthood in the EDs spectrum [31]. In particular, the results show an interesting dissimilarity between younger and older participants with ED. ED1 group, shows a significant difference with respect to the control group, concerning the ER Knowledge factor [23]. This result is particularly interesting, meaning that age is important in developing a refined ability to distinguish and understand emotional responses. However, the difficulties in managing affect seem to persist as a characteristic feature of EDs. This prevalence and endurance of difficulties connected to the ER response are coherent with the struggles in overcoming the symptomatology of the spectrum [19]. It should be mentioned that the treatment administered to the clinical sample, with a specific "module" reserved to mindfulness practicing, could play a role. The literature documents a positive effect of mindfulness practices in gaining awareness and tools to improve the ability to understand emotional responses [45].

ER difficulties seem to be associated with behavioural maladaptive outcomes. ED1 reported more difficulties in scales related to internalizing issues, such as anxiety, depression, recursive thoughts and difficulties in managing behaviours in the social context [46]. Further analysis on larger samples that also take into account time, in terms of years of persistence, and treatment of the symptoms, are needed in order to better understand the link between these characteristics and whether it is possible to actually state a bi-directional relation between symptoms, and the connected effects on the body and the brain, e.g. [47], and individual characteristics.

Interestingly, the endurance of illness did not emerge to significantly impact results, whereas results showed a partial influence of pharmacological treatment. A combination of antidepressants and antipsychotics treatment is associated with a lower performance in WM tasks performance, whereas antidepressants seem to interact with results at specific self-report scales.

A few limitations of this study warrant mentioning. First, the clinical sample size is not very large and the age variability is wide. Further studies are needed to better understand specific aspects of cognitive functioning. Despite these limitations, the study shows some strengths. Firstly, having a focus on adolescence and young adulthood, it takes into account a less investigated developmental period, and secondly, it adds knowledge about inhibition and WM in a population that has documented issues related to control processes.

What is already known on this subject?

A great part of the literature mostly focused on adults with EDs found impairments in WM and EF, showing an association between EDs and the reduced ability to control emotions and impulses. In fact, most of the studies that investigate control processes in EDs mainly focus on complex EF abilities in young adulthood. Emotion dysregulation seems to be an important predictor of binge eating and a core factor that may predict the onset of EDs .

What does this study add?

This study adds knowledge about specific aspects of Inhibition and WM in a less investigated developmental time in EDs, while also investigating the possible connection between these cognitive abilities and emotional and behavioural self-reported difficulties, taking into account as well complex variables such as time, in terms of duration of illness and pharmacological treatment when present.

Ethics statement

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee (Ethical Code of Italian Psychology Order and the Ethical Guidelines of the Italian Association of Psychology) and with the 1964 Helsinki declaration and its later amendments. At the time we collected the data no ethical

committee was yet present to which we could refer to in our organization. Informed written consent

was obtained from the participants or their parents if they were minor before data collection.

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