

Relationship between neuropsychology, clinical traits, psychopathology and attitudes towards change in eating disorders

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Abstract

Background: Research on the neuropsychological characteristics of eating disorders (EDs) has primarily focused on inhibitory control, set-shifting and central coherence, as well as attention bias and decision making. These neuropsychological aspects may be related to a more severe clinical status and also influence attitudes towards therapeutic change.

The objective of this research was to analyse the relationship of psychopathological and clinical variables with neuropsychological characteristics of patients with EDs and to see the possible influence of these variables on patients' attitude towards change.

Methods: An observational analytical cross-sectional study was performed. The participants were 74 consecutive outpatients who received treatment at an ED unit. They were assessed during a 6-month period, using clinical (Psychiatric Status Rating Scale, modified) and neuropsychological tests (Letter Number Sequencing test; Stroop test; Symbol Digit Modalities Test; Rey-Osterrieth Complex Figure Test). They were asked to complete several self-report psychopathological questionnaires: Body Shape Questionnaire; Eating Disorders Inventory; Beck Depression Inventory; State-Trait Anxiety Inventory; Dissociative Experiences Scale; Attitudes Towards Change in Eating Disorders Scale (ACTA), but 23 participants (31.08%) did not return them. Descriptive statistics and multivariate analysis were performed to study the relationships between clinical and psychopathological neuropsychological variables.

Results: Nineteen patients (25.68%) were diagnosed with restricting anorexia nervosa (AN), 19 (25.68%) with purging AN, 14 with bulimia nervosa (18.92%), 9 with binge eating disorder (12.16%) and 13 with ED not otherwise specified (17.57%). There were no significant differences among the groups regarding the scores on neuropsychological tests. Body mass index (BMI) was related to the majority of the neuropsychological scores. Depression (BDI), severity of the illness status and BMI, were predictors of deficits in working memory ($F=3.46$; $p < 0.01$, 33% of the variance). On the other hand, higher score on time of the copy [$B=3.56$; 95% CI (0.82-6.29), $p < 0.01$] and lower score on memory time [$B=-2.31$; 95% CI [-4.58-(-0.05)]; $p < 0.05$] predicted the score on the "Precontemplation" subscale of the ACTA ($F=2.59$; $p < 0.05$; 16% of the variance). Higher score on the copy time [$B=1.43$; 95% CI (0.42-2.45); $p < 0.01$] and lower score on the style index [$B=-14.01$; 95% CI (-24.98-(-3.04)); $p < 0.01$] predicted the score on the "Contemplation" subscale of the ACTA ($F=3.40$; $p < 0.05$; 22% of the variance).

Conclusions: The main results suggest that neuropsychological dysfunctions in EDs are transdiagnostic dimensions and that BMI, the severity of the illness and depression predict some of these disturbances. Besides, they influence the attitudes towards change. The findings highlight the need of setting up a broad framework to increase the acknowledgment of the problem. This approach could enhance conventional therapy, providing additional cognitive remediation therapy to motivational interview aimed to improve the decisional balance. At present, there are no definitive conclusions about whether neuropsychological disturbances are underlying traits or consequences of the illness, thus comprehensive longitudinal studies are needed.

Plain English Summary

Eating disorders (EDs) represent major public health problems because of their prevalence and long-term dysfunction in a number of patients that highlights the need for further research. Neurocognitive deficits such as set-shifting and central coherence have been suggested as potential transdiagnostic features that might contribute to the outcome of EDs. Executive functioning is related with the decision-making necessary for change during the therapeutic process. It includes the cognitive processes that allow individuals to regulate their emotion and adapt their behaviour according to their goals. Thus, improving executive functions and working memory could help in treatment and functional recovery.

There are a large number of publications about specific neurocognitive issues in EDs, mainly inhibitory control, decision making, central coherence, cognitive flexibility, attention bias, and working memory impairment. Several of these studies have also analysed the link between these neurocognitive issues and long-term outcomes. There are no definitive conclusions about if they are underlying traits or consequences of the illness. Furthermore, the relationship of neuropsychological features with the motivation to change has not been ascertained. The present work highlights the influence of some neurocognitive process on the attitudes towards change in patients with ED regardless their diagnostic subtype, suggesting that a more controlling and less flexible attitude is associated with reduced motivation.

Background

Eating disorders (EDs) are characterized by a variable clinical course related to multiple factors (1) as well as diagnostic instability, that is probably associated with certain common vulnerability traits and needs a comprehensive approach (2-5). Among the potential transdiagnostic traits that contribute to psychopathology are some neurocognitive dysfunctions, involving the interaction of decision-making, volitional and cognitive control processes (6). Neurocognition consist of the following main processes: memory, attention, visuospatial and executive functions. Cognitive control is performed by means of executive functions which allow individuals to adapt information process and behaviors according to their goals and to self-regulate their emotions. They may constitute a complex network of large-scale brain system in which several neuropsychological dimensions could be engaged, such as cognitive and behavioral inhibitory control, cognitive flexibility, central coherence, selective attention, working memory, and decision making. These functions interact with the volitional, motivational, cognitive and affective network, being essential for adaptive emotional, social, and physical functioning (7-9). A number of studies have been performed in order to elucidate how the dysfunctional interactions between these processes are related to mental disorders and also to see if they are underlying traits or consequences of the illness (6).

Concerning the neuropsychological aspects in EDs, several researches have focused on a single diagnostic category or neurocognitive domain and some of the main findings could be summarized as follows: Deficient inhibitory control has been linked to binge eating (BED) and bulimia 4 nervosa (BN); set-

shifting difficulties or cognitive rigidity and weak central coherence, that is bias towards detail accompanied by a limited ability to understand context, have been reported in the anorexia nervosa (AN) group; lastly, attention and decision-making bias have been associated indiscriminately in all the diagnostic groups (7-10). Based on both, set-shifting and central coherence, neurocognitive endophenotypes might be identified (5, 11, 12) that could be predisposing factors, intensified with several variables, as weight loss and duration of the disorder, even persist after recovery. Hence, it would be interesting to carry out researches with heterogeneous ED samples to evaluate interactions between neurocognitive processes and ED's severity, including relevant covariates, for instance, duration of illness or comorbid psychopathology, as depression or anxiety (7).

Concerning the relationships among neuropsychological dimensions, psychopathological disturbances and clinical manifestations of EDs, a number of researches with neurocognitive task have been performed, suggesting that some neurocognitive deficits might be associated with psychopathological variables. Among those neuropsychological variables that might play a relevant role in EDs are impairment in the ability to focus attention on target stimuli in the presence of relevant distractor stimuli (food or weigh/shape related), cognitive inflexibility and weak central coherence (14,15).

Inhibitory control, defined as the ability to filter out irrelevant stimuli and suppress behavioural responses, may be measured by interference control in Stroop's test. Several studies with this task have found increased interference when words related to the body are used in patients with EDs (22,23). Although binge eating might be associated with deficient inhibitory control and restrictive behaviour with excessive inhibitory control, cognitive inhibition measured by interference has not specifically related to psychopathological features such as drive for thinness or body dissatisfaction (16,24). Working memory is commonly explored with spatial and digit span tasks, and impaired memory has been associated with the frequent comorbidity of depressed mood symptoms (9) and length of illness in binge eating disorders (BED). In addition, executive functioning encompasses domains that together are responsible for the control of such cognitive processes as setting goals, planning and organizing. It influences goal-directed behaviour and self-regulation (7). One indicator of executive functioning, set-shifting, also termed cognitive flexibility, involves the ability to observe and respond to changes in rules and move back and forth between tasks, operations or sets (25). Impaired ability in this area is postulated to contribute to rigid approaches to understanding and problem-solving and to obsessive behaviour. It is moderately heritable, and deficits have been shown in both women with AN and women with high levels of obsessiveness who have no history of EDs (11). Interestingly, these set-shifting deficits persist after recovery from AN (12). Set-shifting appears to be among the most interesting endophenotype candidates (12) since numerous systematic reviews have found evidence of poor set-shifting in all EDs (13). Consistently, behavioural inflexibility, that is to say, "inability to switch between modes of thinking and difficulty to adapt to changing rules or categories" (27), is considered as an endophenotype feature of EDs (10,28-30). On the other hand, weak central coherence has been pointed out as a potential etiologic or maintenance factor for EDs (13), particularly those with AN (54). It refers to global processing difficulties with increased local processing, i.e., excessive attention to detail, such as overvaluation of body image in opposition to a superior sense of self (14,15). These neuropsychological factors, set-

shifting and weak central coherence, would likely make more difficult for patients to develop new cognitive and behavioural skills and could influence their outcomes (54). Relationships between these neurocognitive domains, eating psychopathology and other relevant issues, as perfectionism, comorbid psychopathology, or motivation, need to be further elucidated, seeing as several authors have also related perfectionism with neuropsychological deficits (31).

A variable that interferes with the outcome of EDs is the attitude towards change (32,33), defined as the position where each subject is regarding changing the disease behaviour and it helps to ascertain the patient's motivational state. Following the transtheoretical model of change (36), the health behaviour change involves progress through different stages, from precontemplation (refusing to consider the presence of a disorder) towards contemplation, preparation or decision, action, maintenance and relapse, as described in the method section. The therapist helps the patient identify the attitudes towards change's phase and adapts interventions accordingly, in order to make therapy more effective. In this setting, patients achieve the ability to determine their own pro and cons to shift the decisional imbalance towards change, and neurocognitive functions would be essentials for this task. The attitude towards change might mediate the effect of another variables, such as age at onset and nutritional status, on the psychopathological outcome (34,35). Further longitudinal research may help to determine whether neurocognitive deficits also influence attitudes towards change. If that was so, cognitive remediation therapy would have some complementary utility in promoting change (8,37,38), helping the patient to acquire reasoning and decision-making capabilities. Although there is not yet strong evidence (22), cognitive remediation therapy could be very useful in the treatment of eating and weight disorders (40).

In summary, taking into account that inhibitory control, working memory impairment, cognitive inflexibility and weak central coherence could contribute to the perpetuation of EDs, influencing the motivation to change (41–45), it would be interesting to conduct neuropsychological assessments besides psychopathological and attitudes towards change measurements at the beginning of the treatment. The objective of the present research work was to integrate the neuropsychological assessment within the comprehensive clinical examination of EDs in order to analyse the possible relationship between some neuropsychological features and psychopathological and clinical variables. As the design of the study could not permit to consider neuropsychological traits as possible predisposing factors, we studied the effect of several clinical variables on them. Subsequently, the aim was also to study the possible predictive value of the neurocognitive test scores on the patients' attitudes towards change, thus, to consider them as maintenance factors.

Methods

A cross-sectional observational analytical study was performed. The participants were women who consecutively presented for treatment at the Eating Disorders Outpatient Unit of General University Hospital of Ciudad Real during a 6-month period. Inclusion criteria were (1) diagnosis of anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED) or eating disorder not otherwise specified (EDNOS) according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5);

(2) female gender; (3) age between 18 and 50 years; (4) a current clinical state that permitted psychometric evaluation. Comorbid symptoms of depression and anxiety were permitted. Patients were excluded if they 1) spoke a language other than Spanish; (2) did not give written informed consent; (3) were male; (4) had comorbid bipolar disorder, psychotic disorder, major depressive disorder, organic mental disorder, attention-deficit hyperactivity disorder, autism spectrum disorder, Tourette syndrome or chronic fatigue syndrome.

Participants

At the beginning of the study, 74 patients were included. The mean age was 28.97 years (standard deviation, SD, 9.30). The participants were informed about the procedure, and those who agreed to participate signed the informed consent. Clinical assessments and neuropsychological tests were administered, and the participants were given psychopathological self-report questionnaires to complete. Twenty-three participants (31.08%) did not return the questionnaires.

Although the sample was finally reduced to 51 subjects for most of the psychopathological variables, neuropsychological and clinical features could be evaluated in the 74 patients who were initially included. When the patients who did not return the questionnaires were compared to the ones who did, no differences were found regarding age, body mass index (BMI), age at onset, course of the disorder and use of drugs, education level, diagnoses, compensatory symptoms or neuropsychological scores.

Procedure

All patients who participated in the study were offered one year of treatment. This included twelve personal sessions of motivational enhancement therapy, six psycho-educational group sessions and twenty cognitive-behavioural therapy sessions. Treatment was based in Fairburn's program (46) with 20 sessions of 50 minutes based on enhanced cognitive behaviour therapy. Pharmacological treatment was provided when necessary.

Each day, selected patients were informed about the study and its procedure, and informed consent was obtained. After this, the self-report questionnaires were provided. Maximum confidentiality was guaranteed by removing any identifying information from the patients' clinical data and storing data in a password-protected Excel base. The local Clinical Research Ethics Committee approved the study.

Instruments

All psychopathological tests were given to the patients to complete at the hospital while they waited for their appointment. The evaluation started with the Letter Number Sequencing test, followed by the Stroop test, the Symbol Digit Modalities Test and the copying portion of the Rey-Osterrieth Complex Figure Test (ROCFT). As it was necessary to wait five minutes before performing the drawing from memory task, the clinical questionnaire was given to the patients after the figure copying task; when the questionnaire was completed, the patients were asked draw the complex figure from memory.

Clinical test:

Clinical interview

A clinical interview was completed to collect information about symptoms, body parameters, exclusion and inclusion criteria and diagnoses and to obtain data regarding age at onset and education level (necessary for neuropsychological evaluation).

Status

The patient's clinical status was evaluated by the Psychiatric Status Rating Scale. This scale is based on Herzog's work (33) and was updated with the DSM-5 criteria for the different disorders. Clinical status was divided into three groups, each of which included two different categories: scores of 5-6 indicated that the patient met the criteria for the disorder ("Definite criteria, severe" and "Definite criteria"); scores of 3-4 indicated partial recovery ("Marked" and "Partial remission"), and scores of 1-2 indicated total recovery ("Residual" and "Usual self"). Afterwards, to improve statistical power, these categories were combined to create a dichotomous variable: "No evidence of illness" (Usual self, Residual, Partial remission) and "Evidence of illness" (all other categories). The original scale is included in Additional file 5.

Psychopathological tests:

Body Shape Questionnaire (BSQ).

The BSQ was validated for the Spanish population by means of a 34-item self-report questionnaire with a six-point Likert-style rating scale (1= never; 6= always) (47). It measures concerns about body weight and shape in ED. Its internal consistency using Cronbach's index is good (0.97), as is its concurrent validity. It differentiates clinical from nonclinical subjects and people with more or less concern about their weight. A score of 105 is the cut-off point for the Spanish population (47). In the present population α was 0.76.

Eating Disorders Inventory_(2nd edition)_(EDI-2).

The EDI-2 is a self-report questionnaire with 91 items (11 scales: "Drive for thinness", "Bulimia", "Body dissatisfaction", "Ineffectiveness", "Perfectionism", "Interpersonal distrust", "Interoceptive awareness", "Maturity fear", "Ascetism", "Impulsiveness" and "Social insecurity"). The internal consistency (Cronbach's alpha) is higher than 0.80 in ED samples. Reliability coefficients (alpha) were from 0.83 to 0.93 in samples of patients from the original studies. The EDI-2 is validated for the Spanish population (48,49) and in the present population α coefficients were also higher than 0.80.

Beck Depression Inventory_(BDI).

The BDI is a self-reported questionnaire with 21 items for evaluating the existence and severity of depressive symptoms. Its internal consistency is higher than 0.85 (50,51). In the present population α was 0.89.

State-Trait Anxiety Inventory (STAI).

The STAI is divided in two independent scales that measure state and trait anxiety. Cronbach's alpha is 0.90 for trait anxiety and 0.94 for state anxiety (52–54). In the present population α was 0.82 for Anxiety-State, and 0.70 for Anxiety-Trait.

Dissociative Experiences Scale (DES).

The DES is a self-assessment questionnaire based on a visual analogue scale composed of 28 dissociative experiences; it asks how often the subject experiences these dissociative events (0-100%). An average score of 30 or more indicates that dissociative disorder is expected (55–58). The DES comprises 3 scales: "Derealization and depersonalization", "Absorption" and "Amnesia" (59). Its internal reliability (Cronbach's alpha) is 0.93, and its retest-reliability is 0.87 (59). In the present sample α was 0.84.

Attitudes Towards Change in Eating Disorders Scale (ACTA).

The ACTA, a Spanish validated self-report questionnaire with 59 items, was used to evaluate the attitudes towards change in cognitive, affective, behavioural, and relational features in ED patients (46). It is based on Prochaska and DiClemente's theoretical model concerning the phases of change (60). The ACTA comprises 6 scales: "Precontemplation", "Contemplation", "Decision", "Action", "Maintenance" and "Relapse". The "Precontemplation" subscale refers to the refusal to consider the presence of a disorder. The "Contemplation" subscale reflects a state in which the subjects recognize their eating problem, although they may under-evaluate their importance and shows no motivation to change their behaviours. The "Decision" subscale reflects that the patient has decided on a date to begin changes. The "Action" subscale shows evidence of change in different areas: cognitive (positive thoughts about the resolution of the disorder), behavioural (changing habits for other, healthier ones), and affective (the patient perceives the disorder as an unpleasant problem that must be modified). The "Maintenance" subscale evaluates the stability of the achievements obtained in the action phase. Finally, the "Relapse" subscale is a subjective assessment of any worsening that the subject may experience. The reliability of each scale is from 0.90-0.74, and their retest-reliability ranges from 0.86-0.64 (46). It is designed for ED patients. An additional file describes the scale in greater detail [see Additional file 1] (in this study, the Spanish version was used). In the present population Cronbach's alpha reliability coefficient was also higher than 0.72 for all the subscales.

Neuropsychological variables:

Working memory.

This variable was measured using the Letter Number Sequencing test (LNS III) included in Wechsler Adult Intelligence Scale (WAIS-III) (61). For this test, participants listen to verbal sequences of letters and numbers that gradually increase in length and must be memorized, ordered and repeated back to the tester. The reliability and validity of this test are high, but the available data are related to intelligence evaluation. Two indexes are obtained: Total score on LNS III (number of correctly answered attempts)

and SpanLN (the greater number of digits remembered by the subject); this second is the most frequently used.

Inhibitory attention

“Stroop’s effect” (62) is the delay in reaction time between congruent and incongruent stimuli. It is examined using the Stroop test, which measures inhibitory attention. A basic task to prove this effect consists of naming the font color of printed words, what is easier and quicker if word meaning and font color are congruent. The Stroop’s effect occurs when there is a mismatch between the name of a color and the color that it is printed on. To name the color of the word takes longer when the color of the ink does not match the name of the color and also it is more prone to errors. Test-retest reliability is high in all studies (0.69-0.89) (63). The test comprises three pages: Two of them represent the “congruent condition”, in which participants are required to read the names of colours (henceforth referred to as colour words) printed in black ink (W) and to name different colour patches (C). On the third page, which represents the colour word (CW) condition, colour words are printed in an inconsistent colour of ink (for instance, the word “red” is printed in green ink). Thus, in this incongruent condition, participants are required to name the colour of the ink instead of reading the word. In other words, the participants are required to perform a less automated task (i.e., naming ink colour) while inhibiting the interference arising from a more automated task (i.e., reading the word). An additional file describes this test in more detail [see Additional file 2] (in this study, a Spanish version was used). The indexes obtained were W (the number of words read on the first page), C (the number of colours named on the second page), CW (the number of colours named on the third page) and interference. All these indexes are corrected by age.

Sustained attention

The Symbol Digit Modalities Test (SDMT) (64,65) mainly evaluates attention (included sustained attention) (66), optical tracking, speed of mental processing and visuo-motor speed. The test is based on the pairing of meaningless geometrical images with numbers from 1 to 9 according to a previous model. Participant must pair more geometrical images as possible in 90 seconds without mistakes. The indexes obtained are the total score (number of corrected pairs) and the scored SDMT (corrected by age and education level). (Additional file 3)

Executive function

The ROCFT (67,68) consists of copying a complicated line drawing and then drawing it from memory. Several indexes are obtained: quantitative and qualitative scores of copied and memorized reproduction accuracies (scored using Osterrieth’s method, as explained in Additional file 4), style, order and central coherence (explained in Additional file 4) (69–72). A global approach, for example, is shown by a tendency to draw the main structural elements first and place local elements in relation to this framework. On the other hand, individuals may copy the figure by first drawing local details and failing to maintain

their overall spatial organisation. We can see a figure perform by disjointed parts in very young children and individuals with right hemisphere damage, although healthy adults differ in the degree to which they use a local or global strategy. Scoring and the style, order and coherence indexes are explained in Additional file 4. The indexes obtained were copy and memory accuracy, copy and memory time, copy and memory type, order index, style index and central coherence index.

Data analysis

SPSS 19.0 was used to analyse the data obtained.

A descriptive analysis was performed, followed by an inferential analysis. The statistical level accepted as significant was 5% ($p < 0.05$). Qualitative variables were statistically analysed by means of the chi-square test for independence. Quantitative variables were examined for normal distribution using the Kolmogorov-Smirnov test if there were more than 50 data points and the Shapiro-Wilk if there were fewer than 50 data. Student's t-test and the Mann-Whitney U test were used for dichotomous independent variables, and ANOVA and the Kruskal-Wallis test were used for independent variables with more than two categories. Pearson's and Spearman's correlations were used for quantitative independent variables.

Multivariate analysis was performed using simple linear regression to evaluate models of quantitative dependent variables. The variables included in the models were those that were statistically significant in the bivariate analysis of our sample and those that were statistically significant in previous studies or were considered of interest for the current study due to their transdiagnostic meaning (e.g., BMI, dichotomous status, age at onset of ED, antidepressant use, benzodiazepine use, total DES score, anxiety, depression, Perfectionism score). Later, the models were simplified to improve their alignment.

Results

Clinical, psychopathological and neuropsychological characteristics

Nineteen patients (25.68%) were diagnosed with restricting AN, 19 (25.68%) with purging AN, 14 (18.92%) with BN, 9 (12.16%) with BED and 13 with EDNOS (17.57%). The mean age at onset was 16.62 years (SD 6.54). The mean time of duration of the illness was 12.35 years (SD 9.41). Regarding status, 38 patients (51.35%) had evidence of illness, and 36 (48.65%) had no evidence of illness at the time of consult. A total of 52.70% were being treated with a psychotropic drug. The main descriptive results are summarized in Table 1. When consecutive analyses of variance with post hoc comparisons were performed, no significant differences were found among the diagnostic groups concerning the duration of the disorder, time of onset, clinical status or use of drugs.

Table 1: Qualitative clinical variables and their relationship with each clinical subtype

| Variable | Total sample N=74 Fr (%) or mean (SD) | Restricting AN n= 19 Fr (%) or mean (SD) | Purging AN n=19 Fr (%) or mean (SD) | BN n=14 Fr (%) or mean (SD) | BED n=9 Fr (%) or mean (SD) | EDNOS n=13 Fr (%) or mean (SD) |
|----------------------------------|--|---|--|--------------------------------------|--------------------------------------|---|
| Age at onset | 16.62 (6.54) | 17.05 (7.01) | 15.79 (2.82) | 18.14 (7.00) | 11.89 (3.79) | 18.85 (9.24) |
| Number of years with the disease | 11.14 (9.32) | 10.95 (9.48) | 13.00 (10.60) | 10.21 (7.83) | 21.44 (9.82) | 9.46 (4.99) |
| Pharmacotherapy | 52.70% | 47.40% | 73.70%* | 42.90% | 55.60% | 38.50% |
| Clinical status | | | | | | |
| NS | 9 (12.20%) | 2 (10.50%) | 1 (5.30%) | 2 (14.30%) | 1 (11.10%) | 3 (23.10%) |
| R | 12 (16.20%) | 2 (10.50%) | 2 (10.50%) | 2 (14.30%) | 2 (22.20%) | 4 (30.80%) |
| PR | 15 (20.30%) | 3 (15.80%) | 3 (15.80%) | 4 (28.60%) | 2 (22.20%) | 3 (23.10%) |
| M | 11 (14.90%) | 1 (5.30%) | 3 (15.80%) | 4 (28.60%) | 3 (33.30%) | 0 (0%) |
| DC | 18 (24.30%) | 6 (31.60%) | 6 (31.60%) | 2 (14.30%) | 1 (11.10%) | 3 (23.10%) |
| SC | 9 (12.20%) | 5 (26.30%) | 4 (21.10%) | 0 (0%) | 0 (0%) | 0 (0%) |

NS: normal status; R: residual; PR: partial remission; M: marked; DC: defined criteria; SC: severe criteria; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Fr: frequency (χ^2 40.619, df 4). *** $p < 0.001$

Descriptive data of the neuropsychological variables are shown in Table 2. There were no significant differences among the diagnostic groups with regards to the scores on neuropsychological tests in the analysis of variance with post hoc comparison. However, when clinical status and the copy time on the (ROCFT) were considered, there were statistically significant differences regarding "dichotomous status" (Mann-Witney test $Z = -2.253$, $p < 0.05$) between patients who did not meet the criteria for disorder ($Md = 42.51$) and patients who met the criteria ($Md = 32.75$).

Table 2: Descriptive data for neuropsychological measurements

| Variables | Mean | Median | SD |
|------------------------------------|---|--------|-------|
| Quantitative variables | | | |
| SpanLN | 4.80 | 5.00 | 0.94 |
| Stroop | | | |
| W-corrected for age | 100.97 | 108.00 | 26.43 |
| C-corrected for age | 75.49 | 74.50 | 11.26 |
| CW-corrected for age | 46.28 | 46.50 | 8.65 |
| Interference | 4.50 | 3.25 | 11.83 |
| SDMT score | 54.64 | 55.00 | 11.36 |
| ROCFT copy time (min) | 3.07 | 3.00 | 2.04 |
| ROCFT copy quantitative (direct) | 34.45 | 35.00 | 2.46 |
| ROCFT memory time (min) | 2.72 | 2.00 | 1.52 |
| ROCFT memory quantitative (direct) | 19.60 | 20.00 | 6.14 |
| Order index | 2.23 | 2.33 | 0.67 |
| Style index | 1.56 | 1.67 | 0.29 |
| Central coherence index | 1.45 | 1.52 | 0.32 |
| Qualitative variables | | | |
| SDMT scaled score | Very low 8 (10.81%); Low 2 (2.70%); Normal 51 (68.92%); High 13 (17.57%) | | |
| ROCFT copy types | I 46 (62.16%); II 10 (13.51%); III 5 (6.76%); IV 11 (14.86%); V 1 (1.35%); VI 1 (1.35%) | | |
| ROCFT memory types | I 58 (78.38%); II 7 (9.46%); III 1 (1.35%); IV 5 (6.76%); V 1 (1.35%); VI 2 (2.70%) | | |
| ROCFT observations | No observations 53 (71.62%); Completion 6 (8.11%); Poorness 5 (6.76%); Child/Perfectionism/Repeated lines/Very small/Unconnected 2 each (2.70%) | | |

LNS: Letter Number Sequencing; SpanLN: index of the Letter Number Sequencing test; W-, C-, WC-: indexes of the Stroop test; SDMT: Symbol Digit Modalities Test; ROCFT: Rey-Osterrieth Complex Figure Test; min: minutes; I...VI: types of performance on the ROCFT; SD: standard deviation

The descriptive data for psychopathological variables (Table 3) show that the highest mean scores on the ACTA were obtained on the “Action” subscale, followed by the “Relapse” subscale variable. The mean score on the BSQ was above the cut-off point of 105 (an average score over 105 points suggests the presence of a disorder related to body dissatisfaction). Regarding the STAI, the mean “State” and “Trait” scores were also above the calculated mean score of 18.20 (SD 11.62) and 23.35 (SD 10.6) for the

Spanish population respectively (73). The mean DES score was 14.16 (SD 15.17); an average score over 30 points suggests the presence of a dissociative disorder.

Table 3: Variables of psychopathological tests

| Variable | Mean | Median | SD |
|------------------------|--------|--------|-------|
| ACTA | | | |
| Precontemplation | 10.73 | 10.00 | 8.46 |
| Contemplation | 16.42 | 16.36 | 9.34 |
| Decision | 17.22 | 17.27 | 94.41 |
| Action | 26.04 | 26.00 | 7.64 |
| Maintenance | 14.86 | 15.00 | 9.00 |
| Relapse | 17.51 | 15.71 | 11.37 |
| EDI-2 | | | |
| DT | 11.61 | 12.00 | 6.77 |
| B | 3.61 | 3.00 | 5.23 |
| BD | 14.76 | 15.00 | 8.88 |
| I | 11.37 | 9.00 | 8.33 |
| P | 7.22 | 7.00 | 3.85 |
| ID | 5.86 | 5.00 | 4.44 |
| IA | 10.57 | 10.00 | 7.71 |
| MF | 8.78 | 6.00 | 6.22 |
| A | 6.49 | 5.00 | 5.00 |
| IR | 6.18 | 5.00 | 10.49 |
| SI | 8.65 | 9.00 | 5.69 |
| BSQ | 126.16 | 123.00 | 45.59 |
| DES | | | |
| DES-amnesia | 6.67 | 3.13 | 10.49 |
| DES-absorption | 22.66 | 21.11 | 21.63 |
| DES- depersonalization | 10.09 | 0.83 | 17.95 |
| DES-total | 14.16 | 8.93 | 15.17 |
| BDI | 20.88 | 22.00 | 10.34 |
| STAI | | | |
| STAI-state | 30.69 | 31.00 | 14.00 |
| STAI-trait | 35.92 | 35.00 | 13.26 |

DT: Drive for thinness; B: Bulimia; BD: Body dissatisfaction; I: Ineffectiveness; P: Perfectionism; ID: Interpersonal distrust; IA: Interoceptive awareness; MF: Maturity fear; A: Ascetism; IR: Impulsiveness; SI: Social insecurity.

Relationships between neuropsychological, clinical and psychopathological variables

Firstly, we performed bivariate analyses to see the correlations between neuropsychological test scores and clinical and psychopathological variables (Additional file 6, with tables 5 and 6 included). No significant correlations were found between neuropsychological test scores and EDs variables such as BSQ, Bulimia or drive for thinness of the EDI-2. However, clinical variables such as the severity of the disorder, time of duration, body mass index, depression and also dissociation and attitude towards

change correlated with several neuropsychological variables. Then, because the design of the study could not allow seeing if the neuropsychological features were prior to the commencement of the illness (no longitudinal study and patients with a long lasting illness), we considered the following hypothesis: the duration and severity of the illness as well as probably comorbid variables (dissociation, depression and anxiety scores) might predict the neuropsychological test scores and, subsequently, these neuropsychological factors might predict the patient's attitudes towards change. In accordance with this model, when the neuropsychological variables were considered as dependent variables and the clinical and psychopathological variables were considered as independent variables or confounding factors in the multiple linear regression analysis, several variables reached statistical significance ($p < 0.05$). They are presented in Table 4.

Table 4: Multiple linear regression models (only significant variables)

| Dimension | Dependent variable | Independent variable | B (CI) | p |
|-----------------------------|-------------------------|-------------------------------|-----------------------|--------|
| Working memory | LNS III | Depression | -0,26 [-0,38 - | <0.001 |
| | | Severity (Dichotomous status) | (-0,14)] | <0.05 |
| | | BMI | 1,52 (0,11 a 2,92) | <0.01 |
| | SpanLN | Depression | 0,13 (0,04 a 0,21) | <0.001 |
| | | Dichotomous status | -0.07 [-0.11-(-0.03)] | <0.01 |
| Inhibitory attention | Interference | Perfectionism | 1.07 (0.16-1.99) | <0.05 |
| | | DES-Absortion | 0.41 (0.01-0.82) | <0.05 |
| Sustained Attention | SDMT score | Depression | -0.95 [-1.49-(0.40)] | <0.001 |
| | | STAI-trait | 0.46 (0.42-0.88) | <0.05 |
| | | Perfectionism | 1.09 (0.31-1.87) | <0.01 |
| Executive functions | ROCFT time of copy | STAI-state | -0.04 [-0.08-(0.00)] | <0.05 |
| | | BMI | -0.04 [-0.08-(0.00)] | 0.06 |
| | ROCFT copy quantitative | Age at onset | -0.11 [-0.21-(-0.01)] | <0.05 |
| | | Perfectionism | 0.20 (0.01-0.40) | <0.05 |
| | Central coherence index | Antipsychotics use | 0.59 (0.08-1.10) | <0.05 |
| | | Antidepressant use | 0.25 (0.05-0.46) | <0.05 |
| Sedative-hypnotic use | | -0.25 [-0.48-(-0.02)] | <0.05 | |

B: beta coefficient; CI: 95% confidence interval; p: level of statistical significance; LNS: Letter Number Sequencing; STAI: State-Trait Anxiety Inventory; DES: Dissociative Experiences Scale; SpanLN: index of the LNS; SDMT: Symbol Digit Modalities Test; BMI: body mass index; ROCFT: Rey-Osterrieth Complex Figure Test. Dichotomous status: evidence of illness vs no evidence of illness.

Working memory

When total score on the LNS III was considered as dependent variable, depression (BDI), dichotomous status and BMI, were predictors ($F=3.46$; $p < 0,01$, 33% of the variance); that is, lower number of correctly answer attempts were associated with higher depression scores, severity of illness and lower BMI.

On the other hand, depression was inversely associated with the score on the SpanLN whereas dichotomous clinical status was directly associated ($F= 3.39$; $p < 0.01$, 25% of the variance); that is, higher scores on depression and evidence of illness were significant predictors of impaired working memory.

Inhibitory attention

In the model in which "Interference", measured with the Stroop's test, was considered as a dependent variable, the score on the "Perfectionism" subscale of the EDI-2 and the score on the "Absorption" subscale of the DES were directly associated with "Interference"; That is, perfectionism and absorption were significantly predictors of inhibitory attention or interference ($F= 2.73$; $p < 0.05$, 19% of the variance).

Sustained attention

In the model in which the sustained attention, assessed with the SDMT, was considered as a dependent variable: depression (BDI) was inversely associated and anxiety trait (STAI-trait) as well as "Perfectionism" were directly associated with the score on the SDMT. Therefore, higher depression scores, lower anxiety trait and lower perfectionism scores significantly predicted less sustained attention ($F= 4.15$; $p < 0.001$, corrected 33% of the variance).

Executive function

When the copy time on the ROCFT was considered as a dependent variable, none of the other variables were significantly associated. In the model in which the copy score on the ROCFT was considered as a dependent variable, the age at onset of illness was inversely associated and "Perfectionism" was directly associated; thus lower age at onset and higher perfectionism predicted higher copy scores ($F= 3.92$; $p < 0.05$, 26% of the variance), that is the patients tend to have greater tendency to focus on the details. When the central coherence index was used as the dependent variable, the use of antidepressants and antipsychotics were directly associated and the use of benzodiazepines and hypnotic sedatives inversely associated ($F= 2.27$; $p < 0.05$, corrected 15% of the variance).

Relationship between neuropsychological variables and attitude towards change

Higher score on time of the copy [B=3.56; 95% CI (0.82-6.29), $p<0.01$] and lower score on memory time [B=-2.31; 95% CI [-4.58-(-0.05)]; $p<0.05$] predicted the score on the “Precontemplation” subscale of the ACTA ($F=2.59$; $p<0.05$; 16% of the variance). Higher score on the copy time [B=1.43; 95% CI (0.42-2.45); $p<0.01$] and lower score on the style index [B= -14.01; 95% CI (-24.98-(-3.04)); $p<0.01$] predicted the score on the “Contemplation” subscale of the ACTA ($F=3.40$; $p<0.05$; 22% of the variance). In addition, the score on the “Decision” subscale of the ACTA was predicted by the following variables ($F=3.19$; $p<0.05$; 23% of the variance): working memory (SpanLN) [B=-3.76; 95% CI [-6.88 -(-0.64)]; $p<0.05$], quantitative copy score [B=1.31; 95% CI (0.29-2.32); $p<0.05$], order index [B=4.69; 95% CI (0.29-9.09); $p<0.05$] and style index [B=-17.06; 95% CI [-28.08 – (-6.05)]; $p<0.001$].

Discussion

The main findings of the present work show that ED clinical subtypes do not differ significantly in terms of neuropsychological features, according to the neuropsychological tests used. This might suggest that some neuropsychological dysfunctions are transdiagnostic dimension of EDs, related to emotional and cognitive issues and probably influenced by the severity and duration of the illness. The results are summarized as follows: Overall, we found a relationship between some neuropsychological test scores and certain clinical features, mainly BMI, age at onset, time of duration of the disorder, clinical status and depression. Furthermore, in the light of our results, perfectionism is associated with higher tendency to focus on details, but directly related with sustained attention. Furthermore, the absorption dimension of dissociation is associated with inhibitory attention. Regarding the influence of the neuropsychological features on the attitude towards change, being in precontemplation, contemplation or decision stages, with no change towards action, is predicted by the patient’s tendency to focus on the details, accuracy, and also by working memory deficits. These mentioned problems might be linked with some difficulties with planning and performing analyses of medium-long term consequences, reflecting motivational and decision-making deficiencies (6). Lastly, psychopharmacological treatment might be considered as a confounding factor, ought to its influence on different variables and performance on neurocognitive tasks, as central coherence.

The present results might have relevant clinical implications because of the possible effect of cognitive remediation therapy on functional recovery. In the setting of enhanced cognitive-behavioural and motivational therapies, behavioural change towards healthier attitudes could be promoted by training volitional as well as cognitive control skills (6). Moreover, the assessment of EDs along dimensional terms, as performed in the present study, helps to clarify that the neuropsychological features are not specific to diagnostic categories, moving from symptoms-based classifications towards disorder models based on the complex interaction of underlying and maintenance mechanisms (6).

Neuropsychological features of ED and related clinical and psychological factors

Attention.

Inhibitory attention, assessed by interference on the Stroop test, was higher in those patients with EDs who participated in the study than expected in normal population; this is consistent with other researches (63). Our results show that the psychopathological characteristics most related with inhibitory attention are perfectionism and dissociation (absorption). Inhibitory attention has also been previously related to neuroticism and to a more controlling, less flexible attitude (74) as well as other EDs clinical variables (18,23,74). Likewise, we found that depression negatively influence sustained attention, whereas perfectionism could make a positive influence on it.

Working memory and executive functioning.

The average working memory of the patients included in this study was lower compared to the general population. Other authors (74), who exclusively explored patients with an AN diagnosis, found even lower scores which could be explained by the existence of worse clinical condition (74–76).

Severe clinical status, together with low BMI and depression, have predictive value for working memory deficits. Few researches on the topic of working memory in EDs have previously considered factors such as comorbid pathology, psychopharmacological treatments and patient clinical status (7), which were all included in our model. Therefore, one interesting point of the present study is that simultaneously considers co-occurring psychopathology, duration of the illness, severity, use of psychopharmacologic treatment, perfectionism, dissociation, attitudes towards change and all the other factors that were analysed in this integrative model. Further longitudinal studies are needed to elucidate how all these variables interact to have a synergic effect in the outcome. Our findings suggest that a negative emotional state of people with severe EDs could interfere with working memory. Working memory has been defined as “the holding mechanism in the mind for keeping a small amount of information in a temporarily heightened state of availability” (22). It contains not only what we think of as the conscious mind, but also any other on-going processing and temporary memory functions outside of conscious awareness. Therefore, cognitive-emotional interactions may influence this process (77).

Regarding executive functioning, cognitive inflexibility, the need for control in matters related to food and the difficulty of developing alternatives for managing everyday problems are common characteristics of people with EDs (38), possible related with some other deficits in executive function (28,30). The instrument used in this paper, the ROCFT, is a complex test with multiple indexes providing quantitative and qualitative information (67). It has been considered an important measure of executive functioning in other samples of population (80,81). Likewise, ROCFT has been identified as a measure of visuo-construction, and it has been found to correlate with visual neuropsychological tests, including measures of visual perception, judgment of spatial relations, visual organization, and set-shifting (78,79). It could be related with deficits in body shape integration and body disturbances (80). However, we did not find any significant relationship with body shape dissatisfaction. The average score for drawing from memory was lower than that of the general population, probably due to deficits in nonverbal memory and poverty in visuospatial integration, as described in other ED studies (15,23,87). Nevertheless, copying accuracy

and copy time scores were higher than expected with respect to the reference population, a finding that seems to be related to perfectionism.

From a clinical point of view, the fact that BMI has an inverse relationship with the copy and memory time on the ROCFT suggests the possible existence of difficulties concerning executive processing in patients with a lower BMI. It has been previously pointed as a predictor of treatment outcomes in AN (32,82) being the physical criterion most commonly used as an indicator (34,82,83). Considering all the EDs, a slowdown could happen in the processing of information in patients with severe clinical status, compared to the general population, as well as decreased flexibility when performing assessment tasks (14,18,24,84–86), greater interference with distracting stimuli, tendency to pay excessive attention to details and deficient visuoperceptive and global integration (86–88); that is in accordance with the main findings of the present work.

Neuropsychological features associated with dissociation and with attitude towards change.

Depression, together with clinical status and BMI, predicted dysfunction in working memory. Likewise, dissociation together with perfectionism predicted inhibitory attention, that is, interference with distracters stimuli. These findings are consistent with the multidimensional model of emotional regulation, which outlines the role of neurocognitive process, specifically the ability to filter and gate information (23). The relationship of the absorption dimension of dissociation with inhibitory attention has special relevance in EDs. Dissociation, considered as a disruption in the usually integrated functions of consciousness, memory, identity, or perception (89), is associated with fragmented or inadequate encoding information. Dissociation plays an important role in EDs and is related to mood-modulation mechanisms (90): Firstly, "cognitive narrowing" process probably prevents unpleasant meaningful thoughts and provides an escape from distressing self-awareness (90). Afterwards, leading to emotional deregulation, dissociation can take over endogenous attention and interfere with cognitive control process (91). Consequently, this may restrict the patients' ability to deal with the long-term consequences of their behaviour and be related to decisional imbalance, with an apparent effect on motivational state (85).

Patients with more severe clinical status, who did not believe that they had a problem, that is, those being in the "Precontemplation" phase, tended to focus more on details, needing more time to perform those complex cognitive processes that require planning and coordination, as evaluated by the ROCFT. The same happened for patients who were in the "Contemplation" and "Decision" phases which are stages representing less mobilization for change.

The mentioned findings highlight the fact that, in patients with long-term resistant EDs, a comprehensive assessment is needed to make an appropriate therapeutic plan. Those patients who remain unmotivated to change could be more reluctant to conventional cognitive behaviour treatment. Additionally, motivational therapy might not be entirely successful in people with deficits in executive functioning. Consequently, as it has been previously underlined, an integrative model of assessment and therapy is needed. It ought to include an approach focused on emotional self-awareness, acceptance and effective

neuropsychological training (23). The aim should be to identify and plan objectives and decisions that promote enduring changes.

Limitations

Some limitations deserve special mention, such as the cross-sectional nature of the study, which makes it impossible to elucidate whether the neurocognitive deficits are endophenotypic, that is, whether they existed prior to the psychopathology, being predictors, and will persist after recovery. Furthermore, the sample size was small considering the heterogeneity of the population studied and the 30% of the sample that did not complete all the questionnaires. The absences of statistically significant differences between the people who did and did not complete all the tests suggest that abandonment was not related to neuropsychological variables or the patients' clinical situation.

The relationship between psychotropic drug use and attention and cognitive speed, as well as the fact that patients taking psychotropic drugs are generally those with the greatest comorbidity or risk, lead to consider it a possible confounding factor in the study. Other unfavourable effects of the presence of depressive or anxiety symptoms at the beginning of therapy on executive function have been described in different studies (8,92).

Conclusions

Neuropsychological dysfunctions in the population studied and their relationship with the duration of the illness, BMI, clinical status, depression, perfectionism, dissociation and the attitudes towards change, underline the importance of a comprehensive assesment in people with EDs. These transdiagnostic deficits could be summarized as follows: reduced working memory, increased inhibitory behaviour and difficulties in executive functioning, compared to the general population. Being in the precontemplative or contemplative attitude towards change are associated with a more controlling and less flexible neuropsychological functioning.

Clinical impact and future lines of study

The overall analysis of the sample shows results regarding the relationship between several neuropsychological dysfunctions (i.e. inhibitory behaviour, sustained attention, working memory, central coherence) and EDs, as indicated in previous studies. The findings of the present study also support the transdiagnostic perspective, since the participants' DSM-5 diagnosis was not as relevant as other clinical variables related to clinical status, comorbid depression and duration of the disorder.

The findings indicate also that factors related to excessive attention to detail, the loss of a global perception of the situation and the inhibition of the attention by distractors stimuli, are related to greater therapeutic resistance, and probably ought to perfectionism and cognitive inflexibility, influencing the attitude towards change. A comprehensive assessment and the incorporation of cognitive remediation therapy should be recommended in order to help patients to acquire cognitive control skills, achieve

emotional regulatory goals, exclude irrelevant stimuli for the decision-making process and enhance motivational techniques.

List Of Abbreviations

Attitudes Towards Change in Eating Disorders Scale ACTA

Anorexia nervosa AN

Beck's depression inventory BDI

Binge eating disorder BED

Body Mass Index BMI

Body Shape Questionnaire BSQ

Bulimia nervosa BN

Bulimic Investigatory Test, Edinburgh BITE

Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition DSM-5

Dissociative Experiences Scale DES

Eating disorders ED

Eating Disorders Inventory EDI

Eating disorder not otherwise specified EDNOS

Letter Number Sequencing LNS

Rey-Osterrieth complex figure test ROCFT

State-Trait Anxiety Inventory STAI

Symbol and Digit Modalities Test SDMT

Wechsler Adult Intelligence Scale WAIS

Declarations

Ethics approval and consent to participate: Informed consent was signed and Local Clinical Research Ethics Committee (Hospital General Universitario from Ciudad Real) approved the study.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: BMS collected, analysed and interpreted the patient data. LBF and TRC supervised every part of the investigation work and were contributors in writing the manuscript. VMM contributed in writing and translating the manuscript. All authors read and approved the final manuscript.

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