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Neuropsychological Functioning in Anorexia Nervosa and Bulimia Nervosa

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Additional information is available at the end of the chapter

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Abstract

Anorexia nervosa and bulimia nervosa are eating disorders in which a wide range of neuropsychological alterations are exhibited; however, the neuropsychology of bulimia nervosa has been poorly studied, and inconsistency has been found in results from different studies. Therefore, the aim of this chapter is to evaluate the differences in the neuropsychological functioning among women with anorexia nervosa and bulimia nervosa and with no eating disorders. Seventy-two women participated in this study: 18 with anorexia nervosa, 24 with bulimia nervosa and 30 without any eating disorder; all of them answered the neuropsychological version of the Wechsler Adults Intelligence Scale-III (WAIS-III), the Rey Complex Figure Test, the Tower of London Task and the Wisconsin Card Sorting Test. Overall, the results showed similar difficulties in anorexia nervosa and bulimia nervosa groups, such as in the visuoconstructive process, executive functioning (specifically in planning skills to achieve a goal, cognitive flexibility and working memory), in selective attention and in nonverbal reasoning and common sense judgment when facing complex problems. These findings open the possibility to reformulate intervention programs for management of bulimia nervosa and consider the use of cognitive remediation therapy, which is already used in anorexia nervosa with a good prognosis.

Keywords: neuropsychology, anorexia nervosa, bulimia nervosa

1. Introduction

Anorexia nervosa (AN) and bulimia nervosa (BN) are eating disorders (ED) whose prevalence is increasing [1–3]; therefore, it is important to determine the factors that could contribute to

their development and maintenance in order to generate more effective and better-targeted treatment strategies.

In recent years, several studies have found a relationship between AN, BN and a wide range of neuropsychological disorders. Overall, it is reported that the affected neuropsychological functions are the visuoconstructive skills, attention, visual and working memory, learning ability and executive functions, specifically the cognitive flexibility and planning skill for solving complex problems [4–9].

From the neuropsychological point of view, AN is the most studied ED and most of the research is focused on identifying difficulties in the cognitive flexibility, planning skills and central coherence. The results are homogeneous [4] and have even allowed to test strategies for the neuropsychological rehabilitation of patients, which have been effective [8, 10, 11].

The cognitive flexibility difficulties exhibited by the patients with AN are based mainly on their inability to change thought patterns keeping a repetitive behavior in spite of the feedback provided, whereas in planning, failures are found in the anticipation, organization and integration of information to solve problems; finally, regarding the central coherence, patients have trouble integrating information, forming a global vision and putting it in a real context [12–15]. It is important to take these difficulties into consideration since they seem to have implications in the patients' daily life (e.g., accurate count of calories, excessive exercise, rigid rituals that are part of their daily routine such as grooming or going to work, and in cause-effect thoughts between noncontingent events: if I do not lose weight, I will be completely miserable).

The BN neuropsychology including the effect of its difficulties in the patients' daily life and their possible rehabilitation has been less explored. Some studies suggest that alterations in BN are different from those of AN due to the impulsivity exhibited by the people with this disease [16, 17]; however, others studies state that there are no differences in the alteration of functions, but, in any case, different combinations in failures and different degrees of severity are present probably due to the disease evolution time or malnutrition level [18–20]. In a recent research study [4], it was observed that despite the impulsive characteristics, planning and cognitive flexibility were not significantly different from the participants with AN.

The results are not entirely consistent because in some studies, patients' clinical severity or disease evolution level was not considered. It is also worth noting that the criteria used to determine the diagnosis are not always mentioned, the same test has been used to measure different neuropsychological functions, and the inclusion of control groups paired with the clinical groups has often been omitted. Finally, the total obtained scores are usually reported, but the functions involved in task solving failed are omitted [16, 20–22].

Considering the information previously described, the aim of this study was to evaluate whether there are differences in neuropsychological functioning of women with AN, BN and with no ED. The central hypothesis is that neuropsychological functioning is similar in individuals with AN or BN and different from people without these disorders.

2. Method, results and discussion

2.1. Method

2.1.1. Participants

Seventy-two women were evaluated: 18 with anorexia nervosa and 24 with bulimia nervosa who met the diagnostic criteria of the Diagnostic and Statistical Manual 5th edition (DSM-V) [23] and 30 without ED, paired according to age and educational level.

The mean age of the group without ED was 19.3 years ($SD = 1.46$), the mean body mass index (BMI) was 21.92 ($SD = 2.31$), and the mean educational level was 13.7 years ($SD = 0.82$). Participants with BN had a mean age of 20.12 years ($SD = 2.75$), a mean BMI of 23.45 ($SD = 2.74$) and a mean educational level of 14.24 years ($SD = 0.86$). In the group of participants with AN, the mean age was 18.89 years ($SD = 1.4$), the mean BMI was 16.88 ($SD = 0.91$), and the mean educational level was 13.03 years ($SD = 0.62$). The mean time of the ED evolution in the group was 5 years ($SD = 1.23$).

None of the participants showed other ED such as other nosological conditions, existence of brain lesions, alcohol or substance abuse, developmental or neurological disorders, severe malnutrition and severe anxiety or depressive states. In order to discard these conditions, some questions, taken from the DSM-V, were included to the eating disorders diagnostic interview (IDED-IV) at the time of assessment, and also, the medical records of participants with AN and BN were reviewed.

In addition to the IDED-IV, the subjective global assessment generated by the patient was also used only in the group of participants without eating disorders in order to measure nutritional status. In this test, the mean score obtained was 1.92 ($SD = 1.74$), that is, no problems, or risk of malnutrition was noticed. Besides, serious anxiety or depression symptoms were discarded by Beck Depression and Anxiety Inventories (scores > 30 : 7.98 [$SD = 4.16$] and 9.52 [$SD = 7.13$], respectively).

2.1.2. Instruments

In order to create the study groups, IDED-IV designed to perform a differential diagnosis for ED according to the DSM-IV-TR was used; it also includes questions related to alcohol and substance abuse [24]. The version used for this research was the one translated into Spanish by [25], modified according to the DSM-V criteria and adapted for the Mexican population by the Nutrition Research Project at the National Autonomous University of Mexico (UNAM), Campus Iztacala.

The subjective global assessment generated by the patient is a method based on the original assessment of Detsky et al. [26]. This two-part assessment that evaluates the nutritional status is more specific and faster than other types of assessment such as albumin, skin sensitivity tests and anthropometric tests [27]. The first part of the assessment is a self-administered questionnaire addressed to obtain medical history data (weight differences, current dietary intake vs.

the regular intake, digestive symptoms present in the last two weeks, functional capacity and metabolic requirements), while the second part is a test performed by the health professional in order to know the physical signs (subcutaneous fat and muscle loss and the presence of edema or ascites). The rating is from zero to nine, and the higher the score, the more severe the symptoms of malnutrition.

The Beck Depression and Anxiety Inventories are self-administered questionnaires consisting of 21 multiple-choice questions, which can be used as of 13 years old. The first one has affective questions related to depressive symptoms, such as hopelessness and irritability, cognitions, such as guilt or feelings of being punished, as well as physical symptoms, such as fatigue and weight loss, while the second one is aimed to discriminate between somatic symptoms of anxiety. In Mexico, they are standardized with a reliability of 0.87 and 0.83, respectively [28, 29].

The assessment of the neuropsychological skills was carried out using the neuropsychological version of the Wechsler Adult Intelligence Scale-III (WAIS-III). This is a test of individual application that assesses the intellectual ability of people between 16 and 64 years old, it is divided into 14 subtests organized into two scales: verbal and nonverbal performance, standardized in Mexico with a reliability of 0.85 and 0.69, respectively, with an overall reliability of 0.86 [30]. The application of the neuropsychological version provides information on the most relevant aspects of cognitive functioning by performing a detailed review of the intellectual functions and allows measuring the neuropsychological functions in a global and integrative way, and it is a specific and sensitive method to neuropsychological failures [31].

The Wisconsin Card Sorting Test (WCST) is designed to measure cognitive flexibility, abstract reasoning skills and the development and maintenance of strategies to achieve a goal [32, 33]. In the Latin American population, it has been validated with a reliability of 0.82 [34]. It consists of four stimulus cards and 128 response cards; the goal is to classify the response cards with the stimulus cards according to three criteria: color, shape and number. The classification criteria are never made explicit; it is the participant who deduces them through the feedback offered by the evaluator ("right" or "wrong"). The classification criterion is changed without notice after 10 consecutive correct answers. The qualification criteria are as follows: number of applied attempts, correct answers, total number of errors, perseverative responses (when the participant insists on responding to a criterion that is not correct), perseverative errors (errors that follow the perseveration principle), nonperseverative errors (errors that do not follow the perseveration principle), number of completed categories (number of sequences of 10 consecutive correct answers), failure to maintain the attitude (an error after five or more consecutive answers but before completing the category), attempts to complete the first category and the conceptual level that reflects an understanding of the classification principles.

The Rey Complex Figure (RCF) Test assesses the visuospatial construction skills and visual memory [31, 35]. It is a paper-and-pencil test in which a complex stimulus card (5 × 7 in.) has to be copied, but it cannot be identifiable unless components are visualized and hierarchized by an analytical activity. It consists of a total of 18 perceptual units organized around a basic rectangle and divided by a horizontal and a vertical line into eight equal pieces, which in turn are intersected by two diagonal lines including a wide variety of internal and external stimuli. It is applied in two modes, copy and memory, with a time span of three minutes each. Its scoring

considers rotation errors, location errors, repetition and review of the unit or its parts, distortion errors, angulation deficiencies, errors in the size of any unit or the full figure, total absence of unit and number of used colors, whose ideal is 18 (one per unit), which are essential to identify the drawing sequence. In Mexico, the test is standardized with a reliability of 0.83 for copying and 0.78 for memory [36].

The Tower of London-Drexel (TOL-DX) Task is an instrument that assesses executive functions, specifically skill planning [37] which is a process that requires the ability to conceptualize changes, generate and select alternatives, and keep attention [31, 38]. It has a reliability of 0.72 [39] and consists of two wooden bases (one for the test applicator and one for the evaluated participant) with three vertical towers and three colored beads (blue, red and green). The goal is to solve 10 problems of increasing difficulty moving the beads in the fewest possible moves to match the presented model. The test scoring criteria are as follows: number of movements (number of times that the beads are moved after surpassing the minimum necessary to solve the problems), starting, execution and overall time, the time violation at the first minute (i.e., after one minute has elapsed and the problem has not been resolved) and two rules: (I). Do not place more beads than the ones that can fit in each tower and (II). Do not move more than one bead at the same time.

2.1.3. Procedure

Patients from a private nutrition clinic in Mexico City were included in the AN or BN groups. The screening of participants without eating disorders was conducted in different public universities. All participants signed an informed consent (in the event of minor participants, the parents were also asked to sign an informed consent); they answered the IDED-IV in order to confirm the presence or absence of ED and exclusion criteria; medical records of participants with AN and BN were also reviewed; and all participants were weighed and measured to calculate their BMI. Later on, the RCF, the WCST and the TOL-DX were administered individually and in a different order, whereas the subscales of the WAIS-III were applied in the order proposed by Lezak [31] for the neuropsychological version: incomplete figures, vocabulary, digits and symbols keys, similarities, design with cubes, arithmetic, matrices, digit retention, information, drawing ordering, comprehension, symbol search, letter and number sequencing and object assembling.

2.1.4. Statistical analysis

The Shapiro-Wilk test was performed to corroborate the normal distribution of the data and its compliance with the assumptions to complete the analysis. In order to compare the neuropsychological performance among the three groups and identify statistically significant differences ($p < 0.05$), three multivariate analyses of variance (MANOVA) were carried out: one for the RCF, another for the WCST and a third one for the TOL-DX. Three ANOVAs were performed for the WAIS-III analysis in order to compare the verbal IQ, performance IQ and overall IQ, and two MANOVAS, one for the index scores and one for the 14 subtests that make up the test.

2.2. Results

A total of 72 participants were assessed: 18 with AN, 24 with BN and 30 with no ED. The mean age, BMI and educational level of the groups are shown in **Table 1**.

Group	N		Age	BMI	Edu
Without ED	30	Mean	19.3	21.92	13.7
		SD	1.46	2.31	0.82
Bulimia	24	Mean	20.12	23.45	14.24
		SD	2.75	2.74	0.86
Anorexia	18	Mean	18.89	16.88	13.03
		SD	1.4	0.91	0.62

BMI = Body Mass Index; Edu = Education.

Table 1. Age, body mass index and educational level among the groups.

In order to compare the neuropsychological performance among participants of each group and to identify whether there are statistically significant differences $p < 0.05$, four MANOVAS were conducted, one for each mode of the RCF, another for the WCST and a fourth one for the TOL-DX; three ANOVAS were performed to compare the verbal IQ, nonverbal performance IQ and overall IQ; and two more MANOVAS were carried out, one for index scores and another one for the 14 subtests of the WAIS-III.

The results of the RCF showed significant differences in both copy and memory modes, Wilk's lambda = 0.23, $F(2, 69) = 2.17$, $p < 0.05$, with an effect size of $\eta^2 = 0.52$ and Wilk's lambda = 0.23, $F(2, 69) = 1.82$, $p < 0.05$, with an effect size of $\eta^2 = 0.51$, respectively.

The univariate analyses of the copy mode showed statistically significant differences in the number of colors used, location error b (when the unit is attached to the figure, within the space that corresponds to it, but shifted) partial repetition, distortion errors a (uncoordinated trace), b (tangency error), c (closure error) and d (incomplete line), poor angulation and total score. The univariate analyses of the memory mode showed similar results to those of the copy mode; the statistically significant qualification criteria were execution time, location errors b and c (when the unit is attached to the figure, but outside its corresponding space), partial repetition (any component of the unit was drawn more than once), distortion errors a and d, omission and total score. According to Levene's statistic, the assumption of variance homogeneity was met in all cases. The means of each group and the F value for each significant variable are shown in **Tables 2** and **3**.

Rey Complex Figure—Copy							
Variable	Group						F(2, 69)
	No ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Colors	21.23	3.61	28.58	5.55	27.06	5.91	16.60*
Location b	1.14	0.83	1.79	1.11	1.69	1.16	3.72*
Partial repetition	0.18	0.03	1.32	0.75	0.91	0.36	4.58*
Distortion a	1.42	0.90	3.42	2.76	3.94	2.25	7.51*
Distortion b	3.73	2.42	5.87	3.16	4.00	2.60	4.49*
Distortion c	1.36	1.19	1.33	1.94	2.06	1.95	4.48*
Distortion d	1.18	0.38	1.73	1.04	1.75	1.13	3.31*
Deficient angulation	1.18	1.17	2.95	2.23	3.00	2.16	10.30*
Total score	25.44	6.13	21.10	4.53	21.81	4.53	5.64*

* $p < 0.05$.

Table 2. Univariate F means in the significant qualification criteria from the copy mode of Rey complex figure.

Rey Complex Figure—Memory							
Variable	Group						F(2, 69)
	Without ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Execution time	2.83	1.19	2.27	1.12	3.95	3.84	3.17*
Location b	0.93	0.86	1.79	1.41	1.78	1.47	4.70*
Location c	0.80	0.33	1.54	1.46	1.25	1.16	6.19*
Partial repetition	0.53	0.30	1.57	0.33	1.57	0.83	4.99*
Distortion a	1.45	0.88	2.63	1.83	2.91	2.39	4.26*
Distortion d	1.83	1.18	2.65	1.34	3.00	1.53	4.91*
Omission	3.80	2.09	6.46	2.02	5.00	2.40	10.20*
Total score	18.56	4.88	11.02	3.38	13.86	4.96	19.69*

* $p < 0.05$.

Table 3. Means and univariate F value in the statistically significant qualification criteria from the memory mode of Rey complex figure.

Tukey's post hoc tests showed that both AN and BN groups used a greater number of colors in the copy mode, made more location and distortion errors, had more angulation difficulties and omitted more units in the memory mode, and their scores were lower. Execution time differences were only found in participants with AN since they took longer time to complete the memory task.

The WAIS-III analyses included three ANOVAS to compare verbal IQ, performance IQ and overall IQ, and two MANOVAS, one for the four index scores (verbal comprehension, perceptual organization, working or operational memory and processing speed) and another one for the 14 subtests (picture completion, vocabulary, digit symbol-coding, similarities, block design, arithmetic, matrix reasoning, digit span, information, picture arrangement, comprehension, symbol search, letter-number sequencing, and object assembly).

The ANOVAS results showed no significant difference in verbal IQ, but they did in the performance IQ and overall IQ. Tukey's post hoc tests showed that the participants without eating disorders obtained higher scores. However, the average scores of all participants were within the expected values according to their age and educational level. The mean and coefficients are shown in **Table 4**.

IQ	Group						F (2, 69)
	Without ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Verbal	101.53	5.95	100.90	7.25	101.72	1.01	2.96
Performance	106.80	4.62	101.67	4.22	101.38	5.12	11.28*
Total	102.77	4.74	100.37	5.31	101.05	5.79	8.11*

* $p < 0.05$.

Table 4. F and means of the nonverbal performance IQ and the total IQ on the WAIS-III.

The MANOVA for the index scores showed significant differences, Wilk's lambda = 0.69, $F(2, 69) = 3.31$, $p < 0.05$, with an effect size of $\eta^2 = 0.27$. According to Levene's statistic, all cases met the assumption of variance homogeneity. The univariate analyzes showed statistically significant differences in two scores: perceptual organization (picture completion, block design and matrix reasoning) and working or operational memory (arithmetic, digit span and letter-number sequencing). Tukey's post hoc tests showed that both groups, AN and BN, had more difficulties. **Table 5** shows the mean scores and the univariate F value of each index score.

Index score	Group						F(2, 69)
	Without ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Verbal compression	105.15	9.49	104.50	9.96	105.58	9.07	0.12
Perceptual organization	110.56	7.81	102.96	9.89	102.11	10.22	10.08*
Working memory	104.50	3.21	102.25	9.89	102.00	3.48	3.26*
Processing speed	110.46	13.61	109.83	15.66	102.72	23.92	1.74

* $p < 0.05$.

Table 5. Univariate F and means of the index score.

The results of the MANOVA carried out for the 14 subtests showed significant differences, Wilk's lambda = 0.45, $F(2, 69) = 1.94$, $p < 0.05$, with an effect size of $\eta^2 = 0.33$. According to Levene's statistic, all cases met the assumption of variance homogeneity. The univariate analyses showed statistically significant differences in picture completion, block design, picture arrangement, comprehension and symbol search. **Table 6** shows the mean scores for each group and the univariate F value in the 14 subscales. Tukey's post hoc tests showed that both groups, AN and BN, had difficulties identifying the missing parts of the figures, reproducing two-color models with cubes, rearranging the cards and telling a story, and providing solutions to everyday problems. Regarding the same stimuli found within a group of symbols, only participants with AN showed a significant difference compared with the other groups, as they had fewer trials answered.

Subscales	Groups						F(2, 69)
	Without ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Picture completion	22.83	0.98	21.71	1.73	20.75	1.37	4.51*
Vocabulary	36.73	7.64	35.21	5.76	36.08	6.46	0.34
Digit symbol— coding	79.93	12.15	80.95	12.32	79.97	11.79	0.18
Similarities	23.77	2.94	23.08	3.43	23.34	3.48	0.37
Block design	50.97	6.31	43.83	7.15	43.39	8.65	9.00*
Arithmetic	17.50	2.15	16.58	1.86	16.72	2.86	1.28
Matrix reasoning	22.86	2.75	21.33	2.33	21.95	2.88	2.67
Digit span	17.87	3.58	17.38	3.33	17.28	3.14	0.22
Information	22.13	3.08	22.12	2.91	22.44	2.83	0.76
Picture arrangement	20.30	2.19	16.04	3.20	16.83	3.76	15.42*
Comprehension	22.40	3.77	19.79	3.61	20.33	3.27	5.80*
Symbol search	32.36	5.04	30.08	6.72	26.63	5.65	3.84*
Letter-Number Sequencing	11.06	1.85	10.45	1.84	11.22	1.76	1.10
Object assembly	38.10	7.48	36.33	6.02	35.78	5.49	0.85

* $p < 0.05$.

Table 6. Means and univariate F in WAIS-III subtests.

In the WCST, MANOVA results showed significant differences, Wilk's lambda = 0.44, $F(2, 69) = 1.70$, $p < 0.05$, with an effect size of $\eta^2 = 0.42$. According to Levene's statistic, all cases met the assumption of variance homogeneity. The univariate analyses showed statistically significant differences in nine out of the 10 evaluated qualifying criteria, and the exception was the number of correct answers. **Table 7** shows the means of each group and the univariate F value of the dimensions. Tukey's post hoc tests showed that both groups, AN and BN, had a higher number

of attempts and more total, perseverative and nonperseverative errors; they persisted in responding to a stimulus feature that was not correct; and they had difficulty understanding the classification principles (color, shape and number) and therefore, deducting categories (a sequence of 10 consecutive correct answers).

Wisconsin Card Sorting Test							
Dimensions	Group						F (2, 69)
	Without ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
Number of attempts applied	82.13	9.62	103.46	20.97	111.78	21.68	18.26*
Correct answers	67.81	5.48	67.03	15.17	67.06	15.92	0.03
Total number of errors	14.57	5.29	33.88	24.01	38.61	25.45	11.31*
Perseverative responses	6.97	3.57	14.92	12.32	16.94	11.26	8.05*
Perseverative errors	6.63	3.26	13.58	10.82	15.56	10.07	8.05*
Nonperseverative errors	7.31	3.84	20.25	19.49	26.22	22.21	8.99*
Percentage of conceptual level responses	77.93	5.35	60.29	20.91	54.56	24.31	12.21*
Number of entire categories	5.94	0.31	4.87	1.75	4.22	1.81	10.51*
Attempts to complete the first category	13.13	2.54	16.67	23.87	27.33	31.99	3.91*
Failure to maintain the attitude	0.34	1.33	0.91	0.67	1.06	0.99	8.37*

* $p < 0.05$.

Table 7. Means and univariate F from the significant dimensions of the Wisconsin Card Sorting Test.

The MANOVA of the TOL-DX was statistically significant, Wilk's lambda = 0.56, $F(2, 69) = 2.18$, $p < 0.05$, with an effect size of $\eta^2 = 0.41$. According to Levene's statistic, all cases met the assumption of variance homogeneity. Regarding the number of movements exceeding the minimum necessary, the univariate analyses showed statistically significant differences in six out of the 10 problems evaluated by the instrument, as well as in the number of total movements. Tukey's post hoc tests showed that both groups, AN and BN, resorted to a greater number of moves to solve the problems. Mean and univariate F value of each of the problems and the total movements for the three groups are shown in **Table 8**.

Univariate analysis also showed significant differences in the execution time $F(2, 69) = 4.09$, $p < 0.05$ and in the violation of Rule II $F(2, 69) = 12.27$, $p < 0.05$. Tukey's post hoc tests showed that both groups, AN and BN, needed more time to solve the problems ($M = 363.48$ s, $SD = 81.60$ and $M = 337.13$ s, $SD = 108.84$ respectively) than participants without any ED ($M = 193.66$ s, $SD = 82.60$). Regarding moving more than one bead at the same time, the BN group showed a

difference: the number of violations of the participants with anorexia (3) was lower than those of the participants without ED (5) and the participants with bulimia (16).

Problems	Group						F (2, 69)
	No ED		Bulimia		Anorexia		
	M	SD	M	SD	M	SD	
1	2.08	1.26	3.16	2.35	2.26	1.22	2.46
2	2.83	1.06	5.87	4.33	4.89	4.74	3.13*
3	1.70	1.31	3.38	2.18	2.28	1.36	1.27
4	3.75	2.58	6.04	5.11	6.39	4.88	4.36*
5	2.70	2.11	4.67	3.68	4.17	3.24	3.61*
6	2.10	1.57	2.37	2.23	1.95	1.52	0.14
7	2.50	1.12	4.71	3.63	3.98	2.80	3.81*
8	2.26	2.11	4.33	3.66	4.00	1.41	6.72*
9	1.07	0.07	2.29	2.49	1.94	1.33	2.23
10	0.83	0.61	3.16	1.17	2.67	2.29	7.89*
Total movements	20.91	11.73	35.00	16.36	30.48	15.86	12.91*

* $p < 0.05$.

Table 8. Means and univariate F from the movement per problem and from the total of movements of the Tower of London.

2.3. Discussion

The aim of this study was to evaluate differences in the neuropsychological functioning of women with AN, BN and without ED. The main finding is that both eating disorders had similar difficulties in solving neuropsychological tests. According to the features measured by the RCF, the TOL-DX, the WCST, as well as the WAIS-III subscales of picture completion, block design, picture arrangement, comprehension and symbol search [31–33, 39, 40], failures were found in the visuoconstructive process, executive functioning, specifically in the skill planning to achieve a goal, cognitive flexibility and working memory, and in selective attention and common sense judgment when solving complex problems.

In RCF, the number of colors showed a consistent stimuli fragmentation, which implies that both groups, AN and BN, struggled to make an analysis that would allow them to visualize and prioritize the units. Therefore, at the moment of integrating the total figure, the unions of some lines were forced to coincide resulting in a disproportionate figure with errors. The participants identified the structures and organized their elements but in a fragmented way, focusing on the details and not in the stimuli globality for its construction. Organizational strategies and unit hierarchy are related to problems in the visuoconstructive process [31], whereas the detailed approach on stimuli is related to weak central coherence [41]. These results are in agreement with the results of several articles focused on AN [12, 42, 43], and they open the possibility to also consider the weak central coherence as a BN difficulty.

Regarding the memory mode, participants from both groups, AN and BN, made various omissions; nevertheless, the results of this study do not allow us to conclude about the existence of visual memory alterations, because this would require the copy to be developed without fragmenting the figure since the same fragmentation directly affects the possibility of stimulus recovery [32], and in this case, different fragmentations of origin were presented. Thus, to assess visual memory in these populations, it is worth considering one or more other tests, such as the picture set test [44] or the neuropsychological test for memory and visual learning DCS [45].

Difficulties to analyze and synthesize complex information in tasks designed to evaluate perceptual organization were also observed in the WAIS-III results. Participants at both groups, AN and BN, struggled to organize the elements that formed the stimuli and to analyze the data to conceptualize their shape and size.

In the subtest of picture completion, participants with either AN or BN focused on nonessential details and even on elements that were not present in the stimuli, concentrating more on nonrelevant details as the test difficulty increased, making the perception of globality more difficult each time. If it is considered that regardless of the task with which they are evaluated, such characteristics were observed, changes in selective attention could occur. This important finding is opposite to what some authors have mentioned about attentive difficulties being only observed when stimuli are related to food and body shape, as in the case of the Stroop Color and Word Test adapted for ED [16, 46, 47], and it also contradicts some research studies which indicate that alterations are found at the basic attention levels such as alertness and sustained attention [19, 48]. This focusing on the details also reinforces the hypothesis of the existence of weaknesses in the central coherence process.

The tendency of focusing on irrelevant details and making misinterpretations consequently was also clearly reflected in the picture arrangement subtest, which is a complex task that requires to make inferences discriminating the important information from the one that is not. Thus, the difficulties in producing a response by inhibiting others that are not relevant to solve a task together with the alterations found in the sequential thinking (i.e., the ability to identify relationships and set properties between events) make it very likely for participants with either AN or BN to struggle to pay attention to the context characteristics, which is an important skill for the implementation of goal-directed behavior [31, 32, 49], especially if we consider the difficulties in understanding concepts and social practices observed in the comprehension subtest of WAIS-III.

According to the features measured by TOL-DX and the WCST, the performance of the AN and BN participants shows neuropsychological failures in executive functioning, specifically in planning and cognitive flexibility [31–33, 39, 40]. Findings in the performance of AN participants agreed with those reported by several authors [9, 13, 16, 20, 43, 50, 51], and the difficulties exhibited by the BN participants corroborate the results of preliminary investigations [4, 14].

In the Tower of London Task, difficulties arose in delineating, organizing and integrating the sub-goals, that is, participants with either AN or BN did not follow strategies according to an

overall plan of action. These difficulties are similar to those found by Alvarado and Silva [4], who considered that planning a series of sub-goals, anticipating the effects of a movement related to the ultimate goal, rejecting or accepting a move as part of the correct series and retaining the resulting sequence of correct moves for the final execution have a crucial component: the proper functioning of working memory [32]. Nevertheless, this function could suffer deterioration, which seems to have been corroborated in this investigation, not only because of the similarity in executions but also by the significant results of the WAIS-III index score (working memory).

Considering the above, it is also possible to state that there is an alteration in the prospective memory of the AN and BN participants, which is an essential element for behavioral planning as it is indispensable for the anticipation of future events for both formulating and implementing plans [49], so it would be worthwhile to conduct an investigation to assess it specifically in participants with the same characteristics and to identify whether there are difficulties affecting the solution of complex problems or not.

The results of the WCST show that the rigidity of thought is also a trait shared by the patients with either AN or BN, since both failed to make changes in response patterns and in the development and maintenance of strategies to achieve an objective despite receiving feedback [4, 14, 15], demonstrating the presence of inflexible thinking for task monitoring and plan designing.

Furthermore, considering that planning to achieve a goal focuses on the orbitofrontal area [46], that cognitive flexibility occurs in dorsolateral area [32, 33, 38, 40] and that the results suggest difficulties in sequential thinking, that is, establishing relationships between events and making common sense judgments (especially when understanding some concepts and social practices), it should be taken into consideration that people with either AN or BN have trouble with decision making, and the acquisition and use of an attribution system to interpret the intentions of others [49], especially if it is taken into account that some studies with AN patients [52, 53], designed to assess the theory of mind, have obtained similar results to those obtained in this study.

According to the results of this research, neuropsychological difficulties between AN and BN were homogeneous, and there were only differences in the execution time of the memory mode of the RCF. In the symbol search subscale of the WAIS-III for AN participants, they took longer time to deliver the figure, not only because they had not finished but also because they expected to recall other stimuli and had fewer found symbols since their answers were checked several times before continuing, and in the violation of the Rule II of the Tower of London Task in the BN group, they committed fouls when they could not solve the problem. This behavior may be attributable to their obsessive traits in the case of the AN group and to their impulsivity in the case of the BN group [18, 42, 54]. However, these characteristics did not affect their cognitive ability in the other tests.

This is consistent with the findings of some authors who observed no differences in the neuropsychological functions alteration and mentioned that the differences found in other

studies may be due to the lack of consideration of the disease evolution time or severe malnutrition, especially in the case of AN [14].

It is important to note that, in patients with eating disorders, the neuropsychological difficulties may be related to certain alterations in the neural mechanisms, such as altering neurotransmitter alteration levels, decreased brain volume, blood flow and cerebral metabolism, which have been observed through neuroimaging studies [21, 55]. However, due to the huge number of variables, it is difficult to demonstrate the correlation between brain and functional changes [56]. In the case of AN, there is a preliminary study in which patients at an early stage were evaluated, and it was found that the neurobiological abnormalities may predict neuropsychological difficulties during follow-up [57]. This could be an indication that some neuropsychological disorders appear previously, so the weight of the disposition and the consequences of each type of ED should be clarified.

On this regard, there are known investigations in which executive functioning has been compared in patients with eating disorders vs. healthy relatives and similar difficulties have been found; this could be a family trait associated with an increased risk of developing these disorders [58–61]. In addition, the visuoconstructive skills, planning and flexibility of thought have been compared in participants with eating disorders associated symptoms, and it was noted that the performance is more similar to that of the participants with AN and BN than that of the participants without eating disorders; however, it should be similar to normal populations since they do not have conditions of malnutrition, dehydration or other secondary comorbidity associated with eating disorders [4, 62]. This suggests that the neuropsychological difficulties appeared prior to AN or BN and also that the degree of alteration depends on the conditions of the disease.

The sample size used in this study was limited, so studies with a larger number of participants at each study group should be conducted in order to extend and detail the data showed in this study.

In conclusion, it is possible that the impulsivity observed in participants with BN is not directly involved in the performance of neuropsychological testing as many authors have mentioned because, despite of the differences with AN, the difficulties in the neuropsychological processes were basically the same. Therefore, further research shall be conducted to reformulate BN intervention programs and to take cognitive remediation therapy into consideration, which has already been used with a good prognosis in anorexia nervosa.

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