REVIEW

Rev Bras Psiquiatr 2004;26(2):107-117

Neuropsychology of eating disorders: a systematic review of the literature

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Abstract

Background: *The pathophysiology of eating disorders is still unknown, with many factors possibly involved. The existence of a central nervous system (CNS) dysfunction is being investigated with particular interest. One of the most employed strategies to reach this goal is the evaluation of cognitive functioning of patients with eating disorders with neuropsychological tests.*

Objective: *To evaluate the current knowledge about the neuropsychology of ED.*

Methods: *We performed a review of several data bases (including MedLINE, PsychoINFO, LILACS and Cochrane Data Bank), using terms related to main theme of interest. The review comprised articles published up to January, 2004.*

Results: *Anorexia Nervosa (AN) was the most studied ED from the neuropsychological point-of-view, with studies tending to elicit attentive, visuo-spatial, and visuo-constructive deficits among such patients. On the other side, patients with Bulimia Nervosa (BN) exhibited déficits in the selective aspects of attention and in executive functions. As yet, there is no study covering the neuropsychological aspects of binge-eating disorder. After successful treatment, individuals show improvement of some cognitive deficits, while other seem to persist.*

Conclusions: *The ED are possibly associated with a certain degree of neuropsychological dysfunction, even though there is no consesus with regard to which function is particularly impaired. The fact that some cognitive dysfunction tend to disappear after treatment argues in favor of the hypothesis that these are functional deficits. Other deficits, however, tend to persist, suggesting that they may precede the development of eating disorders or even contribute to their development or to a worse prognosis. The study of the neuropsychological aspects of ED may help tailoring more selective therapeutic approaches to patients suffering from these disorders.*

Keywords: *Eating disorders. Anorexia nervosa. Bulimia. Binge Eating Disorder. Neuropsychology.*

Introduction

Neuropsychology examines the relationship between behavior and mental functioning by means of psychometric tests or qualitative exams of the cognitive, sensory-motor, perceptual and emotional areas. It comprises the study of the behavioral expression of central nervous system (CNS) lesions, helping to screen for different manifestations of brain dysfunctions. Among several clinical utilizations, it serves as an auxiliary tool for diagnosis and documentation of psychiatric disorders and it is used to evaluate clinical effects of therapeutic interventions.

The etiology of eating disorders (ED) is unknown. The possibility that there is a dysfunction of the central nervous system (CNS) in patients with these disorders has been explored in several ways, including studies of neuropsychological test performance. An increasing number of studies assessing the relationship between several mechanisms of cognitive processing and certain eating behaviors have been conducted, aiming to achieve a better understanding of the pathophysiology of ED.

A great variety of cognitive deficits, assessed by several neuropyshcological tests, have been described in patients with ED. In some studies, patients with anorexia nervosa are characterized by attentional and visual perception deficits.[6,31,43,55] Other findings are associated with bulimia nervosa, and abnormalities related to the executive functions were described.[25,33,39] The increasing interest in this field can be demonstrated by the higher number of scientific publications in the last decade. However, several methodological issues have been found in these researches, generating conflicting results. The aim of this article is to assess the current state of the studies related to the neuropsychology of ED.

Methodology

A bibliographic research was performed using the following databases: MedLINE, PsychoINFO, LILACS and Cochrane Data Bank. Original articles and reviews about the subject 'cognitive functions' and ED published up to the year 2004 were sought for the following medical subject headings (MeSH): 'eating disorder', 'anorexia nervosa', 'bulimia nervosa', 'binge eating disorder', 'binge', 'body image', 'obesity' X 'neuropsychology', 'neuropsychological assessment', 'neupsychological tests', 'neuropsychological evaluation', 'executive functions', 'memory', 'visuoperception', 'vigilance' and 'attention'. Lastly, the bibliographic references of the selected articles were also assessed in order to detect articles not found electronically. The articles found were then analyzed and classified, firstly according to the diagnostic category (anorexia nervosa, bulimia nervosa and binge eating disorder) and, afterwards, according to the type of cognitive function evaluated.

Cognitive functions in anorexia nervosa

Several cognitive functions were assessed in anorexia nervosa (AN) especially the attentional capability, memory, visuoconstruction and the learning capability. We will present below the main alterations observed in the cognitive functioning of AN patients, subdivided according to the group of assessed functions.

1. Attention

The studies assessed used different classifications of cognitive functions and a great diversity of neuropsychological tests to measure them. Therefore, in order to allow the comparison of the findings of the several articles selected, it was used a classificatory system of the cognitive functions described by Lezak[35] which subdivides the attention in several subitems: selectivity, sustained attention, division, and alternance. It is worth highlighting that most tests are not able to assess only one single aspect of attention In general, however, each test has a higher weight in a determined task, in detriment of the others. Additionally, as slower processing speed usually underlies attention deficits,[35] we opted for including the former in this section.

1) Psychomotor speed

Kingston et al.[29] and Jones et al.[25] compared patients with AN and normal controls and verified that the former had a significantly worse performance in the Digit Symbol of the Wechsler Adult Intelligence Scale – Revised (WAIS-R) or in an alternative form of this sub-test known as the Letter-Symbol of the Naylor Harwood Adult Intelligence Scale (NHAIS). The study by Palazidou et al.[43] obtained similar results, using the Symbol Digit Coding. Jones et al.,[25] Kingston et al.,[29] and Szmukler et al.[53] observed that AN patients show worse performance in part A of the Trail Making Test (TMT) and in the Stroop C. Some researchers did not succeed, however, to demonstrate the presence of abnormalities in the psychomotor speed of AN patients.[58,6,25,38,53]

In one recent study with AN patients and normal controls, Green et al.[20] noted that patients had lower reaction time and slower motor speed than controls. Hamsher et al.[22] also noted that 7 of the 20 patients assessed with AN show some degree of motor slowness. The Digit-Symbol depends on the motor speed for its adequate performing. Therefore, a plausible hypothesis would be that a general slowness due to malnutrition could contribute to an impaired performance by AN patients in tests such as the Digit-Symbol, independently of a primary deficit in the information processing.

2) Sustained attention or vigilance

Laessle et al.,[30,31,32] using a Continuous Performance Test (CPT), compared AN patients to normal controls and verified a worse performance of the former, suggesting vigilance deficits. Jones et al.,[25] using the Talland Letter Cancelation Test-R, obtained similar results. However, Bradley et al.,[6] Green et al.,[20] and Jones et al.[25] did not find performance deficits in AN patients.

3) Selective attention

The excessive concern with eating, body weight, and shape is a characteristic symptom of ED. This fact led cognitive theories about AN to suggest that: the selective attention to information associated with food and appearance is a reasoning distortion which has an important role in the maintenance of dysfunctional behaviors associated with ED.[18,57] These reasoning distortions may occur due to the patients' cognitive schemas. which are ways of organizing the information obtained from life experiences and may produce systematic errors in the information processing.

Aiming to assess the way in which ED patients process information, researchers have used the emotional version of the Stroop Color-Naming Test (Stroop). In this version, ED patients have to name as quick as possible the colors in which a series of words associated with eating, body format (e.g., fat, diet, hips) or neutral words (e.g., ocean, clock) are written. In AN, due to the action of cognitive schemas, the words associated with eating and body shape would be more accessible under the cognitive perspective than neutral words. Consequently, the meaning of words related to these themes would interfere more intensively in the answer requested by the test – saying the color in which the word is written- generating higher color naming latencies and showing an attentional bias.

Bem-Tovin et al.,[3] Bem-Tovin et al.,[4] Channon et al.,[9] Cooper and Fairburn,[11] Cooper et al.,[11] Jones et al.,[25] Long et al.[36] and Perpina et al.[44] compared AN patients to normal controls and reported a significant attentional bias for words associated with eating in AN patients. However, Lovell et al.[37] did not find significant differences between groups.

On the other hand, studying the attentional bias for words associated with body shape and weight, Chanon et al.[9] and Perpina et al.[44] did not find differences between AN patients and normal controls. However, Bem-Tovin et al.,[3,4] Bem-Tovin et al.,[4] Cooper and Fairburn,[11] Cooper et al.,[14] Fassino et al.,[15] Jones et al.,[25] Long et al.[36] and Lovell et al.[37] showed a significant attentional bias among AN patients. In one study by Lovell et al.[37] the bias was observed even in anorexic patients whose disease had remitted two years earlier.

Green and McKenna[21] assessed 120 normal children and adolescents matched by gender. They noted a selective bias for words associated with food among 11-year-old girls, what was not observed for words associated with body shape. In the group of 14-year-old patients it was found a significant interference effect for words associated with food and body shape. It was not found any significant effect among male subjects. Therefore, the attentional bias regarding words about eating probably starts before that related to words associated with body shape, what may be due to an early social induction for restrictive eating behavior, particularly among women. At some degree, this interference effect may be found also among normal subjects who had food restriction and who showed concern about thinness.[42,44,52]

Rieger et al.[45] studied the occurrence of attentional bias using the Visual Probe Detection Task on AN patients and noted a bias for words associated with body shape and weight. They suggested that AN patients may have a higher probability of paying attention to information related to weight gain, and ignoring consistent information about weight loss. This attentional effect may serve to maintain the concerns about body weight and shape and the fear of putting on weight, even in the presence of contradictory information.

This selective processing of themes related to eating and body shape has been interpreted as a sign of the existence of specific cognitive schemas among AN patients, and seems to be correlated with the degree of psychopathology.[4,23,57]

In general, these studies suggest that AN patients seem to show more prominent attention deficits in the areas of vigilance and selective attention.

2. Memory

In this section we have chosen to use different divisions of memory, as each author privileged a specific classification system. Some authors aimed to distinguish implicit from explicit aspects, whereas others distinguished short- and long-term aspects. By definition, explicit memory comprises all of the following: learning, codification, storage, recall and recognition of verbal and non-verbal materials which occur consciously, encompassing therefore short- and long-term memories. Working memory was considered separately.

1) Short- and long-term memories

Bradley et al.,[6] Lauer et al.[33] and Palazidou et al.[43] assessed the short- and long-term verbal memories of AN patients and found a normal performance. However, Bayless et al.,[2] Green et al.,[20] Jones et al.,[25] Kingston et al.,[29] and Mathias and Kent[38] noted that AN patients had worse performance than normal controls in tests which assess short- and long-term verbal memories.

Bradley et al.,[6] Hamsher et al.,[22] Kingston et al.,[29] Mathias and Kent, Palazidou et al.,[43] and Witt et al.[58] did not observe short- and long-term visual memory deficits. Bayless et al.[2] and Fox[17] applied the Benton Visual Retention Test in AN patients and observed that they had an impaired performance in short-time evocation. However, these patients had also some difficulty to copy drawings, one of the pre-requisitions to perform that test, what may explain this result. Jones et al.,[25] using delayed recall of the Rey-Osterrieth Complex Figure, noted worse performance among AN patients than among controls.

2) Working memory

Bradley et al.,[6] Gillberg et al.,[19] Lauer et al.[33] and Witt et al.[58] assessed the working memory of AN patients and reported normal performance. In one study by Hamsher[22] 18 patients (out of 20) were normal in performance tests which assessed working memory.

3) Implicit and explicit memory for words related to shape, weight and eating

Channon et al.[9] and Hermans et al.[23] studied the implicit memory for words related to shape, weight and eating and did not find deficits among AN patients. On the other hand, Hermans et al.[23] and Sebastian et al.[48] studied the explicit memory for words related to body shape and weight and eating. AN patients showed an explicit memory bias favoring a better memorizing of words associated with these themes (in comparison to neutral words). This bias was not correlated with measures of anxiety state and trait, what suggests that this explicit memory bias is not caused by selective processing of negatively assessed material among relatively anxious subjects, but to a specific bias for information associated with food, weight and shape. These data corroborate the findings of Vitousek et al.[57] who found that AN patients have a selective memory for information associated with body shape and weight, indicating that this information is well established within memory structures. Ruminations about appearance and weight in which AN patients are frequently engaged seem to lead to the construction of strong associative links between concepts associated with AN and other varied memory representations. These elaborations

Table 1 – Results of studies which assessed attention and selective memory for words related to eating, body shape and weight

STUDY	CLASS	SAMPLE	TESTS	RESULTS
Cooper, 1992	I	36 BN, 36 NC	Stroop-VM	Only patients had selective attention for words associated with eating, weight and body shape.
Cooper, 1992	I	12 AN, 12 BN 36 NC	Stroop-VM	Patients and volunteers of the control group with high eating restriction had selective attention for words associated with eating, weight and body shape.
Cooper, 1993	II	75 BN	Stroop-VM	Presence of attentional bias for words associated with weight and eating.
Green, 1993	II	120 NC	Stroop-VM	Selective attention for words associated with eating and body shape becomes higher with the increase of age only among women. The effect for words associated with eating seems to begin before the effect for words associated with shape.
Perpina, 1993	I	18 AN, 14 BN, 32 NC	Stroop-VM	AN patients showed selective attention for words associated with eating and BN patients had it for words associated with body shape.
Cooper, 1994	I	58 BN	Stroop-VM	There was a decrease in the attentional bias for words related to eating, weight and body shape after treatment.
Long, 1994	I	36 AN, 42 NC 51 obese,	Stroop-VM	AN patients and obese subjects under eating restriction showed attentional bias for words associated with eating, and body size.
Overduin, 1995	II	51 NC	Stroop-VM	Controls with restrictive attitudes showed attentional bias for words associated with eating. There was no bias for words associated with body shape.
Sebastian, 1996	I	10 AN, 10 BN, 10 EDNOS, 60 NC	ET, FRT	AN, BN and EDNOS patients showed explicit bias for words associated with weight and body shape.
Black, 1997	I	16 BN, 29 NC	Stroop-VM	There were no differences between groups.
Cooper, 1997	I	12 AN, 12 BN, 18 NC	Stroop-VM	Patients showed attentional bias for words related to eating and weight and in both groups of patients. Only AN patients showed attentional bias for words related to body shape.
Lovell, 1997	I	54 AN, 35 BN 33 NC	Voc, Stroop-VM	There was no attentional bias in any group for words associated with eating. AN and BN patients showed bias for words associated with body shape.
Stewart, 1997	II	32 NC	Stroop-VM	Continuous eating restriction was associated with selective bias for eating-related words.
Jones, 1998	I	16 BN, 16 NC	Stroop-VM	Patients showed selective attention for words associated with eating, weight and body shape.
Hermans, 1998	I	12 AN, 12 NC	CR, WCT	Patients showed explicit memory bias for words related to eating, weight and body shape.
Rieger, 1998	I	16 AN, 17 BN, 32 NC	VPDT	Patients showed attentional bias for words related to weight and body shape.
Sackville, 1998	I	20 AN, 53 NC	Stroop-VM	It was observed selective bias for words associated with eating, weight and body shape among AN patients.
Carter, 2000	II	98 BN	Stroop-VM	Presence of attentional bias for words related to eating and body shape.
Fassino, 2002	I	20 AN, 20 NC	Stroop-VM	Patients showed attentional bias for words associated with body weight and shape.

Class I = group studies, controlled and randomized, or controlled but non-randomized; Class II = group studies without controls. Sample: AN = anorexia nervosa, BN = bulimia nervosa, NC = normal control, EDNOS = eating disorder non-otherwise specified. Tests used: CR = Cued Recall Test, Stroop-VM = Stroop Color Naming Test- modified version, ET= Encoding Task, FRT= Free Recall Test, Voc = Vocabulary (WAIS-R), VPDT =Visual Probe Detection Task, WCT = Word Completion test.

are able to act as mnemonic clues to recover and activate the information about weight, shape or food.

Summing up, patients with anorexia nervosa seem to show preservation of learning memory capability showing in general, however, a selective memory bias for words related to eating, body shape and weight.

3. Visual perception, visuo-spatial and visuo-constructive skills

Kinsbourne and Bemporad (*apud*[6]) suggested that AN patients may show right parietal lobe dysfunction, a finding potentially responsible for body image disturbance. Thompson and Spana[55] noted a correlation between visuo-spatial deficits and the decrease in the accurateness of estimation of body shape in normal individuals. Bradley et al.[6] and Casper et al.[8] noted a difficulty in processing visual information among AN patients. Kingston et al.[29] used the Block Design and the Picture Completion (WAIS-R) and found worse performance of AN

patients when compared to normal controls. Additionally, these authors performed a qualitative performance analysis and concluded that the worse performance was not due to motor slowness or attentional deficits. Gillberg et al.,[19] Jones et al.,[25] Mathias and Kent,[38] and Szmukler et al.[53] also found impairment in visuo-construction and visuo-spatial capabilities among AN patients. Fox[17] reported that AN patients have impaired performance in the Benton Visual Retention Test, as well as difficulty to perform complex drawings. However, the control group used in this study was heterogeneous, i.e., it consisted of patients with several psychiatric disorders, and also had not a homogeneous distribution of males and females. In turn, Gillberg et al.,[19] Hamsher et al.[22] and Szmukler et al.[53] assessed AN patients, comparing them with normal controls, and could not find any significant performance differences between the groups.

AN patients in general seem to show visuo-spatial and visuo-construction deficits, being still needed further studies for a better assessment of the correlation between these deficits and body image disturbance.

4. Executive functions

Jones et al.,[25] Fox,[17] Palazidou et al.,[43] and Szmukler et al.[53] noted deficits in the planning and problem-solving capabilities of AN patients. Fassino et al.[15] observed impaired abstraction capability and cognitive flexibility among patients with anorexia nervosa restrictive type, when compared to normal controls. Similarly, Lauer et al.[33] noted an impaired performance among AN patients in the Dual Task Design. However, as the reaction time is critical for this task, the impaired performance in this test could be attributed to the slowness typically associated with inanition. Green et al.,[20] Lauer et al.,[33] Mathias and Kent,[38] and Witt et al.[58] also noted an executive dysfunction among AN patients. However, Kingston et al.,[29] using the Stroop CW and the TMT, which assess cognitive flexibility, did not find significant differences between 46 hospitalized AN patients and 41 controls, although a higher number of AN patients showed impaired performance in these tests.

In general, therefore, some AN patients seem to show impairment in the executive functions. However, several of the abovementioned studies did not separate the restrictive from the purging subtypes, what could distort their results. This separation could facilitate the understanding of the different results detected.

5. Mathematic reasoning

Bradley et al.,[6] Gillberg et al.[19] and Mathias and Kent[38] compared AN patients to normal controls and could not identify significant differences between the groups regarding mathematic reasoning. Hamsher et al.[22] and Neumarker et al.[41] found deficits in this field. However, the tests used by these authors to assess the mathematic reasoning are extremely dependent on the attentional capability, which is decreased in these patients. In the study by Neumarker et al.,[41] weight recovery led to performance improvement in the tests used.

6. Verbal functions

Jones et al.[25] compared the performance of patients with current AN, recovered AN and normal controls. These authors reported that patients with current AN had worse performance when compared to the other groups. Fox[17] applied the Information (WAIS-R) in 15 AN patients and compared their performance with a group of patients with other psychiatric disorders. The AN group showed a significantly worse performance in this test. Bayless et al.,[2] Bradley et al.,[6] Gillberg et al.,[19] Hamsher et al.,[22] Mathias and Kent[38] and Witt et al.[58] did not detect deficits in verbal functions of AN patients.

7. Learning capability

Witt et al.[58] compared the performance of hospitalized AN patients, normal subjects, depressed and diabetic patients on the Symbol-Digit Paired-Associate Learning Test [which assesses associative learning skills (association between non-related visual stimuli)]. These authors noted that the group of AN patients showed a significant impairment in the leaning capability, which could not be assigned to depression or to clinical diseases, as anorexic patients showed a much worse performance than the other ill controls. However, Bradley et al.,[6] Hamsher et al.,[22] Kingston et al.,[29] Mathias and Kent,[38] and Szmukler et al.[53] did not observe learning deficits in AN patients. The results from these studies suggest that learning capability seems to be preserved among most anorexic patients.

Cognitive functions in bulimia nervosa

Cognitive functions in bulimia nervosa (BN) were much less studied than in AN. We may note that in BN the most frequently assessed functions were attention and executive functions. We will present below the main alterations observed in the cognitive functioning of BN patients.

1. Attention

1) Psychomotor speed

Ferraro et al.[16] compared the performance of BN patients and normal controls in the Symbol Digit Modalit Test (SDMT) and verified that BN patients showed significantly worse performance than normal controls. Jones et al.,[25] using the Digit Symbol (WAIS-R), also found similar results.

2) Sustained attention or vigilance

Laessle et al.,[30,31,32] using the CPT in BN patients noted their significantly worse performance compared to a normal control group. As a whole, these data suggested that BN patients could show vigilance deficits. However, Jones et al.,[25] also using the CPT, could not find statistically significant performance differences between 38 BN patients and 39 normal controls. Lauer et al.,[33] using the d2: Brickenkamp test also found a normal performance among fourteen BN patients.

3) Selective attention

Using the emotional Stroop task, for ED, Black et al.[5] did not observe an attentional bias for words associated with eating and body shape. Lovell et al.,[37] also using the Stroop test, compared 24 patients with current BN, 11 bulimic patients with symptom remission and 33 normal controls. These authors did not find significant differences between groups regarding the words associated with eating. However, BN patients still under

Table 2 – Main results of studies on the neuropsychologyof eating disorders

STUDY	CLASS	SAMPLE	TESTS	RESULTS
Fox, 1981	I	15 AN, 15 CODs	WAIS-R, WISC-R, WRAT MOMSSE, TMT, BRT	AN patients had worse performance in the tests which assessed verbal functions, attention, executive functions, visuo-construction, visuo-spatial capabilities and short-term memory.
Hamshe, 1981	I	20 AN	SHS, Inf, Comp, Arit, DS, BD, DSy, TR, SDLT, BRT, JOT, FRec, TTDC, COWAT, CO, VRT	Decrease in the number of deficits shown by patients after the treatment.
Small, 1983	I	27 AN	WAIS	The performance in the arithmetic and digit span test predicted weight gain after a treatment program.
Witt, 1985	I	16 AN, 16 DP, 16 DP, 16 NC	SDLT, VisR, DS, Inf, DSy, TMT	AN patients showed deficits in the learning capability not correlated to the degree of weight loss.
McKay, 1986	I	30 BN, 30 NC	LNNB	BN patients showed worse performance in tasks which assessed executive functions.
Toner, 1987	I	44 AN, 24 NC	MFFT	AN patients of the purging subtype showed more rapid and more imprecise responses than those of restrictive subtype.
Laessle, 1989	I	17 AN, 22 BN, 22 NC	CPT	AN and BN patients had significantly worse performance on the CPT.
Laessle, 1990	I	30 BN, 23 NC	CPT	Patients showed worse performance, suggesting vigilance deficits.
Palazidou, 1990	I	17 AN, 9 NC	BMCST, BMAPS	AN patients showed worse performance in tests which assess executive functions and visuo-perception.
Casper, 1991	II	8 AN	VOC, BD, FAS, CFT	Deficits in the processing of visual information.
Jones, 1991	I	50 AN, 38 BN 39 NC	CPT, TMT, LM, Dsy, BD, EFT, TLCT, ReyF, Sim, Comp, Voc, BSRT, BSMT	AN patients showed worse performance than other groups in tests which assess verbal functions, executive functions, short- and long-term memories, visuo-construction, visuo-perception, vigilance and psychomotor speed. BN patients had executive deficits.
Thompson, 1991	II	69 NC	DASRS, BRT	There was correlation between deficits in visuo-spatial capability and decrease in the accuracy to estimate body shape.
Laessle, 1992	I	8 BN, 9 AN, 22 NC	CPT	Patients showed worse performance than normal controls.
Szmukler, 1992	I	21 AN, 18 NC	TMT, DSy, LSy, BD, PS, AMT, VC, RAVLT, SDLT	AN patients showed deficits in attention, visuo-spatial processing and executive functions.
Kaye, 1995	II	9 AN, 7 BN	MFFT	BN patients showed significantly higher impulsivity than AN patients.
Gillberg, 1996	I	51 AN, 51 NC	WAIS-R	Patients showed significantly worse performance only in the object assembly subtest.
Green, 1996	I	12 AN, 17 NC	BVT, SRT, FAT, FTT, IFRT	It was noted worse performance of patients in the tests which assess immediate memory and psychomotor speed.
Kingston, 1996	I	46 AN, 41 NC	DSy, LSy, TMT, BD, Stroop, PC, Rey-F, T-Fig, SD, PM, AMT, MP, SDMT	AN patients had significantly worse performance in tasks which measured attention, visuo-spatial capability and immediate memory. After the treatment there was improvement only on attention.
Bradley, 1997	I	20 AN, 20 NC	PPVT, WISC-R, VST, VTD, CO, CRT, CPT, MRT, JOT, PCT, DLT, SDNMT, F'S, DSPALT, DVMS	Patients showed higher difficulty to process visual information.
Ferraro, 1997	I	23 BN, 28 NC	SDMT, WCST, AEFT	Patients showed deficits in the psychomotor speed, in the processing of information, in the problem-solving capability and difficulties in the control of impulses.

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Table 2 – Main results of studies on the neuropsychologyof eating disorders

STUDY	CLASS	SAMPLE	TESTS	RESULTS
				impaired.
Mathias, 1998	I	34 AN, 31 NC	WAIS-R, TMT, NART-R, WMS-R, ReyF, AMT, RAVLT, FAS, COWAT	AN patients showed worse performance in tests which assess immediate and delayed memory, verbal fluency, attention, visuo-construction and visuo-spatial capabilities.
Lauer, 1999	I	12 AN, 14 BN	D2, TMT, DTD, FPR, MVMT, CT, DS, LPST	Both groups showed difficulties in the tasks which assessed attention and executive functions. The speed of processing information and the problem-solving capability improved significantly in both groups after the treatment.
Neumarker, 2000	I	18 AN, 25 NC	CFT 20, Voc, NSB	Number-processing capability was worse among patients. After weight recovery there was significant improvement of performance.
Bayless, 2002	II	59 AN	WAIS-III, WL, BRT, COWAT, TMT, WRAT-3	Worse performance in tests which assess visual and verbal memories.
Fassino, 2002	I	20 AN, 20 NC	WCST	Patients showed decrease in the abstraction capability and cognitive flexibility
Lawrence, 2003	I	12 AN, 12 NC	NART-R, PRM, TAFC	Patients showed learning deficit of visual discrimination.
Moser, 2003	I	28 Na	RBANS, WRAT-3	The cognitive functioning of patients improved after the treatment, especially the memory and psychomotor speed.

Class I = group studies, controlled and randomized, or controlled but non-randomized; Class II = group studies without controls.

Sample: AN = anorexia nervosa, BN = bulimia nervosa, NC = normal controls, CODs = controls with psychiatric disorders, DeP = depressed patients, DP= diabetic patients
Tests used: AEFT =Affect/Eckman Faces Test, AMT = Austin Maze Test, Arit = Arithmetic of the Wechsler Adult Intelligence Scale – Revised (WAIS-R), BD = Block design (WAIS-R), BMAPS = Bexley Maudsley Automated Psychological Screening, BMCST = Bexley Maudsley Category Sorting Test, BRT = Benton Visual Retention Test, BSRT = Babock Story Recall Test, BSMT = Buschke Selective Reminding Test, BVT = Bakan Vigilance Task, CO= Coding (of the Wechsler Intelligence Scale For Children-Revised = WISC-R), Comp = Comprehension (WAIS-R), CDT= Computer-driven test of threat-associated processing, CFR = Chimeric Face Task, COWAT = Controlled Oral Word Association Test, CPT = Continuous Performance Test, CRT = Card Rotation Test, CT = Corsi Task, D2 = D2: Brickenkamp Letter Cancellation Task, DLPST = Daily-Living Problem Solving Task , DLT = Dichotic Listening Task, DS = Digit Span (WAIS-R), DSy = Digit Symbol (WAIS-R), DSPALT = Digit –Symbol Paired Associates Learning Task, DTD = Dual Task Design, DVMS = Denman Verbal Memory Scale, EFT = Embedded figures test, DASRS = Differential Aptitude Test-Space Relation Scale, FAS = Verbal Fluency , FAT = Focused Attention Task, FPR = Free Paragraph Recall, F'S = Coding F's Task, Frec = Facial Recognition Test, FTT = Finger Tapping Task, IFRT = Immediate Free Recall Task, Inf = Information (WAIS-R), JOT = Judgment Of Line Orientation Test, LM = Logical memory (W A IS-r) , LNNB = Luria-Nebraska Neuropsychological Battery, LSy = Letter Symbol of the Naylor Harwood Adult Intelligence Scale (NHAIS), MFFT= Matching Familiar Figure Test, MOMSSE = Mattis Organic Mental Syndrome Screening Examination, MP = Milner Pathway in Reverse, MRT= Mental Rotation task, MVMT = Munich Verbal Memory Test, NART-R = Revised National Adult Reading Test, NSB = Number Sequence Battery, NSDNMT = Nonverbal Scale of the Denman Neuropsychological Memory Test, PC = Picture Completion (WAIS-R), PCT = Perceptual Closure Test , PM = Prose Memory, PPVT = Peabody Picture Vocabulary Test-Revised, PRM = Pattern Recognition Memory, PS = Problem Solving (NHAIS), RAVLT = Rey Auditory Verbal Learning Test, RBANS = Repeatable Battery for the Assessment of Neuropsychological Status, ReyF = Rey Osterrieth Complex Figure, SD = Series of digits (Benton Battery) , SDMT = Symbol Digit Modality Test, SDLT = Serial Digit Learning Task, SHS = Shipley-Hartford Scale, Sim = Similarities (WAIS-R), SRT = Simple Reaction Time, Stroop = Stroop Color-Word Naming Test, TAFC = Two-Alternative Forced-Choice Visual discriminations, T-Fig = Taylor Complex Figure, TLCT = Talland Letter Cancellation Test-r, TMT = Trail Making Test, VC = Visuospatial Construction (NHAIS), VisR = Visual reproduction (WMS), Voc = Vocabulary (WAIS-R), VST = Visual Search Test, VTD =Visual Task requiring dot enumeration, WL=Word Lists (WMS -III), WRAT = Wide Range Achievement Test, WRAT-3 = Wide Range Achievement Test-3.

treatment were significantly slower to name words associated with body shape when compared to those already in remission and with the control group. However, Cooper and Fairburn,[12,12,13] Jones-Chesters et al.,[26] Perpina et al.[44] and Rieger et al.[45] identified impaired performance among patients for words associated with weight, body shape and eating. Summing up, patients with BN seem to show an attentional bias for words associated with body weight and shape and deficits in the speed of information processing.

2. Memory

Jones et al.[25] and Lauer et al.[33] assessed the short- and long-term memories of BN patients and compared them to normal controls. In these studies, the authors did not note significant differences between groups. Besides, it was observed that working memory was preserved in these patients.

3. Executive functions

BN patients show more impulsive behavior and a higher frequency of suicide and self-aggressive behavior than AN patients.[56] These differences in the capability of controlling impulses may be mediated by deficits in executive functions. Impaired performance in the Symbol Digit Modalit Test (SDMT), described above, may favor additional evidence for this hypothesis, as the performance in this subtest depends on an adequate inhibition of impulses. Jones et al.,[25] Lauer et al.[33] and McKay et al.[39] noted a significantly impaired performance among BN patients in tasks which assess executive functions.

Steiger et al.[51] raised the hypothesis that the difficulties to control impulses might contribute, somehow, for the genesis of binge eating episodes. Being aware of the urge of having binge eating episodes, the subject would tend to be more vigilant regarding eating, aiming to keep the rising impulse to eat under

control. However, if the definition of an impulsive subject encompasses the failure to have appropriate response inhibition, he/she would have difficulties to contain the eating impulse and would have a binge episode.[51] Therefore, the capability of controlling the impulses would have a moderating effect over the food intake.[25] Kaye et al.[27] compared BN and AN patients and noted higher impulsivity among BN patients. Toner et al.[54] compared restrictive and purging AN patients and noted that patients with the purging type had a more impulsive cognitive style and with significantly faster and less precise responses than patients with the restrictive type. This finding corroborates the existence of a link between executive functions deficits and the occurrence of binge eating episodes or purging episodes.

In contrast to these findings, Laessle et al.[30] did not find evidence of higher impulsivity among BN patients. On the contrary, they were more cautious before answering to the subitems of the test. However, BN patients with history of anorexia were more cautious than those without this history. This is consistent with the idea that a stricter and more controlled cognitive style, typical of anorexia, could persist among BN patients.

4. Verbal functions

Jones et al.[25] compared the performance of 38 BN patients to 39 normal controls in the Similarities, Comprehension and Vocabulary test (WAIS-R) and did not find significant differences between groups.

Cognitive functions in binge eating disorder

We have not found studies using neuropsychological tests to assess the cognitive functions of patients with binge eating disorder. This absence of information may be possibly attributed to the fact that BED is a diagnostic category which was recen-tly incorporated to the DSM-IV.

Effect of the treatment on the cognitive functions

Lauer et al.[33] assessed the neuropsychological profile of AN and BN patients four weeks before the beginning of a therapeutical program and after 7 months of treatment. They noted that the speed of processing information and the problem-solving capability improved significantly and jointly in both groups. The improvement in the cognitive deficits occurred parallelly to the improvement in the symptomatology of ED. Moser et al.[40] also observed an improvement in the speed of information processing and in the memory of AN patients, after a successful treatment of the eating disorder. Regarding attention, Carter et al.[7] and Cooper and Fairburn[13] observed a decrease in the attentional bias for words related to eating, body shape and weight in BN patients after a treatment program.

Szmukler et al.[53] noted that before the treatment 13 AN patients had one cognitive deficit in at least one area, whereas 6 patients had two or more cognitive deficits. The neuropsychological reassessment of these patients just after body weight recovery showed that only 7 patients maintained at least one deficit, while 5 had two or more. However, it is worth noting that, although the improvement was deemed significant, patients still had more deficits when compared to a control group (none of the controls had two or more deficits). As in the previous study, the weight was not totally reestablished among all patients, being possible that they continued to improve, had the nutritional recovery been more complete. Analyzing more in detail the response of cognitive deficits to the treatment of their underlying factors, Kingston et al.[29] verified that after the treatment AN patients improved in relation to controls only in the tasks which assessed attention. However, these patients still showed psychomotor slowness, visuo-spatial deficits and difficulties with the immediate memory. As in the previous study, not all patients showed an ideal minimum weight at the end of the treatment (mean body mass index at the end of the treatment = 17.9). Green et al.[20] also observed that although AN patients increased their weight after treatment and reported a decrease in their depressive and anxiety symptoms, there was no corresponding improvement in the immediate memory and in the motor speed. However, in this study the reassessment occurred within a twelve-week period, not being discarded a further cognitive improvement.

Even assessing patients with full weight recovery, some cognitive alterations seem to persist. Hamsher et al.[22] assessed 20 AN patients and noted that before the treatment 11 of them (55%) had one cognitive deficit and the remaining ones (45%) showed two or more deficits. They noted that, although there was a general decrease in deficits after treatment, 35% of the patients still had some cognitive deficit in at least two measures. Lovell et al.[37] assessed the performance of 23 AN and 11 BN patients, who had been in remission for two years and verified that AN patients still had a significant attentional bias.

Discussion

The assessment of studies about the neuropsychology of eating disorders shows still incipient results. As far as we know this is the first systematic review about the neuropsychology of ED. AN is the ED with the greatest number of neuropsychological studies and, in general, the results point to attentional, visuo-spatial and visuo-constructive deficits. The neuropsychology of BN was less explored, although the studies found suggest that some cognitive alterations may be present. The most found alterations in BN are deficits in selective attention and executive functions. Up to now, there are no neuropsychological studies about binge eating disorder.

In order to better understand the cognitive alterations observed in these patients some considerations should be made. Subjects with normal weight being submitted to a restrictive diet may show a decrease in the capability of sustained attention, as well as difficulties in short-term memory, suggesting that the simple deprivation of food may be associated with deficits in the cognitive function.[21] Possibly, at least partially, the deficits found in AN patients may be associated with food restriction and with the biological alterations consequent to accentuated weight loss. Although BN patients have normal weight, they show binge eating episodes followed by induced vomiting, abusive use of laxatives and periods of eating restriction, and, consequently, may show several organic and systemic alterations. Bayless et al.,[2] Jones et al.,[25] Kingston et al.,[29] Laessle et al.,[30] and Szmukler et al.[53] observed a significant

correlation between low weight in AN (or metabolic signs of hunger in BN) and worse performance in tasks which assessed cognitive flexibility, vigilance and memory. Other characteristic that should be mentioned is that the biological adaptation to hunger is associated with alterations in the neurotransmission systems of the CNS. Therefore, these alterations may be involved in the general reduction of the capability of cognitive processing in ED. However, several studies[15,38,40,58] have not found a relationship between weight loss and cognitive performance. Besides, although several studies have detected an improvement of cognitive deficits after different treatment programs,[22,29,33,40,53] they demonstrate the maintenance of deficits in several patients (35% in the study by Hamsher et al.;[22] 20% in the study by Kingston et al.;[29] 23% in that of Lauer et al.[33] and 28% in Szmuckler et al.'s[53]). These data suggest that, while part of the deficits found on ED may correspond to a 'state', others may correspond to a 'trait' related to the specific pathophysiology of the disorders.

Hamsher et al.[22] observed that AN patients with higher number of cognitive deficits, when compared to those without these deficits, would have a worse prognosis. Of the patients with the highest number of cognitive deficits assessed by this author, 71% showed unfavorable results one year after the end of treatment, defined as non-maintenance of weight gain. Contrastingly, 85% of patients without cognitive deficits or with only one deficit at the end of the treatment succeeded to maintain or increase their weight. Therefore, cognitive performance in the battery of tests applied at the end of treatment was significantly associated with the maintenance of the results obtained, what means that patients who have deficits may be a subgroup with worse prognosis, perhaps due to a CNS-related disorder, which could limit their recovery capability.

Lastly, some authors[22] point to the fact that some AN patients had suggestive evidence of perinatal neurological lesion. This pre-morbid brain dysfunction may contribute for a more severe variant of AN, with worse prognosis.[22] There is also the possibility of a time limit of duration of weight loss, beyond which the normalization of the brain function would be more difficult, or also that a longer period of normal eating and weight maintenance would be required to improve the cognitive functioning.

The analysis of cognitive functions among ED patients is hampered by the lack of uniformity between the studies found. The studies about the neuropsychology of eating disorders use different classification systems of ED, some of them using the DSM-III-R, others the DSM-IV and other ones the criteria described by Russell[46] for BN, what hampers the comparison of results. Besides, the classification system of cognitive functions differs in the several studies analyzed, as well as the tests to assess a determined function. For example, some studies which used the digit symbol, conceptualize it as being a test which assesses psychomotor speed, whereas others used it to assess attention, without defining the concept of 'attention'. The methodology used also differed in the several studies. In the assessment of improvement in the cognitive performance after a treatment program, varied treatment periods and different intervals between the first assessment and reassessment were used. The values of body mass index considered as sufficient to characterize recovery were also different. Besides, several methodological problems were found in some studies, such as the utilization of non-validated tests, very small number of patients, inadequate control group, non-assessment of pre-existent brain lesion and of comorbidities which could have impact in the cognitive functioning. Other aspect that should be highlighted is the lack of comparison between AN and BN subtypes, what could help to prove the validity of the current classification. Lastly, most of the published studies used cases referred to specialized clinics and it is scarcely clear if these findings may be generalized for samples of the general population.

The best outlying of the cognitive profile of ED patients is important to guide more specific therapeutical approaches. For example, conventional BN treatments encourage relaxation of the eating control and this strategy seems to provide good results for many patients. However, highly-impulsive BN patients seem to have worse results.[28] This last subgroup probably shows poorer responses to interventions focused on approaches associated with dietary restriction as these treatments address a dimension which is only peripheral for the maintenance of binge eating episodes in these subjects. Maybe in these cases we should concentrate in the deficient control of inhibitory impulses). The treatment of this subgroup of patients might require an increase in the capabilities of anticipating and inhibiting binge eating episodes (rather than relaxation of the dietary restriction), i.e., specialized interventions which manage primarily the capabilities of controlling impulses and improving self-regulation. On the other hand, the results of the modified version of the Stroop Test previously described may indicate a higher relevance to deal with cognitive schemas. The presence of attention deficits may demand, at least initially, that psychotherapeutical intervention should be oriented to behavioral techniques and simplified instructions.

The deficits found in the several studies analyzed may be secondary to other comorbid pathologies or show neurological sequelae stemming from long inanition periods. It would be therefore interesting to separate patients in groups and verify, among those who have deficits, what is the result obtained with treatment and perform a more comprehensive assessment of the previous history, trying to assess possible causes of lesion not associated with ED.

Conclusion

ED seem to be associated with some degree of neuropsychological dysfunction, although the specific functions which are impaired are not consistent between studies, maybe due to methodological variations. AN patients seem to show attentional, visuo-spatial and visuo-constructive deficits. BN patients seem to show mainly executive function deficits. The fact that after the treatment some patients show improvement in the cognitive functioning may indicate that, in some cases, the deficits are functional. The absence of improvement in the cognitive functioning of some patients after several forms of intervention may suggest that these deficits precede the development of ED, and may thus contribute for their development or for a worse prognosis. A subgroup of patients may also show pre-morbid brain dysfunction and this may be one of the factors

that indicate worse prognosis.

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Sponsor: None
Received 19.03.2004
Accepted 03.05.2004

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