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REVIEW

Neuropsychology of eating disorders: 1995–2012

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Abstract: Eating disorders are considered psychiatric pathologies that are characterized by pathological worry related to body shape and weight. The lack of progress in treatment development, at least in part, reflects the fact that little is known about the pathophysiologic mechanisms that account for the development and persistence of eating disorders. The possibility that patients with eating disorders have a dysfunction of the central nervous system has been previously explored; several studies assessing the relationship between cognitive processing and certain eating behaviors have been conducted. These studies aim to achieve a better understanding of the pathophysiology of such diseases. The aim of this study was to review the current state of neuropsychological studies focused on eating disorders. This was done by means of a search process covering three relevant electronic databases, as well as an additional search on references included in the analyzed papers; we also mention other published reviews obtained by handsearching.

Keywords: eating disorders, anorexia nervosa, bulimia nervosa, binge-eating disorder, neuropsychology, cognitive performance

Introduction

Neuropsychology studies the structure and function of the brain as far as they are related to specific psychological processes and behaviors. It is considered a clinical and experimental field of psychology, the aim of which is to study, assess, understand, and treat behaviors directly related to brain function.[1] Neuropsychology uses psychological, neurological, cognitive, behavioral, and physiological principles, techniques, and tests in order to evaluate patients' neurocognitive, behavioral, and emotional strengths and weaknesses without ignoring their relationship to normal and abnormal central nervous system functioning.[2]

Eating disorders (ED) are serious psychiatric pathologies. They are characterized by a pathological concern with body shape and weight above all. The lack of progress in treatment development, at least in part, reflects the fact that little is known about the pathophysiologic mechanisms that account for the development and persistence of ED. In contrast to the slow progress in understanding ED, basic knowledge of the neural basis of behavior has advanced rapidly in recent years, and this knowledge has begun to yield a better understanding of other serious mental illnesses.[3] The possibility that there is a dysfunction of the central nervous system in patients with ED has been explored in several ways, including studies of neuropsychological test performance. Thus, the study assessing the relationship between cognitive processing and certain eating behaviors has been conducted, aiming to achieve a better understanding of the pathophysiology of ED.[4]

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The specific pathophysiology of ED is unknown, and it is likely that different factors are involved.[4] To date, ED have been described on the basis of overt clinical phenotypes, a method that is perhaps not effective for exploring the specific etiology of these disorders.[5] In order to identify causal factors, new ways of studying the diseases seem to be necessary.[6] Some authors have suggested potential new focuses, including the study of endophenotypes and disease-associated traits, that are more useful in determining the relationship between underlying genes and neuropsychological functions.[5,7] Some researchers (eg, Cavedini et al)[8] state that neuropsychology has yet to produce an explanatory model of ED. Nevertheless, neuropsychological explorations are being used to improve the diagnosis, to obtain better ED data, and to develop more effective therapeutic strategies.[9]

The aim of this study was to review the current state of the neuropsychological studies focused on ED.

Materials and methods

Search process

The search process covered three relevant electronic databases (MEDLINE, EMBASE, and PsycINFO). The general strategy included terms related to ED and neuropsychology. Next, the Medical Subjects Headings were used as well as the Boolean operators AND/OR. The shared MeSH terms were ((("Anorexia nervosa"[MeSH]) OR ("Bulimia nervosa"[MeSH]) OR ("Binge eating disorder"[MeSH])) AND (("Neuropsychology"[MeSH]) OR ("Memory"[MeSH]) OR ("Learning"[MeSH]) OR ("Attention"[MeSH]) OR ("Perception"[MeSH]) OR ("Cognition"[MeSH]) OR ("Executive function"[MeSH]) OR ("Vigilance"[MeSH]) OR ("Concept formation"[MeSH]) OR ("Neuropsychological tests"[MeSH]) OR ("Neuropsychological tasks"[MeSH]))).

Additional searches were carried out on the references included in the papers, published reviews, and via hand searching. Literature search was limited to articles published between 1995 and 2012.

Studies meeting the following criteria were included in the review: (1) studies focused on ED (anorexia nervosa [AN], bulimia nervosa [BN], and binge-eating disorder [BED]) and neuropsychology; and (2) controlled trials and randomized controlled trials. Applied exclusion criteria included: (1) descriptive studies or case reports and cross-sectional studies; (2) interventions targeting populations with unspecified eating disorders (other than binge eating disorder); (3) participants with severe comorbidities; and (4) unavailable full text. Reviews and meta-analyses that fit the inclusion criteria were considered as other sources of articles.

The initial search yielded 129 references. These were combined in an EndNote 9 (Thomson Reuters, Carlsbad, CA, USA) library and screened on the basis of title and abstract; those clearly not meeting the review criteria were excluded as were duplicates. Thereafter, selected references were screened based on the full text. Reasons for exclusion were applied and 57 studies were finally included.

Selected studies are summarized in ascending order of publication year as well as with respect to the main diagnostic implied (Tables 1 and 2). Data extracted included journal reference, number of participants and age at enrollment, sex, tests, follow-up duration (when appropriate), and main outcome measurements related to the neuropsychology of ED.

Procedure

Taking into account previous recommendations,[10] the content of the selected studies was analyzed considering the following functions: attention, memory and learning, visual perception/visuospatial ability, executive functions, and other functions. In addition, the analysis was based on each diagnostic as follows: AN and/or BN and/or BED.

Results

AN

Attention

Considering sustained attention (attention maintained over time), Green et al did not find differences between AN patients and nonclinical participants with respect to attentional focus and the ability to maintain attention. They did so by means of a focused attention task as a measure of the Eriksen effect.[11] With regard to selective attention (intentional, focused attention), the Stroop Test, in its modified version (Emotional Stroop), and a word-recognition test did not enable the authors to confirm specific cognitive deficits in AN patients.[12] Following this emotional Stroop paradigm, significant main effects of group (patients versus controls) and condition (xxxx [words made of xxxxs] neutral, fat, thin), and a significant interaction between group and condition have been reported. Patients with AN seem to have attentional bias to "fat" and "thin" words.[13] With a modified color-naming Stroop task, AN patients, but not unrestrained or restrained eaters, have shown delayed color-naming latencies for both thin and fat word categories and, to a lesser extent, for high-caloric-density food words.[14] With a similar attentional paradigm (eye tracking to examine attentive processes during free visual exploration of

Table 1 Main studies on neuropsychology of anorexia nervosa

Authors	Journal	Sample	Mean age and sex	Tests	Follow-up	Results
Kaye et al[54]	*Int J Eat Disord*	9 AN, 7 BN	22 AN, 19 BN Females	MMFT		AN patients took a greater amount of time to respond after the sample stimulus item was presented. In contrast, the BN patients responded more quickly after the sample item was presented. AN were less impulsive than BN patients.
Gillberg et al[33]	*Compr Psychiatry*	51 AN, 51 C	21 NR	WAIS-R	4.9 years	AN group scored lower than C on the object assembly subtest.
Green et al[11]	*J Psychiat Res*	12 AN, 17 C	26 AN, 21 C Females	BVT, SRT, FAT, TFTT, IFRT	12 weeks	AN group recalled fewer words, displayed poorer reaction times and motor speed than C group. Despite having gained weight there was no corresponding improvement in cognitive performance.
Kingston et al[27]	*Psychol Med*	46 AN, 41 C	22.1 AN, 22 C Females	DS, LS, TMT, BD, Stroop, PC, Rey, TCF, SD, PM, AMT, MP, SDMT	Until weight gain of at least 10%	AN group had a worse performance on attention, visuospatial capacity and immediate memory. Only attention improved with treatment.
Sebastian et al[30]	*Cogn Ther Res*	10 ED 30 WPG 30 C	22.73 21.23 20.36 Females	VS, FRMT		A memory bias for fatness words was found in ED patients. The three groups did not differ in the recall of non-fat or neutral words.
Bradley et al[28]	*J Clin Exp Neuropsychol*	20 AN, 20 C (12 AN retested after weight gain)	15.7 Females	WISC-R LAT CFT, DSPALT, DVMS, CPT	Mean 8.5 months	The two groups did not differ on any of the tests used. AN patients who recovered performed significantly better than C on the Card Rotations Test and Coding F's.
Cooper et al[86]	*Br J Clin Psychol*	12 AN, 12 BN, 18 C	Age NR Females	Stroop		Both patient groups showed attentional bias for eating- and weight-related words. Only AN patients showed attentional bias for body shape-related words.
Hermans et al[29]	*J Abnorm Psychol*	12 AN, 12 C	21.08 AN 24.67 C Sex ratio (M/F), 1/11	CR, WCT		Strong explicit memory bias for anorexia-related words in AN but not in C. There was no evidence for a similar bias in implicit memory.
Mathias et al[20]	*J Clin Exp Neuropsychol*	34 AN (26 inpatients, 8 outpatients) 31 C	22 AN, 20.08 C Females	WAIS-R, NART-R, WMS-R, RAVLT, Rey, AMT, COWA, TMT		AN patients were deficient in their ability to recall meaningful prose and visuospatial information.
Rieger et al[16]	*Int J Eat Disord*	16 AN, 17 BN, 32 C	20.9 AN. 23.9 BN, 20.3 C Females	VPDT		ED patients detected target probes more slowly than C when they appeared in the same location as stimulus words connoting a thin physique. The contrary (faster detection) occurs with words connoting a large physique.
Sackville et al[14]	*Int J Eat Disord*	20 AN, 53 C (LDR-HDR)	19.07 Females	Stroop		AN patients, but not unrestrained or restrained eaters, had delayed color-naming latencies for both thin and fat word categories and, to a lesser extent, for high caloric density food words.

(*Continued*)

Table 1 (*Continued*)

Authors	Journal	Sample	Mean age and sex	Tests	Follow-up	Results
Lauer et al[18]	*J Psychiatr Res*	12 AN, 14 BN	19.7 AN, 21.9 BN Females	LCT (d2), TMT, DTD, FPR, MVMT, RSPMT, DLPST	7 months	Initial testing: AN and BN showed similar impaired performance on attention and problem solving abilities. Their mnemonic functions were preserved. Both improved after treatment.
Grunwald et al[52]	*Int J Eat Disord*	10 AN, 10 C	15.9 AN, 16.14 C Females	HET	Mean 14.5 months	AN patients showed poorer performance than control individuals.
Neumärker et al[50]	*Eur Child Adoles Psy*	18 AN, 25 C	14.5 AN, 15.8 C NR	CFT20, VOC, NS	103.83 days	Initial testing: number-processing performance was lower in patients. With the treatment the prevalence of patients with a subnormal performance was similar to the normal population.
Mendlewicz et al[12]	*Neuropsychobiology*	16 AN, 16 C	17.8 AN, 18.7 C Females	Stroop		Authors did not find specific cognitive deficits in AN.
Bayless et al[51]	*Ann Clin Psychiatry*	59 AN	24.3 Females	WAIS-III, WL I-II, BVRT, COWA, TMT, WRAT-3		Mild cognitive impairments in several tasks. No conclusions about the reversibility with weight gain.
Fassino et al[35]	*Int J Eat Disord*	20 AN-R 20 C	23.8 23.1 Females	Stroop WCST		AN-R patients showed nonspecific attentional biases with a decrease in abstraction capacity and cognitive flexibility similar to those patients with OCD.
Murphy et al[32]	*J Clin Exp Neuropsychol*	16 AN, 16 BN, 16 C	22.3 AN, 22 BN, 25.3 C Females	MWT-B, WIP, BSRT, COWA, AHQ, Rey, SDMT, TMT, CAL		In the conditional-associative learning task, AN patients displayed an impaired performance with neutral material but not with individually threatening material. Such a deficit was not evident in BN or in C.
Seed et al[19]	*Int J Neuropsychoph*	20 AN, 20 C	29.12 AN, 29.31 C Females	Tailored version of CDR		AN patients showed selective impairments on attention, long-term memory and working memory.
Moser et al[25]	*Int J Eat Disord*	28 AN	26.43 Females	RBANS	32.79 days	Although standard scores were improved in the immediate memory, visuospatial/constructional, language, and attention domain standard scores, only the immediate memory domain improvement was statistically significant.
Pieters et al[22]	*J Psychiatr Res*	32 AN 32 C	18 AN, 17.7 C Females	Drawing and copying tasks		AN patients were significantly faster in a drawing task and showed shorter reaction times in copying tasks. Movement times did not differ significantly between the two groups. In the most complex copying task, a significant group × complexity interaction for reaction time (patients shorter) and re-inspection time (patients longer) was found. Patients also made more errors than controls.
Cavedini et al[8]	*Psychiatry Res*	59 AN (26 AN-R, 33 AN-P), 82 C	21.7 AN, 23.4 C Females (96%–97%)	GT, WST, OAT, WCST		AN patients showed deficits on decision-making. While AN-R patients showed an inability to produce an advantageous long-term strategy in the GT, the AN-P patients did not follow either a clearly advantageous or a clear disadvantageous behavioral strategy.
Tchanturia et al[36,78]	*J Int Neuropsychol Soc*	34 AN, 19 BN, 35 C	26.7 AN, 26.5 BN, 24.8 C NR	NART-R, TMT, BT, PST, VFT, CBT HIT		Anorectic patients show impairments on simple alternation and perceptual shift and bulimic patients show difficulties in mental flexibility and perceptual shift.

Pieters et al[23]	*J Clin Exp Neuropsychol*	17 AN, 17 C	17.75 AN, 17.61 C Females	Drawing and copying tasks	2–5 months	AN patients showed shorter reaction times in copying tasks and shorter drawing time in the drawing task than normal controls, and this pattern persisted after weight restoration.
Steinglass et al[3,37]	*J Int Neuropsychol Soc*	15 AN, 11 C	25.6 AN, 24 C Females	WASI, CVLT, Stroop, TMT, COWA, WCST		Patients made more perseverative errors on the WCST, indicating a problem in set shifting.
Tchanturia et al[47]	*J Int Neuropsychol Soc*	29 AN, 14 R-AN, 29 C	28.5 AN, 28.9 R-AN, 26.3 C Females	IGT, NART		AN patients performed poorly in the IGT compared to the C and to the recovered AN participants.
Tokley et al[40]	*J Clin Exp Neuropsychol*	24 AN, 24 C	21.79 AN, 22.04 C Females	Object assembly, GEFT, TMT, SWT		Women with AN showed a significant deficit in abstract thinking performance, which could not be explained by a more general intellectual deficit or diminished information processing speed. The AN sample also showed a greater preoccupation with detail relative to the control group.
Chui et al[53]	*Pediatrics*	66 AN, 42 C	21.3 AN, 20.7 C Females	SBWJ, HVLT-R, VRS (WMS-R)	Mean 6.4 years	AN subjects showed impairments in verbal abilities, cognitive efficiency, reading, mathematics and long-term verbal memory.
Redgrave et al[13]	*Brain Imaging*	6 AN, 6 C	18–45 Females	Stroop task		AN patients showed attentional bias to blocks of fat and thin words.
Southgate et al[38]	*Psyquiatr Res*	20 AN, 14 BN, 26 C	26.80 AN, 25.71 BN, 27.27 C Females	MFFT		AN patients scored significantly higher on the efficiency dimension score than the control group.
Brogan et al[49]	*J Int Neuropsychol Soc*	22 AN, 17 B, 18 Ob, 20 C	29.09 AN, 29.94 BN, 52.11 Ob, 27.75 C Females	IGT		The three clinical groups were significantly impaired on the IGT compared with the C group on both overall task performance and task learning; however, the three clinical groups were not significantly different from each other.
Guillaume et al[45]	*Neuropsychology*	49 AN, 38 BN, 83 C	23.3 AN, 23 BN, 28 C Females	NART, IGT		No significant differences in IGT performance were observed between patients and healthy controls, or between restrictive and purging types of anorexia nervosa.
Hatch et al[92]	*Int J Eat Disord*	37 AN, 45 C	15.16 AN, NR for C	IntegNeuro cognitive battery	89 days	Cognitive impairments appear to normalize with refeeding and weight gain.
Abbate-Daga et al[39]	*BMC Psychiatry*	30 AN (restrictive), 30 C	24.13 AN, 24.67 C NR	TMT, WCST, HSCT, IGT		AN patients showed mental rigidity in both verbal and nonverbal domains.
Giel et al[15]	*Biol Psychiatry*	19 AN, 38 C	24.4 AN, 24.3 C Females	Eye-tracking, food/non-food pictures		AN patients allocated overall less attention to food pictures but showed no early attentional bias toward food pictures. Attentional engagement for food pictures was most pronounced in fasted healthy control subjects.
Sarrar et al[21]	*Psychoneuroendocrinology*	30 AN, 28 C	16.2 AN, 16.7 C Females	p-ORT, TMT, DST, CFT-20-R	2.8 months	Subtle deficits in cognitive flexibility were found in AN patients compared to C. After weight gain, the AN group improved relative to their baseline values in most of the variables but did not reach C values. They still showed slight impairments.

(*Continued*)

Table 1 (*Continued*)

Authors	Journal	Sample	Mean age and sex	Tests	Follow-up	Results
Shott et al[31]	*Neuropsychology*	21 AN, 19 C	25.2 AN, 27.3 C	Implicit category learning task (Gabor patches)		AN patients were less accurate on implicit category learning relative to C. Even when AN patients used the appropriate (ie, implicit) strategy they were still impaired relative to C who also used the same strategy.
Cardi et al[59]	*World J Biol Psychiatry*	29 AN, 17 BN, 13 R-AN, 9 R-BN, 50 C	27.3 ED, 29.5 ED-R, 25.3 C Females	Dot probe task with faces		Patients with a lifetime diagnosis of ED showed an attentional bias to reject faces and a difficulty disengaging attention from these stimuli.

Abbreviations: AN, anorexia nervosa; AHQ, Annett handedness questionnaire; AMT, Austin Maze test; BD, block design; BN, bulimia nervosa; BSRT, Buschke's selective reminding test; BT, Brixton test; BVRT, Benton visual retention test (revised); BVT, Bakan vigilance task; C, control; CAL, conditional associative learning; CBT, cat bat task; CDR, cognitive drug research; CFT, coding F's task; CFT20, culture fall intelligence test 20; CFT-20-R, culture fall intelligence test-20 (revised); COWA, controlled oral word association test; CPT, continuous performance test; CR, cued recall; CVLT, California verbal learning test; DLPST, daily living problem solving task; DS, digit symbol; DSPALT, digit symbol paired associates learning task; DST, digit symbol test; DTD, dual task design; DVMS, Denman verbal memory scale; ED, eating disorders; F, females; FAT, focused attention task; FPR, free paragraph recall; FRMT, free recall memory test; GEFT, group embedded figures test; GT, gambling task; HDR, high in dietary restraint; HET, haptic illusion task; HIT, haptic illusion task; HSCT, Hayling sentence completion task; HVLT-R, Hopkins verbal learning test (revised); IFRT, immediate free recall task; IGT, Iowa gambling test; LAT, lateral asymmetry tests; LCT (d2), letter cancellation task (d2); LDR, low in dietary restraint; LS, letter symbol; M, males; MMFT, matching familiar figure test; MP, Milner pathway in reverse; MVMT, Munich verbal memory test; MWT-B, verbal intelligence; NART, National adult reading test ; NART-R, National adult reading test (revised); NS, number sequence; OAT, object alternation test; PC, picture completion; PM, prose memory; p-ORT, cognitive flexibility computer based test; PST, picture set test; RAVLT, Rey auditory verbal learning test; RBANS, repeatable battery for the assessment of neuropsychological status; RSPMT, Raven standard progressive matrices T; SBWJ, standard battery of the Woodcock-Johnson III; SD, symbol digit; SDMT, symbol digit modality test; SRT, simple reaction time; SWT, spot the word test; TCF, Taylor complex figure; TFTT, two-finger tapping task; TMT, trail making test; VFT, verbal fluency task; VOC, vocabulary battery; VPDT, visual probe detection task; VRS (WMS-R), visual reproduction subscale of the Wechsler Memory Scale (revised); VS, verbal stimuli; WAIS-III, Wechsler adult intelligence scale III; WAIS-R, Wechsler adult intelligence scale (revised); WASI, Wechsler abbreviate scale of intelligence; WCT, word completion test; WCST, Wisconsin card sorting test; WIP, reduced version of the WAIS, German translation; WISC-R, Wechsler intelligence scale for children (revised); WL I-II, word lists I and II of the Wechsler memory scale III; WMS-R, Wechsler memory scale (revised); WPG, weight-preoccupied group; WRAT-3, Wide range achievement test 3; WST, Weigl's sorting test.

food pictures versus non-food pictures), it has been shown that AN patients have more attentional disengagement to food pictures compared with control subjects. Attentional disengagement was positively related to the severity of the disorder (eg, lower body mass index [BMI]). Apart from the selective attention captured by "emotional pictures," this study reports that individuals with AN show no early vigilance (sustained attention) but do show later avoidance when confronted with food information.[15] Words reflecting either a thin or a large physique and positively or negatively valenced emotion words have been used in a visual detection task with ED patients. Both AN and BN patients directed their attention away from stimulus words connoting a thin physique. In contrast, there was a trend to direct their attention towards stimulus words connoting a large physique. Comparing AN and BN, results reflected a tendency for AN patients to direct their attention toward positive emotion words while those with BN tended to direct their attention away from these words.[16] The "divided attention" has been tested by means of the dual task design (Zimmermann and Fimm)[17] in a 7-month follow-up study. Regarding the attentional demands, the level of performance increased, but it must be noted that only divided attention was impaired at the beginning of this study.[18]

In other tasks, predominantly measuring "different facets of attention" (eg, Trail Making Test and letter cancellation test), the level of performance improved as a function of time during treatment.[18] Despite these functions not being impaired at the beginning of the study, other authors have reported that patients are significantly impaired on a number of performance measures related to attentional processes, simple reaction time, choice reaction time, derived "thinking" time, and digit vigilance.[19] In line with Lauer et al,[18] others did not find any significant differences in the attentional or mental tracking capacities (Trail Making Test, revised Wechsler Memory Scale [attention/concentration index], and digit symbol) between AN patients and control participants.[20] Moreover, other authors did not find any significant differences between AN patients and control participants using a digit symbol test either at baseline or follow-up.[21]

With respect to "psychomotor speed," Pieters et al reported that anorectic patients were significantly faster in a drawing task and showed shorter reaction times in copying tasks. In the most complex copying task, patients showed shorter reaction time and longer reinspection time with respect to control participants. In addition, patients committed more errors than control participants.[22] In order to explore the effect of weight restoration, Pieters et al studied

Table 2 Main studies on the neuropsychology of bulimia nervosa and binge-eating disorder

Authors	Journal	Sample	Mean age and sex	Tests	Follow-up	Results
Kaye et al[54]	*Int J Eat Disord*	9 AN, 7 BN	22 AN, 19 BN Females	MFFT		AN patients took a greater amount of time to respond after the sample stimulus item was presented. In contrast, the BN patients responded more quickly after the sample item was presented. AN were less impulsive than BN patients.
Black et al[61]	*Int J Eat Disord*	16 BN, 29 C (RE and non-RE)	23.8 BN (10 retested), 21.25 C Females	Stroop	2 weeks	The data failed to show any specificity in the Stroop effect. Nor did the test provide a useful measure of treatment response.
Cooper et al[86]	*Br J Clin Psychol*	12 AN, 12 BN, 18 C	Age NR Females	Color naming Stroop		Both patient groups showed attentional bias for eating and weight related words. Only AN patients showed attentional bias for body shape-related words.
Ferraro et al[55]	*J Clin Psychol*	23 BN, 28 C	18–41, NR	SDMT, FR, WCST, Eckman faces		Measures reflected marked impulsivity and problem-solving deficits in BN.
Lovell et al[62]	*Br J Clin Psychol*	31 AN, 24 BN, 23 R-AN, 11 R-BN, 33 C	25.48 AN, 26.92 BN, 29.30 R-AN, 34.36 R-BN, 24.72 C Females	Color naming Stroop test		Women currently suffering from bulimia, and those who had recovered from anorexia were found to be more distracted by shape concerns than women who had never suffered eating disorders and women who had recovered from bulimia.
Jones-Chesters et al[63]	*Int J Eat Disord*	32 BN, 16 C	25.25 BN, 26.55 C Females	"Emotional" Stroop task	Retesting after 6–8 days	In a mixed condition (mixture of word types in each block), patients took longer to color-name food/eating and weight/shape words than control words. With blocked presentation (with words from just one set in each block) this effect was magnified; and patients with bulimia nervosa also showed increased naming-latency for "emotion" words.
Rieger et al[16]	*Int J Eat Disord*	16 AN, 17 BN, 32 C	20.9 AN, 23.9 BN, 20.3 C Females	VPDT		ED patients detected target probes more slowly than C when they appeared in the same location as stimulus words connoting a thin physique. The contrary (faster detection) occurs with words connoting a large physique.
Lauer et al[18]	*J Psychiatr Res*	12 AN, 14 BN	19.7 AN, 21.9 BN Females	LCT (d2), TMT, DTD, FPR, MVMT, RSPM, DLPST	7 months	Initial testing, AN and BN showed similar impaired performance on attention and problem solving abilities. Their mnemonic functions were preserved. Both improved after treatment.
Steiger et al[67]	*Int J Eat Disord*	51 BN	27.35 Females	DAPP-BQ	Recording 8–22 days	Urge to binge was higher (on average) prior to eating binges than at comparable times on binge free days, and thus seemed to signal the potential for binge eating.
Carter et al[64]	*Int J Eat Disord*	98 BN	17–45 Females	Color naming Stroop test	6 weeks	Patients processed information more quickly following treatment and that, overall, patients processed food/body words more slowly than control words, but processed color words even more slowly.
Esplen et al[66]	*Int J Eat Disord*	50 BN	26.6 48 females	SRS, A/E MS, BPI-IRS		A lower level of soothing receptivity (indicating a decreased capacity for self-soothing) was correlated with a decreased capacity for evocative memory. A lower level of soothing receptivity and decreased capacity for evocative memory were associated with a greater experience of aloneness.

(*Continued*)

Table 2 (*Continued*)

Authors	Journal	Sample	Mean age and sex	Tests	Follow-up	Results
Murphy et al[32]	*J Clin Exp Neuropsychol*	16 AN, 16 BN, 16 C	22.3 AN, 22 BN, 25.3 C Females	MWT-B, WIP, BSRT, COWA, AHQ, Rey, SDMT, TMT, CAL		In the conditional-associative learning task, AN patients displayed an impaired performance with neutral material but not with individually threatening material. Such a deficit was not evident in BN or in C.
Tchanturia et al[36,78]	*J Int Neuropsychol Soc*	34 AN, 19 BN, 35 C	26.7 AN, 26.5 BN, 24.8 C NR	NART-R, TMT, BT, PST, VFT, CBT, HIT		Anorectic patients show impairments on simple alternation and perceptual shift and bulimic patients show difficulties in mental flexibility and perceptual shift.
Brand et al[68]	*Neuropsychology*	15 BN, 15 C	21.86 BN, 21.64 Females	GDT and NTB		On the GDT, patients with BN chose the disadvantageous alternatives more frequently than did C subjects. Performance on the GDT was related to executive functioning but not to other neuropsychological functions, personality, or disease-specific variables in the BN group.
Mobbs et al[57]	*Eat Behav*	18 BN, 18 C	25.11 BN, 24.28 C Females	Go/no go affective shifting task		BN patients reacted faster than C in the task. BN patients showed poorer discrimination ability than C and inhibition problems (especially with targets related to food).
Southgate et al[38]	*Psyciatr Res*	20 AN, 14 BN, 26 C	26.80 AN, 25.71 BN, 27.27 C Females	MFFT		AN patients scored significantly higher on the efficiency dimension score than the control group.
Liao et al[69]	*J Clin Exp Neuropsychol*	29 AN, 26 BN, 51 C	28.5 AN, 27.8 BN, 29.4 C Females	IGT		BN patients performed poorly.
Davis et al[77]	*Appetite*	65 obese patients with BED, 73 obese patients without BED, 71 C	34.3 BED, 35.2 non-BED, 31.8 C Females	IGT, DDT		BED and obese patients performed worse than C, but did not differ from each other.
Guillaume et al[45]	*Neuropsychology*	49 AN, 38 BN, 83 C	23.3 AN, 23 BN, 28 C Females	NART, IGT		No significant differences in IGT performance were observed between patients and healthy controls, or between restrictive and purging types of anorexia nervosa.
Kemps et al[56]	*J Clin Exp Neuropsychol*	13 BN, 13 C	22.17 BN, 20.76 C Females	Stroop, HSCT, MFFT, BIS-11		BN patients displayed significant impairments on all inhibition measures and posited significantly higher impulsivity scores than the controls.
Legenbauer et al[65]	*J Clin Psychol*	25 BN, 27 C	23.88 BN, 24.74 C Females	Recall and recognition rates of body related, food related and neutral TV commercials		Poorer recognition and recall of body related stimuli was found for BN in comparison to C, suggesting a memory bias.
Brogan et al[49]	*J Int Neuropsychol Soc*	22 AN, 17 B, 18 Ob, 20 C	29.09 AN, 29.94 BN, 52.11 Ob, 27.75 C Females	IGT		The three clinical groups were significantly impaired on the IGT compared with the C group on both overall task performance and task learning; however, the three clinical groups were not significantly different from each other.
Mobbs et al[76]	*Appetite*	16 obese patients with BED, 16, obese patients without BED, 16 C	45.1, 39.3 and 40.2 respectively 34 females	Mental flexibility task		Obese patients made more errors and more omissions than controls in both food and body sections of the task. Obese patients with BED made significantly more errors and omissions than those without BED.

Cardi et al[59]	*World J Biol Psychiatry*	29 AN, 17 BN, 13 R-AN, 9 R-BN, 50 C	27.3 ED, 29.5 ED-R, 25.3 C Females	Dot probe task with faces (rejection or acceptance)	Patients with a lifetime diagnosis of ED showed an attentional bias to reject faces and a difficulty disengaging attention from these stimuli.
Van den Eynde et al[58]	*J Clin Exp Neuropsychol*	40 BN, 30 EDNOS-BN, 65 C	28.3 BN, 27.5 EDNOS-BN, 24 C	LCT (d2), Stroop and go/no go task, GDT	People with BN and EDNOS-BN performed as well as C on all tasks. Attention task performance was poorer in the EDNOS-BN than in the BN group.

Abbreviations: A/E MS, aloneness/evocative memory scale; AHQ, Annett handedness questionnaire; AN, anorexia nervosa; BED, ; BIS-11, Barratt impulsiveness scale version 11; BN, bulimia nervosa; BPI-IRS, BPI, basic personality inventory; BSRT, Buschke's selective reminding test; BT, Brixton test; C, control; CAL, conditional associative learning; CBT, cat bat task; COWA, controlled oral association test; DDT, delay discounting task; ED, eating disorders; ED-R, eating disorders recovered; EDNOS, eating disorders not otherwise specified; DAPP-BQ, dimensional assessment of personality pathology basic questionnaire; DLPST, daily living problem solving test; DTD, dual task design; FPR, free paragraph recall; FR, free recall; GDT, game of dice task; HIT, haptic illusion task; HSCT, Haylings sentence completion test; IGT, Iowa gambling task; LCT (d2), letter cancellation task (d2); MFFT, matching familiar figures test; MVMT, Munich verbal memory test; MWT-B, verbal intelligence; NART, National adult reading test; NART-R, National adult reading test (revised); NTB, neuropsychological test battery; PST, picture set test; RSPM, Raven standard progressive matrices test; SDMT, symbol digits modalities test; SRS, soothing receptivity scale; TMT, trail making test; VFT, verbal fluency task; VPDT, visual probe detection task; WCST, Wisconsin card sorting test; WIP, reduced version of the Wechsler adult intelligence scale.

the performance of AN patients in drawing and copying tasks. Again, AN patients showed shorter reaction times in copying tasks and shorter drawing time in the drawing task compared to normal controls. This pattern persisted after weight gain.[23] This persistence has also been reported in motor tasks after weight recovery of AN patients.[24] Considering the effect of an inpatient treatment program for anorexia nervosa, the neuropsychological functioning improves during treatment with significant changes in psychomotor speed.[25]

In summary, it seems that AN patients have attentional bias to "fat" and "thin" words as well as more attentional disengagement to food pictures. Patients with AN seem to be faster in drawing tasks and tend to show shorter reaction times in copying tasks. Comparing AN and BN, patients with AN tend to direct their attention towards positive emotion words while those with BN tend to direct their attention away from these words. We can conclude that AN patients show more relevant attention deficits in functions such as vigilance and selective attention.

Memory and learning

First of all, it must be noted that different authors study different types of memory with respect to ED. Thus, implicit and explicit memory, short- and long-term memory, and different aspects like learning, recall, recognition of different materials, etc, are usually mentioned.

In this regard, Mathias and Kent explored memory and learning by means of the revised Wechsler Memory Scale, Rey Auditory Verbal Learning Test, Austin Maze, and the Rey-Osterrieth Complex Figure Test. As a result, they found that patients with AN differed from control participants in their performance on the immediate and delayed trials of the logical memory subtests. Patients demonstrated a much poorer ability to recall verbal passages.[20] In a recent analysis of the neuropsychological profile of patients with AN, a relative weakness in visuospatial memory has been reported.[26] Green et al assessed the cognitive performance of AN patients including an immediate free recall task; patients recalled fewer words than nonclinical controls.[11] In addition, Kingston et al reported that anorectic patients had worse performance than controls in different functions including memory.[27] With respect to "long-term memory" or continuing storage of information (analyzing immediate word recall/delayed word recall, word recognition, and picture recognition), patients with AN produced a greater number of errors (words not present in the learnt list) and they showed lower sensitivity index in word and picture recognition. There were no differences in reaction times. In the same study,

working memory (temporary storage and manipulation of the information necessary for different tasks) was explored by means of memory scanning and spatial working memory. In this case, patients had significantly longer reaction times.[19] Working memory has been assessed by Lauer et al by means of material presented verbally (analyzing the backward memory span for digits) and material presented visually (analyzing the backward span). In this regard, AN patients showed normal performance.[18] The work of Green et al showed no differences in the Bakan vigilance task when comparing AN patients and control subjects. The Bakan vigilance task has a high loading on the central executive component of the working memory model.[11]

Considering "explicit memory," two different tasks (verbal and nonverbal) were used in a study by Bradley et al. In addition, different tests of memory were applied. While differences between AN patients and controls were observed with respect to verbal and nonverbal tasks (event related potentials (ERP) waveform amplitudes and latencies), there were no differences on neuropsychological measures, including memory tests.[28] Both "implicit" (word-completion test) and "explicit" (cued recall test) memory for shape-, weight-, and food-related words, have been analyzed in patients with AN. Results showed a strong explicit memory bias for anorexia-related words for patients with AN but not for nondieting controls. There was no evidence of a similar bias in implicit memory.[29] The explicit memory for fatness words has also been studied and a memory bias for these words was found among anorectic patients.[30] Short-term verbal memory (capacity to hold a small amount of information in mind in an available state for a short period of time) has been explored by carrying out a free paragraph recall task and the California Verbal Learning Test in a study by Lauer et al; patients with AN showed normal performance in these tasks.[18]

Another recent study analyzed implicit category learning. Patients with AN were less accurate when dealing with a task in which they and control participants were asked to categorize simple perceptual stimuli into one of two categories. Results showed that, even when patients used the appropriate (ie, implicit) strategy, they were impaired relative to controls when using the same strategy.[31] Comparing BN patients and control subjects, AN patients have shown an impairment performance with neutral material but not with individually threatening material in a conditional associative learning task.[32]

The main conclusions about this function may be summarized with the following results: AN patients show a poorer ability to recall verbal passages and they tend to recall fewer words and commit a greater number of errors with longer reaction times. In addition, patients with AN show a strong explicit memory bias for anorexia related words. While AN patients maintain a normal learning memory capability, they show selective memory biases.

Visual perception and visuospatial ability

In the above mentioned study by Bradley et al, AN patients showed longer latencies for nonverbal (visual) tasks relative to verbal tasks, thus noting a theoretical difficulty in processing visual information.[28] In another study, AN patients showed a worse performance on tasks measuring visuospatial ability (block design and picture completion).[27] Gillberg et al have reported a worse performance of AN patients on the object assembly subtest of the Wechsler Abbreviated Scale Of Intelligence (revised) in contrast with a better result in the block design subtest.[33] Mathias et al assessed visuospatial ability using the Rey-Osterrieth complex figure test and the block design and object assembly subtests of the Wechsler Abbreviated Scale Of Intelligence (revised). There were no differences between AN patients and control participants.[20]

In summary, compared to other functions, there is a shortage of studies on this area, some results suggesting visuospatial deficits in patients with ED.

Executive functions

In a recent study, executive functions were explored using the Ravello Profile in a sample of patients with AN. Patients were within the average range on the assessment of executive functioning except for one measure of set shifting.[26] This Ravello Profile has been suggested as a tool to define a common shared neuropsychological assessment battery.[34] Difficulties in abstraction and flexibility of thought have been reported in AN patients when compared with control participants.[35] Lauer et al found that AN patients showed mild to moderate deficits, particularly on those tasks covering attentional demands and problem-solving abilities, which improved after several months of treatment.[18] Considering cognitive flexibility, a different pattern has been reported for AN and BN patients: patients with AN show impairments on simple alternation and perceptual shift and BN patients show difficulties in mental flexibility and perceptual shift.[36] Difficulties of AN patients with set-shifting tasks have also been reported in other studies.[37] Other authors have suggested that AN patients perform better on local information processing tasks than on global processing tasks[38] and that they show a cognitive rigidity in both verbal and nonverbal domains.[39]

In the same line of thinking, women with AN have shown a significant deficit in abstract thinking performance, which could not be explained by a more general intellectual deficit or diminished information processing speed. Patients with AN have also shown a greater preoccupation with detail relative to control participants.[40] This obsession for details has also been reported by other authors.[41] These deficits in set shifting abilities have been considered independent of starvation in adults.[42] With respect to the set shifting difficulties as traits linked to possible endophenotypes,[43] recently, the set shifting impairment in AN has been reported to be probably unrelated to polymorphisms of *SNAP-25* gene.[44] In addition, the set shifting deficits have not been demonstrated in adolescent patients with AN.[42] In contrast, Kingston et al did not find differences between AN patients and controls by means of cognitive flexibility tasks.[27]

Another explored function is decision making (the capacity to make decisions about a course of action). In this regard, Guillaume et al used the Iowa Gambling Task to analyze this function; they did not find significant differences between patients and controls.[45] By means of the same task, a lower decision-making capacity has been reported in both AN and BN patients.[8,46] In addition, it must be noted that the scores on the Iowa Gambling Task seemed not to improve over time in AN patients.[47] Using the same task, it has been reported that, compared to control women, AN patients and recovered AN patients showed poor set shifting and decision-making skills.[48] Including obese patients, a similar impairment on the Iowa Gambling Task in AN and BN patients as well as in obese participants has been found.[49]

Difficulties in abstraction and flexibility of thought along with an obsession for details are considered the main findings in AN patients. With respect to decision making, a lower decision-making capacity has been reported in both AN and BN patients.

Other functions

With respect to mathematic reasoning, Neumarker et al found that, initially, number processing performance was significantly lower in AN patients compared to controls.[50] However, when the patients restored their normal body weight, the prevalence of patients with a subnormal arithmetic performance was analogous to that in the normal population.

Different studies have failed to report significant differences between patients and controls considering verbal functions.[20,28,33,51]

Bradley et al did not find learning deficits in digit–symbol paired associate learning.[28] Despite having observed a worse performance on attention, visuospatial ability, and memory, Kingston et al did not find learning deficits.[27] In a study by Mathias et al, patients with AN were found to be deficient in the ability to recall meaningful prose and visuospatial information but not in other functions of learning.[20]

Haptic explorations have been developed in AN patients with poorer performance than control individuals. In addition, reproduction quality was unchanged after weight gain and independent of BMI and intelligence. Mean exploration time was similar in AN patients and controls.[52]

From a global perspective, impairments in verbal abilities, cognitive efficiency, reading, mathematics, and long term verbal memory have been reported among AN patients even years after diagnosis and with normal BMI.[53]

BN

Neurocognition in BN is clearly under-researched compared to AN, and the most relevant focus has been the comparison between AN and BN patients with respect to impulsivity.[54,55] In addition, the reported poor inhibitory control in BN patients has been at least partly attributed to an impulsive disposition.[56] Patients with BN tend to react faster than controls in tasks like go/no go affective shifting. They also have poorer discrimination ability than controls and show inhibition problems, particularly when the targets are related to food.[57]

Attention

A recent study has focused on attention by means of a d2-letter cancellation task, among other functions. As a result, authors found out that patients with BN performed as well as healthy controls on the tasks. Attention task performance was poorer in eating disorders not otherwise specified, bulimic type, than in bulimic patients.[58]

With a visual probe detection procedure, Rieger et al found a tendency for AN patients to direct their attention towards positive emotion words while those with BN tended to direct their attention away from these words.[16]

The major finding of Lauer et al was that patients with AN and BN did not differ with respect to their neuropsychological task profiles;[18] both showed mild to moderate deficits, particularly in tasks covering attentional demands and problem-solving abilities.

Cardi et al[59] have reported that AN and BN patients show an attentional bias to rejecting faces and a difficulty disengaging attention from these stimuli. In addition, they have sustained attentional avoidance of accepting faces. In order to analyze the possible continuum of AN to BN to obesity, compared to

obese patients, AN patients (restrictive type) seem to be more attentive to angry faces and have difficulties in being attentive to positive expressions, while obese patients have shown problems in looking for or being attentive to negative expressions.[60]

Patients with BN have shown worse performance in a symbol digit modalities test; despite being faster than controls, they made more errors.[55]

Other authors have not found differences between BN patients and control participants by way of a modified Stroop test.[61] Similarly, Lovell et al used an emotional Stroop task and determined that women currently suffering from BN and women who had recovered from AN were found to be more distracted by shape concerns than women who had never suffered ED and women who had recovered from BN.[62] By means of food/eating, weight/shape, emotion, and neutral words in a Stroop task, Jones-Chesters et al reported that BN patients showed increased naming latency for emotion words.[63]

In order to explore the effects of treatment, Carter et al studied a group of BN patients by means of a Stroop color naming task. Patients performed significantly faster on information processing tasks at posttreatment than at pretreatment and significantly slower on food/body words than on control words. In addition, patients performed significantly slower on color words than on food/body words.[64]

In summary, patients with BN seem to show some attentional biases for weight- and shape-related words as well as an increased naming latency for emotion words.

Memory

Legenbauer et al[65] studied a group of BN patients who were exposed to body-related and neutral TV commercials then assessed recall and recognition rates. Poorer recognition and recall of body-related stimuli was found for BN patients compared to controls, suggesting a memory bias. Esplen et al[66] studied the evocative memory in BN by way of the Aloneness/Evocative Memory Scale. A lower level of soothing receptivity (indicating a decreased capacity for self-soothing) was correlated with a decreased capacity for evocative memory. A lower level of soothing receptivity and decreased capacity for evocative memory were associated with a greater experience of aloneness.

Short-term verbal memory has been assessed by way of a free paragraph recall task and the California Verbal Learning Test in a group of ED patients. After 16 weeks of therapy plus 8 weeks of outpatient status, the number of items recalled decreased in AN patients and increased in patients with BN.[18]

To summarize, poorer recognition and recall of body-related stimuli have been found, suggesting possible memory biases in ED patients.

Executive functions

The study by Lauer et al reported that AN as well as BN patients showed mild to moderate deficits on tasks relating to problem-solving abilities.[18]

Taking into account impulsivity, Steiger et al found that binge eating is closely linked to dietary control in most BN individuals, but this may be less typical of individuals showing marked impulsivity.[67]

Brand et al[68] explored the decision-making deficits in BN patients by means of the Game Of Dice Task. Patients chose the disadvantageous alternatives more frequently than did control subjects. Performance on the Game Of Dice Task was related to executive functioning but not to other neuropsychological functions, personality, or disease-specific variables in the BN group. The authors stated that, in BN patients, decision-making abnormalities and executive reductions could be demonstrated and might be neuropsychological correlates of the patients' dysfunctional everyday life decision-making behavior.[68] In the same line, Guillaume et al studied decision making by way of the Iowa Gambling Task including AN and BN patients as well as controls.[45] These authors concluded that there was not reduced decision making in ED patients. Nevertheless, other authors have found that BN patients performed poorly in this task.[69]

The main results in this area suggest possible decision-making abnormalities and executive reductions in BN patients.

BED

There are several studies based on samples comprising chocolate cravers,[70] fasting and non-fasting normal individuals,[71] overweight/obese females,[72,73] or subjects with different eating disorders.[74,75] In these studies, different paradigms have been used, such as Stroop tasks, visual dot probe task, the visual search paradigm, or eye movement monitoring. Nevertheless, there is a shortage of studies specifically focused on BED.

Considering the keys to control unwanted behaviors and thoughts (attention, inhibitory control, mental flexibility), Mobbs et al[76] compared obese persons with and without BED by means of a food/body mental flexibility task. All patients made more errors and omissions than controls did. Obese patients with BED made more errors and omissions than those without BED. Another study, using the Iowa Gambling Task

and a delay discounting measure, reported that obese and BED patients had worse performance on both tasks compared to control participants, but did not differ from each other.[77]

Discussion

Neuropsychological assessment of ED is being used in order to diagnose better and to conceptualize and design therapeutic plans. It is clear that the main efforts have been expended in AN. Another evident fact is that methodological limitations are more a rule than an exception in the literature regarding this field of study. Is there neuropsychological impairment in ED? Maybe or maybe not. Different types of ED, different populations, different tests, different follow-up periods, different severities, and so on, are hindrances to establishing an accurate answer to that question.

Perhaps the most important question is if the neuropsychological findings reported in ED are reversible with appropriate treatment (ie, are deficits an expression of traits or a mere consequence that emerged during the course of the disorder?). In a study by Green et al,[11] AN patients completed different neuropsychological tasks (on three occasions) over the course of 12 weeks of inpatient treatment. Following treatment, patients did not improve their cognitive performance. On the third occasion the mean BMI was 16.53, which represents undernutrition.[11] Sarrar et al[21] studied the cognitive functions of AN patients before and after weight gain. The mean BMI at the final testing session was 17.4. Lauer et al[18] included BN and AN patients in a study assessing their neuropsychological states before, during, and after a treatment. As a result, in the last testing session (7 months after the beginning of the treatment), the impaired cognitive functions improved similarly in AN and BN patients. The main finding of this study was the absence of association between cognitive and clinical rectifications, which led the authors to suggest the existence of mediating factors (eg, hormonal or metabolic). In this case, the weight status was expressed as a percentage of ideal body weight and changed from 70.1% to 86.8% and from 99.6% to 95.8% in AN and BN patients, respectively. Recently, Pieters et al[23] reported the persistence of some altered patterns after weight restoration (change of BMI from 14.56 to 18.90) in AN inpatients after an average stay of 131 days. Another study[25] showed that neuropsychological functioning improved over the course of treatment, but this improvement was not associated with a change in BMI (from 16.58 to 19.28 after a mean of 32.79 days). In other cases, the neuropsychological assessment was made a period of time after admission in the hospital (eg, 24.6 days in another study by Pieters et al).[22] The study by Carter et al[64] with BN patients reported that patients performed significantly faster on information processing tasks posttreatment than pretreatment and significantly slower on food/body words than on control words. However, patients performed significantly slower on color words than on food/body words. Kingston et al[27] reported that, following treatment, AN patients improved relative to the control group only on tasks assessing attention. In addition, lower weight, but not duration of illness, was associated with poorer performance on tasks assessing flexibility/inhibition and memory. Tchanturia et al[78] analyzed set shifting tasks in AN patients, and difficulties in these tasks did not show any improvement following retesting after weight recovery.

Besides a few studies that stated that cognitive deficits diminished after weight restoration,[79–82] others[11,27,78] have not observed such an improvement. What do neuropsychological deficits represent in ED? To date, this question remains unanswered. The only clear response is that there are severe methodological differences among studies. Are there state-related deficits and trait-related deficits?

The neuropsychological functions in ED have been accompanied by studies based on neuroimaging and neurophysiology in order to correlate structural and functional brain changes with neuropsychological findings.[83,84] Due to the enormous amount of variables (weight, duration of illness, medications, etc), it is difficult to demonstrate the correlation between brain changes and functional changes. In order to establish a cause and effect relationship, it would be necessary to develop longitudinal neuroimaging studies. Is there a time limit of duration of weight loss, beyond which normalization of brain function would be more difficult? Would a longer period of normal eating and weight maintenance be required to improve cognitive functioning?[4] In a recent study based on patients with early-onset AN, authors have suggested that neurobiological abnormalities at initial presentation predict neuropsychological status at follow-up, which might indicate a distinct neurodevelopmental subtype of early-onset AN.[85]

Different changes in AN patients are not specific. For example, Cooper and Todd have found no differences between AN and BN patients.[86] In addition, healthy individuals under a restrictive diet may suffer difficulties in sustained attention and short-term memory.[87] To some extent, it may be that some deficits observed in AN depend on food deprivation (with the corresponding biological consequences). The case of BN seems to be different, with respect to normal weight and overweight individuals. Binge episodes and purging behaviors would cause biological

alterations, which, consequently, would alter performance on neuropsychological tasks.[4]

What is the clinical relevance of such a vast number of studies? Although the results give us some new practical knowledge, these types of studies remain substantially theoretical. Is it necessary to implement new forms of treatment to specifically focus on the neuropsychological impairment of these patients? The authors of one study have observed that patients with more cognitive deficits have a worse prognosis.[79]

Former studies on the neuropsychology of ED highlighted the reversibility of neuropsychological impairments.[18,27] Recent studies try to direct the attention to the neuropsychological impairments as predisposing factors and/or specific eating-disorder-related findings. An example of these efforts to search for ED endophenotypes are the several articles by Lopez et al regarding the concept of central coherence.[88–90] Nevertheless, potential confounding factors, comorbid pathologies, use of different medications, etc, make it difficult to form definitive conclusions.[45] It seems that a jump is being made from the "consequences of malnutrition" to "predisposing factors to suffer ED". It must be noted that the unanimous consensus is that there are no gross neuropsychological deficits in AN.[9] In addition, despite the persistence of impairments after weight recovery stated by some authors,[11,27,78] another study has reported that the cognitive performance of AN patients can show improvement even after a period of 2 years following patient discharge.[91] In a recent study focused on the first admission of adolescent patients with AN, cognitive impairments appear to normalize with refeeding and weight gain.[92]

In summary, the problem with the classification system of ED, the values of BMI considered in different studies, different sample sizes, the absence of ecological paradigms (eg, how neuropsychological deficits affect daily functioning), the possibility of previous neurological lesions (eg, perinatal), the subgroups of ED, duration of illness variability, and comorbid pathologies are some variables to consider before conclusions can be made. In addition, the classification systems of cognitive functions differ considerably among the different studies. As a result, the tests and tasks to assess the same function also differ among studies.

Conclusion

Different neuropsychological alterations have been described in ED, particularly in AN. Nevertheless, there are many inconsistencies among studies, mainly due to methodological biases. It remains unclear if some findings are related to traits or if they are a mere consequence of the core pathology (eg, malnutrition). To date, the clinical and therapeutic relevance of the neuropsychological findings in ED remains unclear. The main change in this field of study may be the view of neuropsychological impairments as predisposing factors of ED rather than a mere consequence of it. Some specific functions such as cognitive flexibility, problem solving, impulsiveness, etc, need to be related to the modern neuroimaging studies on ED in order to clarify the weight of the disposition and the consequences of each type of ED.

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