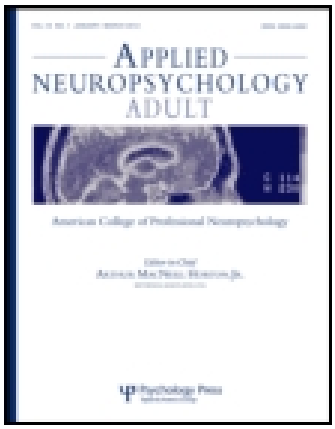

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Neuropsychological Impairments in Anorexia Nervosa: A Spanish Sample Pilot Study

Javier Oltra-Cucarella [a], Raul Espert [a], Luís Rojo [b], Carlos Jacas [c], Verónica Guillén [d] & Sergio Moreno [a]

[a] Unit of Neuropsychology, Hospital Clínico Universitario, Valencia, Spain

[b] Unit of Infant/Juvenile Psychiatry and Eating Disorders, Hospital Universitari y Politècnic La Fe, Valencia, Spain

[c] Unit of Neuropsychology, Department of Psychiatry, Hospital Universitario Vall d'Hebrón, Barcelona, Spain

[d] Faculty of Psychology, University of Valencia, and Unit of Eating Disorders, PREVI Center of Psychology, Valencia, Spain

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Javier Oltra-Cucarella and Raul Espert
Unit of Neuropsychology, Hospital Clínico Universitario, Valencia, Spain

Luís Rojo
Unit of Infant/Juvenile Psychiatry and Eating Disorders, Hospital Universitari y Politècnic La Fe, Valencia, Spain

Carlos Jacas
Unit of Neuropsychology, Department of Psychiatry, Hospital Universitario Vall d'Hebrón, Barcelona, Spain

Verónica Guillén
Faculty of Psychology, University of Valencia, and Unit of Eating Disorders, PREVI Center of Psychology, Valencia, Spain

Sergio Moreno
Unit of Neuropsychology, Hospital Clínico Universitario, Valencia, Spain

This work was aimed at obtaining a profile of neuropsychological impairments in young Spanish participants with anorexia nervosa (AN) to demonstrate that right-hemisphere and frontal capacity impairments are present not only in the acute phase but also after weight recovery in a Spanish sample compared with a healthy control group. Twelve patients with AN in the acute phase (body mass index [BMI] < 17) were compared both to 16 healthy control subjects and 12 weight-recovered AN participants (BMI ≥ 17) matched by age, IQ, and educational level by utilizing a wide neuropsychological battery. Differences were found between AN groups only for long-term verbal memory, which worsens as BMI increases. Among participants with AN as a group, results showed differences in speed of information processing, working memory, visual memory, and inhibition, unrelated to attentional capabilities. We cannot support the hypothesis of a specific right cerebral dysfunction in patients with AN. A general cognitive dysfunction, primarily in information processing, working memory, visual and verbal memory, as well as frontal impairments such as impulsivity and poor behavioral control, appeared unrelated to BMI. We support previous works affirming that neuropsychological impairments in AN are not a consequence of the illness but a risk factor for it to develop.

Key words: *adolescent, cognitive, health promotion*

Address correspondence to Javier Oltra-Cucarella, Unit of Neuropsychology, Hospital Clínico Universitario, Avda. Blasca Ibáñez, 10, Valencia, Spain. E-mail: javi.oltra@cop.es

INTRODUCTION

In the last few years, there has been considerable research about cognitive impairments in anorexia nervosa (AN; Fowler et al., 2006; Gillberg, Rastam, Wentz, & Gillberg, 2007; Green, Wakeling, Elliman, & Rogers, 1998; Guillaume et al., 2010; Kingston, Szmukler, Andrewes, Tress, & Desmond, 1996; Lauer, Gorzewski, Gerlinghoff, Backmund, & Zihl, 1999; Mikos et al., 2008; Seed, McCue, Wesnes, Dahabra, & Young, 2002; Tchanturia et al., 2004). Nonetheless, little is known about neuropsychological impairments in Spanish AN samples. Previous works with Spanish populations have focused on measures of cerebral volume (Oltra-Cucarella, Espert Tortajada, & Rojo Moreno, 2012) or they have not explained in detail their methodology (Andres et al., 2008) and have included only patients with AN versus healthy control subjects. Several theories have attempted to explain neuropsychological impairments found in patients with AN. Early research concerned with brain morphology and functioning tended to focus on the parietal cerebral areas and the *visuoconstructive* capabilities but later shifted to the frontal cerebral areas (dorsolateral prefrontal cortex, ventromedial prefrontal cortex) and associated *executive functioning*. Likewise, earlier works also attempted to link improvements of symptomatology after weight gain with the body mass index (BMI). Despite the findings reported by some authors, who affirmed that neuropsychological functions improved after weight recovery, relationship between BMI, weight, and cognitive impairments is not entirely clear yet (see Oltra-Cucarella et al., 2012, for a review).

Brain Structure

With regards to functional and morphological changes in the brains of females with AN, some studies have affirmed that the hypoactivity found in the right parietal cortex of these patients (Delvenne, Goldman, Biver, et al., 1997; Delvenne, Goldman, De Maertelaer, & Lotstra, 1999; Delvenne, Goldman, De Maertelaer, et al., 1997; Delvenne et al., 1995; Nozoe et al., 1993, 1995) and the hypoactivity found in the anterior cingulated cortex (Kojima et al., 2005; Naruo et al., 2001) reverted after weight gain (Delvenne et al., 1996; Miller et al., 2004), while others found the opposite results (Kojima et al., 2005; Van Kuyk et al., 2009). The cerebral areas most commonly associated with impaired functioning in patients with AN are the parietal cortex, ventromedial prefrontal cortex, gyrus lingualis within the occipital cortex, medial prefrontal cortex, cerebellum, nucleus caudatus, and insula (Grunwald et al., 2001; Sachdev, Mondraty, Wen, & Gulliford, 2008). Mainz, Schulte-Rüther, Fink, Herpertz-Dahlmann, and Konrad (2012) found that grey-matter reductions at admission in patients with AN improved after weight recovery, with the strongest association found in the cerebellum. Frampton, Watkins, Gordon, and Lask (2011) found that regional cerebral blood flow levels did not return to normal in seven out of nine patients up to 4 years after diagnosis. Lateral and third ventricles enlargement has also been associated with starvation and malnutrition observed in AN. N. H. Golden et al. (1995) found significant total ventricular volume enlargement in females with AN compared with control subjects, with third ventricle enlargement being greater than that found in lateral ventricles and both reverting after BMI increased. Chui et al. (2008) found third ventricle and right lateral ventricle enlargement in low-weight subjects with AN after weight recovery with no differences compared with healthy participants. Kingston et al. (1996) found lateral ventricle enlargement at admission with significant reduction after weight gain and that reached values similar to those of healthy controls.

Cognitive Functioning

Although early investigations have hypothesized that cognitive impairments in AN could be secondary to right parietal damage (Kinsbourne & Bemporad, 1984), this theory was later replaced with one focusing on cognitive abilities located in the frontal cerebral areas such as the orbitofrontal cortex, ventromedial cortex, anterior cingulated cortex, and dorsolateral prefrontal cortex (Cavedini et al., 2004; Laessle, Krieg, Fichter, & Pirke, 1989; Pendleton-Jones, Duncan, Brouwers, & Mirsky, 1991; Szmukler, Andrewes, Kingston, Chen, & Stargatt, 1992). Thus, after Halmi et al. (2003) suggested a common pathway might be involved both in AN and obsessive compulsive disorder (OCD), investigations attempted to focus on the frontal impairment profiles by studying cognitive capabilities located in the frontal and prefrontal cerebral areas. Several investigations demonstrated impairments in attentional capabilities (Kingston et al., 1996; Lauer et al., 1999; Seed et al., 2002), mental flexibility (Steinglass, Walsh, & Stern, 2006; Tchanturia et al., 2004), speed of information processing (SIP; Fowler et al., 2006; Gillberg et al., 2007; Kingston et al., 1996; Lauer et al., 1999), working memory (Kemps, Tiggemann, Wade, Ben-Tovim, & Breyer, 2006), and decision making (Cavedini et al., 2004; Tchanturia et al., 2007), while others failed to replicate these findings (Cavedini et al., 2004; Gillberg et al., 2007; Kemps et al., 2006; Kingston et al., 1996; Steinglass et al., 2006; Tchanturia et al., 2007). Nonetheless, an agreement appears to exist about the severity of impairments, given that all of the authors have reported that these impairments are subtle when compared with healthy control subjects.

To date, no consensus has been reached about the improvement of symptomatology after weight gain and BMI increase, so it remains unclear whether these impairments may, once identified, be interpreted as a consequence of starvation or if they were present prior to the disease onset and can be considered a risk factor for developing AN. Kingston et al. (1996) found that impairments in planning—measured by means of the Rey Complex Figure Test—which were evident during the acute phase of the illness, improved after weight gain, but this was not the case in immediate memory and visuospatial capacities. Others such as Bayless et al. (2002), Cavedini et al. (2004), Chui et al. (2008), Fowler et al. (2006) or Mikos et al. (2008) did not find any relationship between BMI and cognitive impairments. In 2001, Grunwald et al. found impairments on somatosensory capabilities attributed to right parietal dysfunction, which did not revert after weight gain. Others reported very modest correlations between BMI increases and neuropsychological improvement (Green et al., 1998; Pendleton-Jones et al., 1991; Sheppard & Vernon, 2008), and others found performances of recovered anorexics similar to those of the healthy control group (Tchanturia et al., 2007).

SIP is among the most investigated cognitive impairments in AN. It is related to the amount of information a person is able to deal with during a given period of time (i.e., how many words can be read in 1 min) or the amount of time that a person takes to complete a task demand (i.e., an arithmetic task or linking numbers on a sheet of paper in ascending order; Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007). Several studies have affirmed that a marked reduction in the speed of global processing appears in patients with AN, evident by a reduced psychomotor speed during complex tasks. Several authors (Fowler et al., 2006; Gillberg et al., 2007; Kingston et al., 1996; Mikos et al., 2008; Seed et al., 2002; Small, Madero, Teagno, & Ebert, 1983; Szmukler et al., 1992; Tchanturia et al., 2004) have found impaired SIP during tasks such as the Trail-Making Test-Part A (TMT-A) or the Coding subscale of the Wechsler Scales (Wechsler Intelligence Scale for Children-Revised and Wechsler Adult Intelligence Scale-Third Edition [WAIS-III]). Conversely, others have found outcomes comparable or even superior to normal healthy control subjects (Bayless et al., 2002; Pieters, Sabbe, Hulstijn, & Probst, 2003; Steinglass et al., 2006).

The aim of this work was to investigate the cognitive impairments present in a Spanish AN sample during the acute phase, while comparing their performance in several neuropsychological tasks with a healthy control group and, as a novelty in works with a Spanish population, with a group of patients with AN after weight recovery. Impairments were expected in SIP, working memory, inhibition, planning, problem solving, and visual memory tasks, but not in verbal memory tasks. Likewise, no relationship was expected between cognitive impairments and BMI, and it was predicted that impairments would continue after weight gain. Thus, performance of the weight recovery group was not expected to be higher than that of the AN sample during the acute phase.

METHOD

Participants

Participants were divided into three groups. Performances on several neuropsychological tests used in previous research (the rationale for using each test is explained in this section) were compared in an observational transversal study design. All participants in this study were female. As AN affects adolescents with increasing frequency (N. H. Golden et al., 2003), participants aged younger than 18 years of age were included in the study to create groups that approach as much as possible real age ranges in eating disorder units (Connan et al., 2006; Fowler et al., 2006; Gillberg et al., 2007; Green et al., 1998; Grunwald et al., 2001; Kemps et al., 2006; Rastam et al., 2001).

Anorexia nervosa group. The anorexia nervosa group (ANG) included 12 inpatients with AN in the acute phase (BMI < 17) admitted to the Eating Disorder Unit at Hospital La Fe in Valencia, Spain. These participants were included if they were inpatients at the beginning of the investigation or if they were admitted once the investigation had begun. All participants in this group met the criteria for AN defined in the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2002) and were diagnosed by an experienced psychiatrist (LRM) by means of the DSM-IV-TR manual and a personal interview. Before diagnosis, all participants underwent a psychiatric clinical interview and medical examination to rule out the possibility of AN symptomatology secondary to medical processes as well as biochemical dysfunction. Laboratory examination included uric acid levels, albumin and prealbumin, liver transaminases (ALT/GPT [Alanine transaminase/Glutamic pyruvic transaminase] and AST/GOT [Aspartate transaminase/Glutamic oxaloacetic transaminase]), liver enzyme levels (GGT [Gamma glutamil transpeptidase] and bilirubin), calcium, creatine kinase, copper levels, cholesterol (low-density lipoprotein and high-density lipoprotein), complementary C3 and C4 serum levels, creatinine, red blood cell folate, alkaline phosphatase, inorganic phosphate, glucose,

hemogram, iron levels, electrolytes (sodium, potassium, and chloride), leptin, magnesium, total plasma protein, transferine, thyroid stimulating hormone (total Triiodothyronine [T3], free Thyroxine [T4], and total T4), vitamin (A, B, E, and D), erythrocyte sedimentation rate, and zinc. None of the participants showed abnormal serum levels. A semistructured interview was used before inclusion to rule out the existence of neurologic or psychiatric disorders (Axe I) other than AN. Inclusion criteria were: (a) diagnosis of AN at least in the last 12 months; (b) aged 15 to 35 years old; (c) BMI <17; and (d) Spanish as their first language. Exclusion criteria were: (a) diagnosis of any psychiatric disease other than AN codified in the DSM-IV-TR Axe I at the time of assessment; (b) diagnosis, at any time during their development, of any neurologic disease; c) IQ estimate of less than 80; (d) presence of behaviors related to impulse control disorder, and (e) drug (alcohol, heroin, cocaine, marijuana) use or abuse 2 days before the assessment. Two participants (16.6%) took anxiolytics as medication (lorazepam, clorazepate potassium, pregabalin), 3 (25%) took antidepressive medication (paroxetine, fluoxetine, duloxetine), and 2 (16%) took neuroleptic medication (ziprasidone, quetiapine). Nine participants (75%) had AN-restrictive subtype and 3 (25%) had AN-purgative subtype.

Healthy control group. The healthy control group (HCG) included healthy control volunteers ($n=16$) recruited from the general population by means of announcements at the University of Valencia and within a high school in the province of Valencia. All participants underwent a semistructured interview to rule out the presence of neurological or psychiatric illnesses. One participant was excluded because of an estimated IQ score of less than 80.

Weight-recovery group. The weight-recovery group (WRG) included weight-recovered inpatients ($n=12$) admitted both as outpatients at the Eating Disorders Unit (Hospital La Fe, Valencia) and to a Psychological Center in Valencia specializing in eating disorders treatment (PREVI; http://www.previsl.com), where patients attended either as inpatients or as outpatients during the day. All participants in this group met the criteria for AN defined in the DSM-IV-TR and were diagnosed by experienced psychiatrists from different hospitals in the community of Valencia. All participants underwent the same semistructured interview as did those in the AN group to discard the presence of neurological or psychiatric illnesses other than AN (Axe I). As they underwent regular medical examinations in PREVI, any medical process was stated before inclusion. Participants in this group underwent the same laboratory examination as did those in the AN group, and none showed abnormal serum levels. All participants fulfilled the criteria to be considered *weight-recovered*: (a) BMI >18, and (b) weight increase $>20\%$ of previous weight more than 6 months before the investigation started. Inclusion criteria were: (a) diagnosis of AN at least in the last 12 months; b) aged 15 to 35 years old; (c) BMI >18; and (d) Spanish as their first language. Exclusion criteria were the same as those in the acute AN group. Three participants (25%) took anxiolytic medication (lorazepam, lormetazepam), 3 (25%) took antidepressive medication (paroxetine, fluoxetine, mirtazapine), and only 1 (8%) took neuroleptic medication (quetiapine). Eight participants (66.6%) had AN-restrictive subtype and 4 (33.3%) had AN-purgative subtype.

Participants from both the ANG and the WRG had a history of illness of at least 1 year (Table 1). Hospital staff obtained participants' weight measures with participants' clothes off during the same morning just before the neuropsychological assessment took place. Because of the restrictive inclusion and exclusion criteria in both clinical groups, it was possible to include only 12 participants both in the ANG and WRG 9 months after the work begun. A large number of candidates was not included because of biochemical imbalance, time since diagnosis of less than 12 months, and no specified subtype of AN or age.

All three groups included Caucasian participants matched by age, educational level, and full IQ. According to the exclusion criteria, participants with

TABLE 1
Time of Illness in Months (Anorexia Nervosa Group and Weight-Recovery Group)

ANG		*WRG*			
Subjects	*Time of Illness (Months)*	*Subjects*	*Time of Illness (Months)*		
1	20	1	60		
2	16	2	24		
3	36	3	48		
4	24	4	114		
5	48	5	24		
6	12	6	26		
7	22	7	72		
8	120	8	24		
9	144	9	228		
10	12	10	72		
11	12	11	156		
12	18	12	192		
N	12	*N*	12	*t*	*p*
Mean	40.33	Mean	86.66	−1,926	.067
SD	44.401	*SD*	70.532		
Min	12	Min	24		
Max	144	Max	228		

any comorbid pathology as defined in the DSM-IV-TR Axe I and/or those who presented with some medical process (such as metabolic illnesses, deregulation, or a history of neurological or developmental illnesses) that had potential to interfere with the results were excluded. All the participants in this study were informed both orally and by written information means and signed the informed consent prior to their inclusion. For females younger than 18, both participants and their parents signed the informed consent to be included in the study, which was approved both by the Ethic and Legal Committee at the Hospital La Fe in Valencia and by the rehabilitation team in PREVI.

Neuropsychological Assessment

All participants underwent the same neuropsychological assessment.

Intelligence. The Spanish version of the Kaufman-Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 2006) was used as an estimate of general intellectual ability (Hamsher, Halmi, & Benton, 1981), which served as the criterion for expected performance on the Wechsler intelligence scales, instead of using Vocabulary or Information subtests as a single estimate (Castro-Fornieles et al., 2007). K-BIT is fast and easy to administer and provides scores comparable to those obtained in WAIS-III. It includes *Vocabulary* and *Matrix* subtests. In the Vocabulary subtest, subjects were shown a sentence and a word fragment completion task related to the sentence simultaneously, and they were required to fill in the missing letters. The Matrix subtest is similar to that in the WAIS-III. Subjects were required to choose the correct answer among several items to complete a picture presented visually. Verbal IQ, Performance IQ, and Total IQ scores were obtained. Items were corrected according to the original instructions in the manual.

Attention and speed of information processing. The Digit Span task in Direct Order (DOD, WAIS-III; Strauss, Sherman, & Spreen, 2006; Wechsler, 1999) was used to assess auditory attention (phonological loop). In this task, subjects were required to repeat increasing sequences of numbers in the same order as was said by the examiner. To assess alternating attention, the Trail-Making Test-Part B (TMT-B) was used (Strauss et al., 2006). In this task, participants were required to link letters and numbers in ascending order in an alternating manner. SIP was assessed by means of the Total Symbol Digit (TSD) score of the Symbol–Digit Modalities Test-Oral form (SDMT; Strauss et al., 2006), the TMT-A, and the words (Stroop-W) and colors (Stroop-C) parts of the Stroop Interference Test (Strauss et al., 2006). The SDMT includes nine figures linked to numbers 1 through 9. Participants were required to say out loud the numbers that corresponded to the figures in serial order for 100 items during 90 s. The oral version of the SDMT was chosen to avoid motor interference. In the TMT-A, participants must link numbers 1 through 25 in ascending order as fast as possible with a pencil. The Stroop Test includes five columns with 20 items per column (total = 100). Participants were required to read out loud as many items as possible. The Stroop-W task includes three words (red, green, and blue) printed in black ink; the Stroop-C task includes five Xs (XXXXX) printed either in red, green, or blue. The Stroop-WC task includes the words from Stroop-W (red, green, and blue) written in the colors from the Stroop-C. However, the colors of the written words never correspond to the meaning of the word itself (i.e., "red" is only written in blue or green). The total number of items correctly identified in 45 s was registered in the three parts of the task.

Working memory. Digit Span in Reverse Order (ROD) and the Letter and Number (L&N) subscale of the Spanish version of the WAIS-III (Wechsler, 1999) were used to assess working memory. The longest series successfully reproduced was registered in each case. In the ROD task, subjects must repeat ascending sequences of numbers, but beginning in the last item backward toward the first item. In the L&N task, subjects must repeat ascending series of letters and numbers said by the examiner, but numbers in ascending order must be said first and then the letters ordered alphabetically.

Inhibition/impulsivity. The Spanish version of the Stroop Interference Color and Words Test Part C (Stroop-WC; C. J. Golden, 2005) was used. The raw score in the Stroop-WC, but not the Interference Index (CW – CW', where $CW = [W \times C]/[W + C]$), was used given that it does not require any transformation and provides a direct interpretation of the construct (López-Villalobos et al., 2010). Errors on the SDMT were registered and were interpreted as an impulsivity factor, as was the time required to draw the Rey-Osterrieth complex figure (Rey-Osterrieth Complex Figure Test [ROCFT]; Rey, 1987).

Memory. To assess verbal memory, the Test de Aprendizaje Verbal España-Complutense (TAVEC; Benedet & Alejandre, 1998), the Spanish adaptation of the California Verbal Learning Test, was used. This task includes a list (List A) with 16 words from four semantic categories: clothes, fruits, tools, and spices. Words are read out loud and participants are requested to recall as many words as possible during five trials. In each trial, there are both a free recall and a semantic recall in which

semantic categories are used as a cue. A second list is introduced after the fifth trial as an interference list (List B), which is performed the same way as List A with one single learning trial. Long-term memory is tested both with free and semantic recall after 20 min. A recognition phase is performed after long-term recall including all the words from List A, all the words from List B, and 12 distractors. Both short- and long-term Free Recall (TAVEC-FR-ST, TAVEC-FR-LT) and Semantic Cued Recall scores were registered, in addition to the Recognition index from List A. One of the Spanish Wechsler Memory Scale-Third Edition (WMS-III) stories from the Logical Memory subscale (Wechsler, 1997) was used both for immediate (WMS-ST) and long-term recall (WMS-LT). In this task, the examiner reads a story out loud and participants are requested to recall as many details as possible both during the short term and long term.

To assess visual memory, the ROCFT (Rey, 1987) was used. The original complex figure by Rey-Osterrieth (Rey, 1987; Strauss et al., 2006, p. 812, Fig. 10.31) was shown to the participants, who were required to perform a short-term memory recall (ROCFT-ST) right after a figure copy task and a long-term memory recall after 20 min (ROCFT-LT). Passage of time was controlled to ensure all participants recalled the figure within the same time interval.

Planning and problem solving. The ROCFT Copy (ROCFT-C) score was registered and used as a measure of planning (Kingston, 1996). It was corrected according to the original instructions by Osterrieth (1944). Eighteen elements are scored between 0 and 2 points according to the accuracy of the design (maximum score = 36). Problem solving was measured by means of a handmade Tower of Hanoi (TH) task that imitated the original sizes (Strauss et al., 2006). In this task, several hoops are placed within one out of three sticks, and subjects are required to place the hoops within another stick in the fewest number of movements. Participants were first required to solve the task using three hoops until completion was achieved in the smaller number of movements (seven). Once achieved, two more hoops (five in total) were added, and the number of movements (TH-Mov) needed to solve the task, the time required (TH-T), and the number of incorrect movements made (TH-E) were registered. Incorrect movements were those in which (a) one hoop was taken before the last hoop was correctly placed, and (b) a hoop was placed over a smaller one in any of the sticks.

Mood. The Spanish version of the Beck Depression Inventory (BDI-II; Sanz, Navarro, & Vázquez, 2003; Sanz, Perdigón, & Vázquez, 2003) and the Beck Anxiety Inventory (BAI; Robles, Varela, Jurado, and Páez, 2001) were used to assess depressive and anxiety symptomatology, respectively. The BDI-II is a 21-item self-report measurement used in clinical settings to assess the severity of depressive symptomatology (maximum score = 90). The BAI is a 21-item self-report designed to assess the severity of clinical anxiety symptomatology (maximum score = 63).

In cases where participants refused to complete any of the tasks (two subjects in the WRG refused to complete the TH task), results were analyzed using lost values to maintain the scores in the tasks that participants did complete.

To test differences between participants in the acute phase and participants after weight recovery, the *T* test for independent groups was used between the ANG and WRG. Based on the assumption stated in the Introduction, and after our first analysis showing that impairments would not recover after weight gain as no differences appeared between groups, both the ANG and WRG were then collapsed (2ANG) and compared to the HCG in all variables included in the study, as performed in previous works. Rastam et al. (2001) found no differences between the left and right cerebral sides in a regional perfusion study and collapsed data from both sides in the AN as in HCGs. Chui et al. (2008) combined those participants who were on oral contraceptive pills and those who had regular menses after finding equivalent brain volumes and cognitive scores to form a clinical group that included participants who met criteria for AN, one participant with a binge-eating disorder, participants in partial remission, and participants free from any symptoms of AN. Tchanturia et al. (2004) found no differences between restricting and binge purge subgroups within the AN group regarding clinical characteristics and neuropsychological performance, and both groups were collapsed.

To find the relationship between weight, BMI, and cognitive impairments, Pearson's bivariate correlations between all variables were performed among participants diagnosed with AN. The Statistical Package for the Social Sciences Version 17 was used for all statistical analyses.

It is known that multiple comparisons can potentially affect the level of confidence and the Type I error probability, which could be avoided by using statistical corrections after multiple comparisons such as the Bonferroni correction or the false discovery rate (FDR). However, reducing the alpha level in this work according to the Bonferroni correction would have meant that only differences $< .0015$ ($\alpha_{\text{Bonferroni}} = .05/33$) would be significant for cognitive variables. As it is very rare to find those *p* values, the probability of making a Type II error increases and we would have been in danger of overlooking important differences (Perneger, 1998). As previous works using the *t* test did not include the Bonferroni

correction for multiple comparisons between groups, for all comparisons both between anorexic groups and between the 2ANG and HCG, Cohen's *d* was calculated to obtain the effect size of the mean differences (Lopez, Tchanturia, Stahl, & Treasure, 2008). Cohen's *d* statistic ranges from negligible ($\geq$0 and $<$0.15), to small ($\geq$0.15 and $<$0.40), medium ($\geq$0.40 and $<$0.75), large ($\geq$0.75 and $<$1.10), very large ($\geq$1.10 and $<$1.45), and huge ($\geq$1.45). However, corrected *p* values after modified FDR corrections for multiple comparisons (B-Y after Benjamini & Yekutieli) are indicated where appropriate. For a detailed explanation about the B-Y FDR correction, readers are referred to Narum (2006). Critical *p* values after B-Y FDR correction were set at .01262 (see Appendix A in Narum, 2006).

RESULTS

Anorexia Nervosa Group Versus Weight-Recovery Group

As can be seen in Table 2, no differences were found in the ratio of restrictive and purgative anorexia subtypes in both groups. As no differences were expected, both subgroups were included in the analysis according to Tchanturia et al. (2004). There were no differences between clinical groups in duration of illness (Table 1). Only differences that are statistically significant are shown within all tables throughout the article. For comparison purposes, descriptive statistics of all cognitive variables are shown in the Appendix. Demographic and cognitive data are shown in Table 3. Significant differences were found in variables of weight and BMI. No significant differences were found in the variables of age, years of education, and Full IQ (FIQ), which means that groups were well matched. Regarding neuropsychological and emotional variables, differences were found in the variable TAVEC Series 5, TAVEC-FR-LT, WMS-LT, and BAI. The magnitude of the differences was large for BMI and medium for the rest of the variables. To obtain a measure of the impact of anxiolytic medication on cognition, Mann-Whitney Tests for comparisons on all the variables included in the work were performed between those participants who were taking anxiolytics ($n = 5$) and those who were not ($n = 19$). The Mann-Whitney Test showed no significant differences between groups.

TABLE 2
Percentage of Subtypes of AN by Group

	Restrictive	*Purgative*		X^2	*P*
ANG	9	3	12		
WRG	8	4	12	.202	.653

Two-Group Analysis

Once the ANG and the WRG groups were collapsed to form the 2ANG and were compared to the HCG, additional impaired neuropsychological variables were found. Table 4 shows demographic statistics. Significant differences were found in the variables of weight and BMI. Regarding cognitive variables (Table 5), differences appeared in the variables ROD, L&N, ROCFT, ROCFT-LT, Stroop-W, Stroop-C, Stroop-WC, TSD,

TABLE 3
Demographic and Cognitive Variables of the Anorexia Nervosa and Weight Recovery Groups

		ANG	*WRG*	*t Test*	*p*	*d'*	*Effect Size*			*ANG*	*WRG*	*t Test*	*p*	*d'*	*Effect Size*
Age	*N*	12	12					TAVEC 5	*N*	12	12				
	Mean	21.67	22.17	*−0.241*	*.812*				Mean	15	13.55	*2.175*	*.041*	*1.25*	*0.53*
	SD	5.01	5.16						*SD*	0.894	1.368				
Weight	*N*	12	12					TAVEC-FR-LT	*N*	12	12				
	Mean	43.183	48.704	*−3.509*	*<.01**	*1.43*	*0.58*		Mean	13.82	11.55	*2.356*	*.029*	*1.00*	*0.44*
	SD	4.323	3.318						*SD*	2.183	2.339				
Years of	*N*	12	12					WMS-LT	*N*	12	12				
Education	Mean	13.92	12.83	*1.008*	*.325*				Mean	15.27	12.36	*2.164*	*.043*	*0.92*	*0.41*
	SD	3.147	1.992						*SD*	2.005	3.982				
BMI	*N*	12	12					BAI	*N*	12	12				
	Mean	16.226	18.753	*–6.325*	*.000**	*2.58*	*0.79*		Mean	14.82	26.70	–2.363	*.029*	*1.03*	*0.45*
	SD	0.65	1.221						*SD*	8.897	13.841				
K-BIT Total	*N*	12	12												
(IQ)	Mean	101.67	98.58	*0.729*	*.474*										
	SD	8.907	11.626												

Note. Height not included. BMI = body mass index; K-BIT = Kaufman-Brief Intelligence Test; TAVEC = Test de Aprendizaje Verbal España-Complutense; FR = Free Recall; WMS = Wechsler Memory Scale; LT = long term; BAI = Beck Anxiety Inventory.

*Significant after Benjamini & Yekutieli's modified FDR correction for six multiple comparisons among demographic variables.

TABLE 4
Demographic Variables: Comparison of Two Groups (2ANG and HCG)

	HCG (N = 16)				*2ANG (N = 24)*							
	Mean	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*t Test*	*p*	*d*	*Effect Size*
Age	18.56	3.949	15	29	21	4.071	15	33				
Height	1.62	0.06	1.51	1.75	1.626	0.052	1.53	1.74				
Weight	57.288	9.643	42.5	79	46.088	4.814	36.4	56	4.715	*p = .000**	*1.46*	*0.49*
Years of Education	12	3	9	17	13.5	2.721	10	20				
BMI	21.77	1.97	18.64	25.79	17.416	1.605	14.95	21.34	7.502	*p = .000**	*2.42*	*0.77*
FIQ	100.56	9.165	86	117	100.13	10.25	80	122				

HCG = healthy control group; 2ANG = both anorexia nervosa group and the weight-recovery group collapsed; BMI = body mass index; FIQ = full IQ.

*Significant after Benjamini & Yekutieli's modified FDR correction for six multiple comparisons among demographic variables.

TAVEC-FR-ST, WMS-LT, BDI-II, and BAI. The magnitude of the differences was small for comparisons on working memory (ROD, L&N), inhibition (Stroop-WC), and memory (TAVEC-FR-ST, WMS-LT, ROCFT-LT); medium for comparisons on weight, SIP (Stroop-W, Stroop-C, SDMT-TSD), and depressive symptomatology (BDI-II, BAI); and large for comparisons on BMI and impulsivity (ROCFT).

Correlational Studies

To perform the correlational studies, all participants diagnosed with AN independently of whether they belonged to the ANG or WRG ($n = 24$) were included. Results (Table 6) showed significant negative correlations between BMI and the variable TAVEC-FR-LT ($r = -.442$, $p = .031$)—indicating that the higher the weight, the worse the long-term memory—and between BMI and BAI ($r = .418$, $p = .047$), but no significant correlations with BMI and any of the variables statistically different between 2ANG and HCG were found.

Regarding neuropsychological variables, significant correlations were found between working memory and SIP related to verbal material ($R_{ROD \times STROOP\text{-}C} = .527$, $p < .01$; $R_{L\&N \times STROOP\text{-}C} = .546$, $p < .01$), which indicates that the faster the information is processed, the better one can hold it in mind and perform cognitive tasks with it. Correlations were found between SIP and verbal memory ($R_{TSD \times WMS\text{-}ST} = .616$, $p < .01$; $R_{TSD \times WMS\text{-}LT} = .681$, $p = .000$), but not between TSD and any measure regarding visual memory. The Stroop task did correlate significantly with verbal memory tasks

TABLE 5
Neuropsychological Variables: Comparison of Two Groups' Statistics

	HCG (N = 16)				*2ANG (N = 24)*							
	Mean	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*t*	*p*	*d*	*Effect Size*
ROD	4.75	0.775	4	6	3.86	1.320	2	7	*2.397*	*.022*	*0.82*	*0.38*
L&N	4.81	0.834	4	6	4.23	0.869	3	6	*2.084*	*.044*	*0.68*	*0.32*
ROCFT	284.19	119.961	125	471	167.82	68.334	84	313	*3.907*	*<.01**	*1.19*	*0.51*
ROCFT-LT	25.625	4.544	17	32	21.614	4.913	12	30	*2.56*	*.015*	*0.84*	*0.39*
Stroop-W	115.19	18.534	95	165	100.41	14.725	66	126	*2.739*	*.011**	*0.88*	*0.40*
Stroop-C	76.44	13.784	54	100	65.77	10.424	47	92	*2.719*	*<.01**	*0.87*	*0.40*
Stroop-WC	53.06	13.478	39	84	43.23	8.997	28	60	*2.700*	*.01**	*0.85*	*0.39*
TSD	63	11.495	46	88	51.50	10.613	29	70	*3.185*	*<.01**	*1.03*	*0.46*
TAVEC-FR-ST	13.50	1.897	8	16	11.91	2.348	8	16	*2.229*	*.032*	*0.74*	*0.35*
WMS-LT	16.13	3.138	9	21	13.73	3.494	5	19	*2.178*	*.036*	*0.72*	*0.33*
BDI-II	5.36	3.028	0	12	22.95	15.432	1	50	*–5.017*	*.000***	*1.58*	*0.62*
BAI	7.43	4.815	1	17	20.38	12.729	1	46	*–4.254*	*.000***	*1.34*	*0.55*

ROD = Reverse Order Digits; L&N = Letter & Numbers subscale; ROCFT = Rey-Osterrieth Complex Figure time for copy; Stroop-W = Stroop Word task; Stroop-C = Stroop Color task; Stroop-WC = Stroop Word and Color Task; TAVEC = Test de Aprendizaje Verbal España-Complutense; F = Free Recall; TSD = Total Symbol Digit score; ST = short term; LT = long term; WMS = Wechsler Memory Scale; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory.

*Significant after Benjamini & Yekutieli's modified FDR correction for 33 multiple comparisons among cognitive variables.

**Significant after Benjamini & Yekutieli's modified FDR correction for 2 multiple comparisons among psychiatric variables.

TABLE 6
Pearson's Correlation Between BMI and Cognitive/Emotional Variables: ANG and WRG Combined

	BAI	*TAVEC-FR-LT*	*Stroop-W*	*Stroop-C*	*WMS-ST*	*WMS-LT*
BMI	.418	−.442				
WMS-ST			.549			
WMS-LT			.618			
ROD				.527		
L&N				.546		
TSD					.616	.681

BMI = Body Mass Index; WMS = Wechsler Memory Scale; ROD = Reverse Order Digits; L&N = Letters and Numbers; TSD = Total Symbol Digit; BAI = Beck Anxiety Inventory; TAVEC = Test de Aprendizaje Verbal España-Complutense; ST = short term; LT = long term; FR = Free Recall; Stroop-W = Stroop Word task; Stroop-C = Stroop Color task; Stroop-WC = Stroop Word and Color Task.

($R_{\text{STROOP-W}\times\text{WMS-ST}} = .549$, $p < .01$; $R_{\text{STROOP-W}\times\text{WMS-LT}} = .618$, $p < .01$), but these correlations were lower than those between SDMT and WMS-III scores. None of the measures of working memory correlated with verbal or visual memory.

To explore the possibility of other explanatory factors, *within*-group analyses were carried out on the 2ANG taking IQ as a factor. Following the work of Bayless et al. (2002), raw scores on the neuropsychological tests of participants with AN were first transformed to IQ scores ($M = 100$, $SD = 15$) using 2ANG means and standard deviations, and were then compared with FIQ scores. Contrary to Bayless et al. (2002), no differences were found in any of the tasks included in the study (Table 7).

DISCUSSION

Several works have shown a wide range of cognitive impairments in patients with AN. The most replicated ones are related to attention (Kingston et al., 1996; Lauer et al., 1999; Seed et al., 2002), working memory (Green et al., 1998; Kemps et al., 2006), cognitive flexibility (Steinglass et al., 2006; Tchanturia et al., 2004), SIP (Fowler et al., 2006; Gillberg et al., 2007; Kingston et al., 1996; Lauer et al., 1999; Seed et al., 2002; Tchanturia et al., 2004), and problem solving (Cavedini et al., 2004; Salvador et al., 2010; Tchanturia et al., 2007). It is yet to be clarified whether these impairments are caused by weight loss and BMI reduction or, conversely, if they may form the basis of the illness and be considered a determinant factor for AN to develop. We have reported a work with Spanish AN samples both in the acute phase and after weight recovery and have shown a pattern of cognitive impairments that confirmed several hypotheses and showed unexpected results.

TABLE 7
Within-Group *t* Test Comparisons

	Mean	*SD*	*SEM*	*t*	*DoF*	*Sig.*
Attention						
KBIT FIQ–DOD	0.042	17.875	3.649	0.011	23	.991
KBIT FIQ–TMT-B	0.125	19.198	3.919	0.032	23	.975
Speed of information processing						
KBIT FIQ–TSD	0.208	13.211	2.697	0.077	23	.939
KBIT FIQ–TMT-A	0.167	18.270	3.729	0.045	23	.965
KBIT FIQ–Stroop-W	0.208	15.872	3.240	0.064	23	.949
KBIT FIQ–Stroop-C	0.125	17.556	3.584	0.035	23	.972
Working memory						
KBIT FIQ–ROD	0.250	17.735	3.620	0.069	23	.946
KBIT FIQ–L&N	0.042	17.591	3.591	0.012	23	.991
Inhibition						
KBIT FIQ–Stroop-WC	0.125	17.792	3.632	0.034	23	.973
KBIT FIQ–ESD	0.000	19.197	3.919	0.000	23	1.000
Verbal memory						
KBIT FIQ–TAVEC-FR-ST	0.083	18.812	3.840	0.022	23	.983
KBIT FIQ–TAVEC-CR-ST	0.167	18.072	3.689	0.045	23	.964
KBIT FIQ–TAVEC-FR-LT	0.375	18.254	3.726	0.101	23	.921
KBIT FIQ–TAVEC-CR-LT	0.042	17.337	3.539	0.012	23	.991
KBIT FIQ–WMS-ST	0.167	15.310	3.125	0.053	23	.958
KBIT FIQ–WMS-LT	0.125	13.566	2.769	0.045	23	.964
Problem solving						
KBIT FIQ–TH-Mov	1.292	19.630	4.007	0.322	21	.750
KBIT FIQ–TH-E	0.750	18.926	3.863	0.194	21	.848
KBIT FIQ–TH-T	1.292	20.099	4.103	0.315	21	.756
Planning						
ROCFT-Copy	0.167	15.435	3.151	0.053	23	.958
Visual memory						
KBIT FIQ–ROCFT-ST	0.083	18.531	3.783	0.022	23	.983
KBIT FIQ–ROCFT-LT	0.125	16.147	3.296	0.038	23	.970

Note. $N = 24$. KBIT FIQ = K-BIT Full IQ; DOD = Direct Order Digits; TMT = Trail-Making Test; Stroop-W = Stroop Word task; Stroop-C = Stroop Color task; Stroop-WC = Stroop Word and Color Task; TSD = Total Symbol Digit; ROD = Reverse Order Digits; L&N = Letter and Number Test; ESD = Error Symbol Digit; FR = Free Recall; CR = Cued Recall; ST = short term; LT = long term; WMS = Wechsler Memory Scale; TH-Mov = Tower of Hanoi Movements; TH-E = Tower of Hanoi Errors; TH-T = Tower of Hanoi Time; DoF = degrees of freedom; ROCFT = Rey-Osterrieth Complex Figure Test.

Intellectual Abilities

Within-subjects results indicated that no task score was significantly lower than would have been predicted on the basis of FIQ. As an average or low-average performance may indicate cognitive impairment if general intellectual abilities are above average, results reported here indicate that differences between groups are not due to abnormal (above or below average) general intellectual functioning. This finding suggests that cognitive impairments are subtle in AN, in line with Cohen's *d* effect size.

Attention and Speed of Information Processing

No differences were found either in DOD or TMT, which means that participants with AN did not show verbal attention impairments, contrary to data reported by Kingston et al. (1996) and Dickson et al. (2008). Differences were found in SIP (Lauer et al., 1999) in cognitive tasks such as the SDMT, Stroop-W, and Stroop-C, but not in TMT-A, which includes a motor component. This made it impossible to replicate previous studies (Kingston et al., 1996; Szmukler et al., 1992; Tchanturia et al., 2004). Data indicate that participants with AN show slowed SIP unrelated to motor function—what would constitute a primary impairment. The fact that no differences were found in SIP tasks such as the TMT, but that they, conversely, were found in the SDMT could be explained by impairments in the right parietal cortex and visuospatial abilities, which are necessary to perform the SDMT task but not the TMT to the same extent, as no spatial figures appear within the task. Kemps et al. (2006) suggested that patients with AN may suffer from impairments in the visual sketchpad and in their connections with the central executive, which is impaired in the anorexic group in this study as differences in the L&N subtest showed up. The fact that visual memory performance is impaired in this sample, together with the absence of a correlation between SDMT and ROCF, cannot support that SIP impairments affect predominantly right-hemisphere neuropsychological capabilities.

Executive Functioning

Differences were found in working memory, both in simple (ROD) and complex (L&N) tasks, in line with results reported by Green et al. (1998) and Kemps et al. (2006). Unexpectedly, given the findings reported in previous literature (Castro-Fornieles, 2007; Szmukler et al., 1992), no differences were found either in planning (ROCFT-C) or problem solving (TH). Working-memory and inhibition capabilities were impaired in anorexic participants both in the acute phase and after weight gain, as can be seen in the differences in the L&N subtest and in the interference part of the Stroop task (Stroop-WC), which indicates that executive functioning is affected in AN (Kingston et al., 1996). This conclusion is supported by the differences in the ROCFT with no difference either in the ROCFT-C or ROCFT-ST scores, which could be interpreted as a reflection of impulsive behaviors. Although the magnitude of the differences was small for working memory and inhibition and medium for SIP, it was large for impulsivity. It is important to note that data regarding SIP, impulsivity, and inhibition remained significantly different between the AN groups and the HCG even after corrected p values for multiple comparisons. Clinicians should take into account executive-functioning impairments as they have clinical importance for rehabilitation given that they could be interpreted as a risk factor for developing AN as well as a maintenance factor (Holliday, Tchanturia, Landau, Collier, & Treasure, 2005; Tchanturia et al., 2011, 2012). Tchanturia et al. (2008) demonstrated improvements on neuropsychological tests after 10 sessions of cognitive remediation therapy including exercises focused on cognitive flexibility as set shifting has been found impaired in AN (Holliday et al., 2005; McAnarney et al., 2011; Stedal, Rose, Frampton, Landro, & Lask, 2012). Lopez, Roberts, Tchanturia, and Treasure (2008) demonstrated clinical improvements after only 3 sessions of cognitive intervention using neuropsychological feedback. Regarding inhibition, our results support the findings reported by Stedal et al. (2012) as worse performance was found in the interference part within the Stroop test. The clinical implications of executive functioning on AN symptomatology will be explained in the next section discussing memory results.

Memory

As expected, significant differences were found in long-term visual memory (ROCFT-LT). Contrary to our hypothesis, however, differences were found in verbal memory both in the short term (TAVEC-FR-ST) and long term (WMS-LT), which is in line with some previous reports (Chui et al., 2008; Green et al., 1998; Kingston et al., 1996) and is contrary to others (Gillberg et al., 2007; Lauer et al., 1999). Unlike in Kingston et al.'s (1996) report, impairments in long-term verbal memory were not related to short-term performance, given that short-term and long-term impairments were found in two different tasks and there were no significant correlations between both tasks. One possible explanation is that differences in verbal memory tasks are dependent on executive processes. As TAVEC provides the opportunity of clustering items (semantic clustering), differences in short-term but not in long-term performance could be explained by executive impairments, which prevent participants from clustering information in the short term. This fact is supported by differences in WMS-LT, as information within this task cannot be clustered for later remembering. Another factor that could explain the differences in verbal memory is the association between stages in learning and memory and impulsivity. One of the stages in learning and memory is *retrieval* of information previously learned (for a detailed explanation, see Oltra-Cucarella, 2013). Impairments in SIP found in participants with AN could cause a slowing-down at retrieving information previously learned, which together with impulsivity impairments could cause participants to retrieve fewer items and to

give up recalling earlier compared with their healthy counterparts. The clinical impact of these suggestions is evident because if memory performance is influenced by impulsive behaviors, then improving inhibition/impulsivity factors would lead to better performance on verbal memory in daily-living situations. Cognitive remediation therapy (Tchanturia et al., 2008) could then be generalized to improvements in verbal memory functioning as a consequence of reduction of impulsive behaviors. Future research may find the extent to which SIP and impulsivity factors affect verbal memory and whether intervention focused on executive functioning improves memory performance. It is unlikely that Spanish translation was a factor affecting performance, as scores were not compared to manual tables within the TAVEC or to any other English verbal memory task.

Verbal memory is the only variable that showed differences between participants in the acute phase and after weight recovery, with better results for the former indicating that verbal memory functioning worsens regardless of weight recovery. Thus, we can conclude that SIP impairments are independent of attentional capabilities and affect equally visual and verbal functions. As correlational data showed that SIP and working-memory capabilities are related to each other, lack of correlation between working memory and visual and verbal memory tasks supports that visual and verbal impairments are a primary cognitive dysfunction in AN. This finding is in line with previous work that have shown unilateral left temporal hypoperfusion in 8 out of 15 and unilateral right temporal hypoperfusion in 5 out of 15 patients, which persisted at follow-up after restoration (Gordon, Lask, Bryant-Waugh, Christie, & Timimi, 1998). It is also in line with work such as that of Chowdhury et al. (2003), Frampton et al. (2011), and Rastam et al. (2001), but is contrary to work by Connan et al. (2006) and Frank et al. (2007).

Regarding the influence of BMI and cognitive status, our results confirmed that cognitive impairments found in participants with AN are not related to BMI as there are no differences before and after weight recovery, and in cases where differences exist—delayed verbal memory—weight-recovered patients perform worse than their counterparts in the acute phase, which supports that cognitive impairments are not a consequence of starvation and could be interpreted as a feature of persons with AN, as stated in previous works (Bayless et al, 2002; Castro-Fornieles et al., 2007; Cavedini et al., 2004; Chui et al., 2008; Fowler et al., 2006; Kingston et al., 1996; Mikos et al., 2008; Pieters et al., 2003; Steinglass et al., 2006; Szmukler et al., 1992; Tchanturia et al., 2004). As expected according to the size of the differences between groups, impairments in the samples included in this study must be considered subtle when compared with healthy counterparts given that none of the cognitive variables fell more than 1.5 standard deviations below the mean of the control group and effect sizes were small to medium except for impulsivity. Only scores on the BDI and BAI were more than 3 standard deviations over the mean of the control group. Effect sizes were small for attention, inhibition, and memory (visual and verbal); medium for weight and SIP; and large for BMI and impulsivity (Bayless et al., 2002; Chui et al., 2008; Tchanturia, Campbell, Morris, & Treasure, 2005).

Emotional Variables

Regarding mood variables, although both depressive and anxious symptomatology are present in anorexic groups compared with their healthy counterparts, higher WRG scores indicate that emotional variables are an important factor in the course of the illness and may worsen even after refeeding. The effect size of differences in the BDI-II and BAI was medium. It cannot be ruled out that depressive mood affects performance on verbal memory tasks. Pendleton-Jones et al. (1991) affirmed that decrements in performance are not subtle deficits but could reflect the effects of anxiety, or maybe both anxiety and neuropsychological deficits are common features of eating disorders such as AN. Data in our study are in agreement with the last statement, as there were differences between clinical groups only in verbal memory despite significant differences in BAI being that the weight-recovered group had the highest scores on anxiety. Thus, our results suggest that verbal memory impairments may be specific to eating disorders and are not related to anxiety. This is in line with findings of a more frequent specific left temporal hypoperfusion in eating disorders (Gordon et al., 1998).

Several factors affect the validity and generalization of our results. First of all, samples should be bigger to obtain stronger results. Nonetheless, sample sizes in this work are very similar to those included in previous research with females suffering from AN (Chowdhury et al., 2003, ANG = 15; Connan et al., 2006, ANG = 16; Dickson et al., 2008, ANG = 24; Fowler et al., 2006, ANG = 25; Frampton et al., 2011, ANG = 9; Green et al., 1998, ANG = 12; Lauer et al., 1999, ANG = 12; Rastam et al., 2001, ANG = 21; Rodriguez-Cano et al., 2009, ANG = 9; Santel, Baving, Krauel, Münte, & Rotte, 2006, ANG = 13; Steinglass et al., 2006, ANG = 15; Uher et al., 2004, ANG = 16), which makes our results as valid as those reported by others. Another factor is that there was no control for any of the personality disorders present in a high percentage of these patients that are associated with neuropsychological impairments linked to the frontal cortex (Haaland & Landro, 2007), such as OCD or impulse control disorder. However, the essence of this work creates a pathway for future studies to demonstrate

the presence of neuropsychological impairments in Spanish inpatients with AN and to discover cognitive patterns that influence the onset and maintenance of the illness. As this is only a pilot study, we hope that future research replicates these findings with the inclusion of larger samples and personality factors to enhance the reliability of data. In summary, we could not support the right-hemisphere impairment theory in AN. Our results showed primary SIP along with working-memory and inhibition/impulsivity impairments unrelated to BMI, which affect and worsen both primary visual and verbal memory abilities during the course of the illness. As cognitive rehabilitation has proven effective for improving cognitive abilities, the clinical implications of our results suggest that interventions must include executive functioning (cognitive flexibility, inhibition/impulsivity; Tchanturia et al., 2008), speed and style of information processing (Lopez, Roberts, Tchanturia, & Treasure, 2008), and visual memory as targets to generalize improvements to other cognitive abilities such as verbal memory.

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APPENDIX

Demographic and Cognitive Statistics

	ANG					*WRG*					*HCG*				
	Mean	*SD*	*SEM*	*Min*	*Max*	*Mean*	*SD*	*SEM*	*Min*	*Max*	*Mean*	*SD*	*SEM*	*Min*	*Max*
Age	21.67	5.02	1.45	15	31	22.17	5.17	1.49	17	33	18.56	3.95	0.99	15	29
Height	1.63	0.07	0.02	1.53	1.74	1.61	0.03	0.01	1.55	1.65	1.62	0.06	0.02	1.51	1.75
Weight	43.18	4.32	1.25	36.40	50	48.70	3.32	0.96	45.35	56	57.29	9.64	2.41	42.5	79
Years of education	13.92	3.15	0.91	10	20	12.83	1.99	0.58	10	17	12.00	3.03	0.76	9	17
BMI	16.23	0.65	0.19	14.95	16.94	18.75	1.22	0.35	17.03	21.34	21.77	1.97	0.49	18.64	25.79
K-BIT VIQ	101.50	12.87	3.71	89	138	100.17	15.17	4.38	82	134	102.69	10.81	2.70	83	120
K-BIT PIQ	104.67	6.87	1.98	91	114	98.58	12.84	3.71	70	116	102.25	7.66	1.91	91	116
K-BIT FIQ	101.67	8.91	2.57	86	122	98.58	11.63	3.36	80	121	100.56	9.16	2.29	86	117
DOD	5.42	1.38	0.40	3	8	5.50	1.24	0.36	4	8	6.13	1.20	0.30	4	9
ROD	4.00	1.35	0.39	2	7	3.75	1.29	0.37	2	7	4.75	0.77	0.19	4	6
L&N	4.33	0.89	0.26	3	5	4.17	0.83	0.24	3	6	4.81	0.83	0.21	4	6
TMT-A	34.75	11.43	3.30	24	62	32.17	9.81	2.83	15	48	37.88	7.79	1.95	24	51
TMT-B	63.58	15.11	4.36	46	95	80.92	29.28	8.45	30	128	65.81	19.02	4.75	25	95
ROCFT-C	34.83	1.03	0.30	33	36	33.83	2.48	0.72	28	36	34.19	1.76	0.44	30	36
ROCFT-T	176.08	82.74	23.89	84	313	155.58	44.18	12.75	90	226	284.19	119.96	29.99	125	471
ROCFT-ST	23.58	5.55	1.60	16	32	21.83	4.69	1.35	14	27	26.00	4.32	1.08	18	32
ROCFT-LT	22.46	4.86	1.40	16	30	21.42	5.01	1.45	12	27.5	25.63	4.54	1.14	17	32
Stroop-W	104.00	13.11	3.79	88	125	96.67	14.85	4.29	66	126	115.19	18.53	4.63	95	165
Stroop-C	66.92	11.00	3.18	50	92	64.00	10.30	2.97	47	81	76.44	13.78	3.45	54	100
Stroop-WC	43.33	8.84	2.55	28	55	42.50	9.06	2.62	30	60	53.06	13.48	3.37	39	84
TSD	54.42	9.31	2.69	39	66	48.00	10.39	3.00	29	70	63.00	11.49	2.87	46	88
ESD	1.75	1.36	0.39	0	5	2.75	4.14	1.19	0	13	2.00	2.13	0.53	0	7
TAVEC 1	6.75	1.36	0.39	4	9	6.25	1.66	0.48	4	10	7.06	1.69	0.42	4	11
TAVEC 2	10.83	2.04	0.59	7	14	10.00	1.86	0.54	7	13	10.69	1.74	0.44	8	14
TAVEC 3	12.17	2.21	0.64	8	16	11.92	2.31	0.67	9	16	12.88	1.63	0.41	10	16
TAVEC 4	13.92	1.93	0.56	10	16	12.67	2.27	0.66	9	16	14.19	1.42	0.36	12	16
TAVEC 5	14.67	1.44	0.41	11	16	13.42	1.38	0.40	12	16	14.81	1.22	0.31	12	16
TAVEC B	7.42	1.56	0.45	5	10	6.58	2.07	0.60	2	9	7.75	1.65	0.41	5	11
TAVEC-FR-ST	12.33	2.46	0.71	8	16	11.50	2.07	0.60	8	15	13.50	1.90	0.47	8	16
TAVEC-CR-ST	12.58	2.71	0.78	7	16	11.75	2.63	0.76	7	16	12.88	2.22	0.55	7	15
TAVEC-FR-LT	13.42	2.50	0.72	8	16	11.50	2.24	0.65	8	15	13.50	2.28	0.57	7	16
TAVEC-CR-LT	13.00	2.13	0.62	9	16	11.50	2.97	0.86	7	16	13.13	2.28	0.57	7	16
TAVEC-R	15.17	0.83	0.24	14	16	14.17	1.27	0.37	12	16	14.87	1.73	0.45	10	16
WMS-ST	15.08	2.61	0.75	9	19	14.33	3.31	0.96	9	20	16.81	3.43	0.86	10	23
WMS-LT	14.83	2.44	0.71	10	19	12.58	3.87	1.12	5	19	16.13	3.14	0.78	9	21
TH-Mov	90.58	58.34	16.84	46	208	94.18	38.96	11.75	39	148	75.63	24.88	6.22	42	129
TH-E	1.42	1.78	0.51	0	5	1.45	1.57	0.47	0	4	0.88	1.31	0.33	0	3
TH-T	403.50	202.18	58.37	126	797	430.73	240.76	72.59	110	850	301.69	157.78	39.44	132	729
BDI-II	15.64	10.47	3.16	3	36	28.75	16.78	4.84	1	50	5.36	3.03	0.81	0	12
BAI	14.83	8.48	2.45	5	32	26.73	13.13	3.96	1	46	7.43	4.82	1.29	1	17

SEM = standard error of mean; BMI = body mass index; ESD = Errors Symbol Digit; K-BIT = Kaufman-Brief Intelligence Test; VIQ = Verbal IQ; PIQ = Performance IQ; FIQ = Full IQ; Stroop-W = Stroop Word task; Stroop-C = Stroop Color task; Stroop-WC = Stroop Word and Color task; TH-Mov = Tower of Hanoi Movement; TH-E = Tower of Hanoi Errors; TH-T = Tower of Hanoi Time; DOD = Direct Order Digits; ROD = Reverse Order Digits; L&N = Letter and Number subtest; TMT = Trail-Making Test; ROCFT = Rey-Osterrieth Complex Figure Test; TSD = Total Symbol Digit; TAVEC = Test de Aprendizaje Verbal España-Complutense; WMS = Wechsler Memory Scale–Logical Memory subtest; BDI-II = Beck Depression Inventory; BAI = Beck Anxiety Inventory; ST = short term; LT = long term; FR = Free Recall; CR = Cued Recall.