A Comparison of Neuropsychological Test Performance on the Ravello Profile between Bulimia Nervosa and Anorexia Nervosa

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D. CLIN. PSYCHOL. DECLARATION OF OWN WORK

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ABSTRACT

Background The Ravello Profile is a battery of standardised neuropsychological measures of areas of functioning that evidence indicates are impaired in Anorexia Nervosa (AN), namely visuo-spatial functioning, central coherence and executive functioning. The neuropsychological profile of individuals with Bulimia Nervosa (BN) is less well established. The current study aimed to examine differences in cognitive performance between people with BN, AN and non-eating disordered controls on the Ravello Profile.

Methods The AN group (N=60) comprised participants from an existing database (Frampton *et al*. 2009). The BN group (N=22) largely comprised participants from NHS adult out-patient services. The non-eating disordered control group (N=20) comprised of colleagues and acquaintances of the researcher. Differences between AN, BN and control samples on visuo-spatial functioning, central coherence, executive functioning and error rates were examined.

Results The AN group performed significantly worse than the BN group on a measure of central coherence and on some measures of executive function, but the BN group did not perform worse than the control group. There was no significant difference between the groups on three measures of visuo-spatial functioning. However, the AN group was significantly slower than both the BN and control group to copy the figure. The results showed some evidence of increased error rates in BN relative to AN, which may reflect greater impulsivity in BN.

Conclusions The results indicate separate patterns of neuropsychological performance between AN, BN and controls, with AN demonstrating poorer performance on measures of executive function and central coherence, whilst BN participants showed higher rates of errors. The BN group were also generally faster to complete some tasks, indicative of a preference for speed over accuracy or impulsivity. Those working with individuals with AN or BN should take into consideration possible effects of their respective cognitive limitations and adapt interventions accordingly.

Neuropsychological Function in People with Bulimia Nervosa: A Systematic Review of the Literature

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Running Head: Review of Neuropsychological Functioning in Bulimia

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(see Appendix 1)

Neuropsychological Function in People with Bulimia Nervosa: A Systematic Review of the Literature

ABSTRACT

Background Despite some reports of specific neuropsychological dysfunction in individuals with Bulimia Nervosa (BN), the findings are inconclusive. The purpose of this systematic review was to examine the current evidence for neuropsychological dysfunction in adults with a formal diagnosis of BN, relative to a non-eating disordered control group.

Methods This is a systematic review of papers assessing neuropsychological functioning in adults with a DSM-IV / ICD-10 formal diagnosis of BN. Four electronic databases were used to search for relevant articles: Embase, Psychinfo, OVID Medline and Cochrane Central Register of Controlled Trials. The included papers were critically evaluated on six areas of methodological quality.

Results Nine studies were included in the review. The strongest evidence for neuropsychological dysfunction in people with BN is in the area of executive functioning, primarily decision making and cognitive inflexibility. Most of the included studies were limited by small sample size.

Conclusions The available evidence suggests that individuals with BN demonstrate poorer ability in decision making and cognitive flexibility tasks, indicative of executive

dysfunction. Those working with individuals with BN should be aware of these potential cognitive deficits and adapt interventions accordingly. As a comprehensive neuropsychological assessment is not often viable, an assessment of decision making and cognitive flexibility may be worthwhile in order for interventions to be better tailored to suit the individual.

INTRODUCTION

The assessment of neuropsychological functioning in people with eating disorders
(ED) has continued to develop, particularly as deficits can have major implications in
terms of assessment, treatment and prevention. It is now recognised that Anorexia
Nervosa (AN) is associated with neuropsychological dysfunction, including deficits in
executive functioning, memory, learning, visuo-spatial functioning and central
coherence (Lena *et al*. 2004; Tchanturia *et al*. 2004; Duchesne *et al*. 2004). However,
the presence or absence of neuropsychological dysfunction in Bulimia Nervosa (BN)
is less clear.

A variety of limitations inherent in the literature have contributed to the lack of
clarity with regards to neuropsychological functioning in BN. Brand *et al*. (2007) and
Duchesne *et al*. (2004) noted that there are relatively few neuropsychological
outcome studies in BN. Furthermore, Lena *et al*. (2004) suggested that it may be as a
result of the high rate of non-standardised assessment tools and the lack of
appropriate control groups used in some studies. There are also a wide range of tests
available which can measure any given construct, making it difficult to make
comparisons across measures. Furthermore, the same test can often be used to
examine several neuropsychological constructs. For example, the Trail Making Test
(TMT) can be used as a measure of scanning, visuo-motor tracking, divided attention,
and cognitive flexibility (Lezak *et al*. 2004).

Despite these barriers, there are reports of specific neuropsychological dysfunction in individuals with BN. The most consistent findings are with regards to attentional and executive dysfunction (Duchesne *et al*. 2004; Lena *et al*. 2004; Ferraro *et al*. 1997; Jones *et al*. 1991; and Laessle *et al*. 1989; 1990; 1992). In a previous systematic review of neuropsychological findings in eating disorders, Lena *et al*. (2004) reported that people with BN show impaired abilities in attention and problem solving, indicative of executive dysfunction. However, there are contradictory findings (e.g. Lovell *et al*. 1997; Lauer *et al*. 1999; and Black *et al*. 1997). Furthermore, some of the methodological issues (e.g. small sample size; measures of varying quality) were inherent in many of the studies, reducing the strength of the findings.

Other neuropsychological domains have also been shown to be affected in BN. There have been reports of poor decision making ability (Duchesne *et al*. 2004). Poor decision making has been proposed to be particularly pertinent to BN given its association with risky eating behaviours. For example, Boeke and Lokken (2006) and Liao *et al*. (2008) reported that individuals with BN often appear to ignore the negative consequences of their bingeing and purging behaviours, indicative of poor decision making ability. The investigation of central coherence is also an area of increasing interest (Lopez, Tchanturia, Stahl, Booth *et al*. 2008; Tokley & Kemps, 2007). However, the assessment of central coherence has so far focused on AN, with only little evidence being available on the presence or absence of this deficit in BN (Lopez *et al*. 2008a; Lopez *et al*. 2008b). Other studies have also indicated deficits in visuo-spatial functioning (e.g. Ferraro *et al*. 1997; Jones *et al*. 1991) and memory

(e.g. Ferraro *et al.* 1997; Beatty *et al.* 1990). Again, there are inconsistencies and limitations within the literature.

It is imperative to have a clearer understanding of the neuropsychological profile in BN in order to guide present and future treatment approaches. This has already occurred for AN. For example, Cognitive Remediation Therapy for anorexia nervosa (CRT-AN) has been developed as an alternative treatment for individuals with AN (Davies & Tchanturia, 2005; Tchanturia, Davies *et al.* 2007). CRT-AN has been proposed to engage individuals with AN who display cognitive deficits and who often cannot initially make use of traditional 'talking therapies'. So far, CRT has not been used with individuals with BN. However, there may be a need for adaptations within routine treatment for BN. Agras *et al.* (2000) and Wilson & Fairburn (2002) reported that neuropsychological dysfunction can interfere with CBT, the treatment of choice for individuals with BN. Thus, increased knowledge of the neuropsychological profile in BN will help clinicians tailor treatment approaches to suit the individual.

The purpose of this systematic review was to examine the current evidence for neuropsychological dysfunction in adults with a formal diagnosis of BN, relative to non-eating disordered controls. Since the publication of previous systematic reviews (Lena *et al.* 2004; Duchesne *et al.* 2004), additional studies have emerged which have specifically investigated differences in neuropsychological functioning between people with BN and controls. Furthermore, more recent studies have endeavoured to improve upon previous literature, increasing the robustness of the findings. Thus, the aim of this systematic review is to increase current understanding of

neuropsychological functioning in BN. By doing so, it is anticipated that there will be

implications for the future assessment and treatment of BN.

METHODOLOGY

Four electronic databases were searched: Embase (1980 – Week 18 2010), Psychinfo (1967 – Week 1 May 2010), OVID Medline (1950 – Week 4 April 2010) and Cochrane Central Register of Controlled Trials (2nd Quarter 2010). A search of Google Scholar was also conducted. To find articles relating to BN and eating disorders, the terms 'Bulimi$' and 'Eating disorder$' were used. To find articles relating to neuropsychology, the terms 'neuropsycholog$' and 'cognitive impairment' were used. The search terms were first entered individually, and were then entered in combination.

The titles and abstracts of the articles were reviewed in order to exclude non-relevant articles. The articles were included if the article included the assessment of neuropsychological performance in adults with a DSM-IV (American Psychiatric Association, 1994) or ICD-10 (World health Organisation, 1992) diagnosis of BN. Articles were excluded if (1) the sample included participants aged < 16 (because individuals under 16 are not fully developed cognitively and therefore cannot be compared to adult populations); (2) the article was not an original peer reviewed research article; (3) the sample included participants with an identified Axis II psychiatric co-morbid diagnosis; (4) there were ≤ 8 individuals with BN included in the study (because these studies were deemed to be insufficiently powered); (5) the BN participants were not reported separately within the results section; (6) the article did not compare the BN sample with a control group or normative data within the results section; (7) the study did not use any valid and reliable

neuropsychological measures; (8) and the study used the DSM-III or DSM-III-R

diagnostic criteria as opposed to the DSM-IV*.

*The DSM-III (American Psychiatric Association, 1980) did not include reference to

the shape and weight concerns associated with BN. Furthermore, the DSM-III did not

include frequency criterion for bingeing and purging. Both of these are included in

the DSM-IV (American Psychiatric Association, 1994) and DSM-IV-TR (American

Psychiatric Association, 2000). These adaptations have resulted in the diagnosis of

BN being much more restrictive (Ben-Tovim, 1988). The DSM-III-R (American

Psychiatric Association, 1987) does not operationalise what a binge constitutes,

making it more open to judgement. Secondly, the DSM-III-R gave a dual diagnosis of

AN and BN to people with AN who binged and purged at least twice monthly (Sunday

et al. 2001). This is now no longer the case, with individuals meeting criteria for AN

who binge and purge being classified into the binge-eating/purge subtype rather

than an additional diagnosis being given. Ben-Tovim (1988) found a greater than ten-

fold reduction in the frequency of the disorder when the DSM-III-R criteria were

applied. This has major implications in terms of what constituted a BN sample in

articles using DSM-III and DSM-III-R diagnostic criteria.

A scoring template was used for the remaining articles (see Table 1), whereby each

paper was rated on six areas of methodological quality. The criterion for this scoring

template was developed in collaboration with the co-authors of this paper. Existing

measures of methodological quality were used as an initial framework (e.g. the

Clinical Research Evaluation Schedule for Trainees, CREST) and then adapted to allow

specific areas relevant to the evaluation of neuropsychological functioning in BN to

be made. To assess inter-rater reliability, six papers were rated by two individuals;

the first author and one of the other authors.

Table 1: *Guidelines for assessing methodological quality of papers*

Use of valid and reliable neuropsychological measure	All or the considerable majority of measure(s) had strong evidence for their validity and reliability	Excellent (3)
	More than 50% of the measures had strong evidence for their validity and reliability	Good (2)
	Most measures had limited evidence for their validity and reliability	Limited (1)
Measure(s) used assessed the relevant area(s)* of neuropsychological functioning well	Excellent assessment of the relevant areas of neuropsychological functioning	Excellent (3)
	Good assessment of the relevant areas of neuropsychological functioning	Good (2)
	Limited assessment of the relevant areas of neuropsychological functioning	Limited (1)
Adequate sample size for comparisons between BN and NC or ND (Alpha at 0.05, power at 0.8, based on Cohen, 1977)	The sample was sufficient to detect a small ES	Excellent (3)
	The sample was sufficient to detect a medium ES	Good (2)
	The sample was only sufficient to detect a large or very large ES	Limited (1)
Matching of control / normative data with BN sample in terms of age and IQ	All measures were compared with well matched control or ND	Excellent (3)
	The considerable majority of measures were compared with well matched control or ND	Good (2)
	Most measures were not compared with well matched control or ND	Limited (1)
Appropriate reporting and application of statistics for comparisons between BN and NC / normative data	All statistics were clearly reported and seemed appropriate	Excellent (3)
	The considerable majority of statistics were clearly reported and seemed appropriate	Good (2)
	From the information provided, most statistics did not appear appropriate	Limited (1)
Sufficient data to calculate effect sizes when comparing BN and NC / normative data	There was sufficient data to calculate ESs for all measures	Excellent (3)
	There was sufficient data to calculate ESs for more than 50% of measures	Good (2)
	There was insufficient data to calculate ESs for most measures	Limited (1)

* Main areas of neuropsychological functioning = executive functioning, visuo-spatial processing/reasoning, memory, attention and central coherence. ES, Effect size; ND, Normative Data

The search produced 203 articles (see Fig 1). After reviewing the titles and abstracts

of those 203 articles, 194 were excluded based upon the exclusion criteria. Nine

articles remained for review.
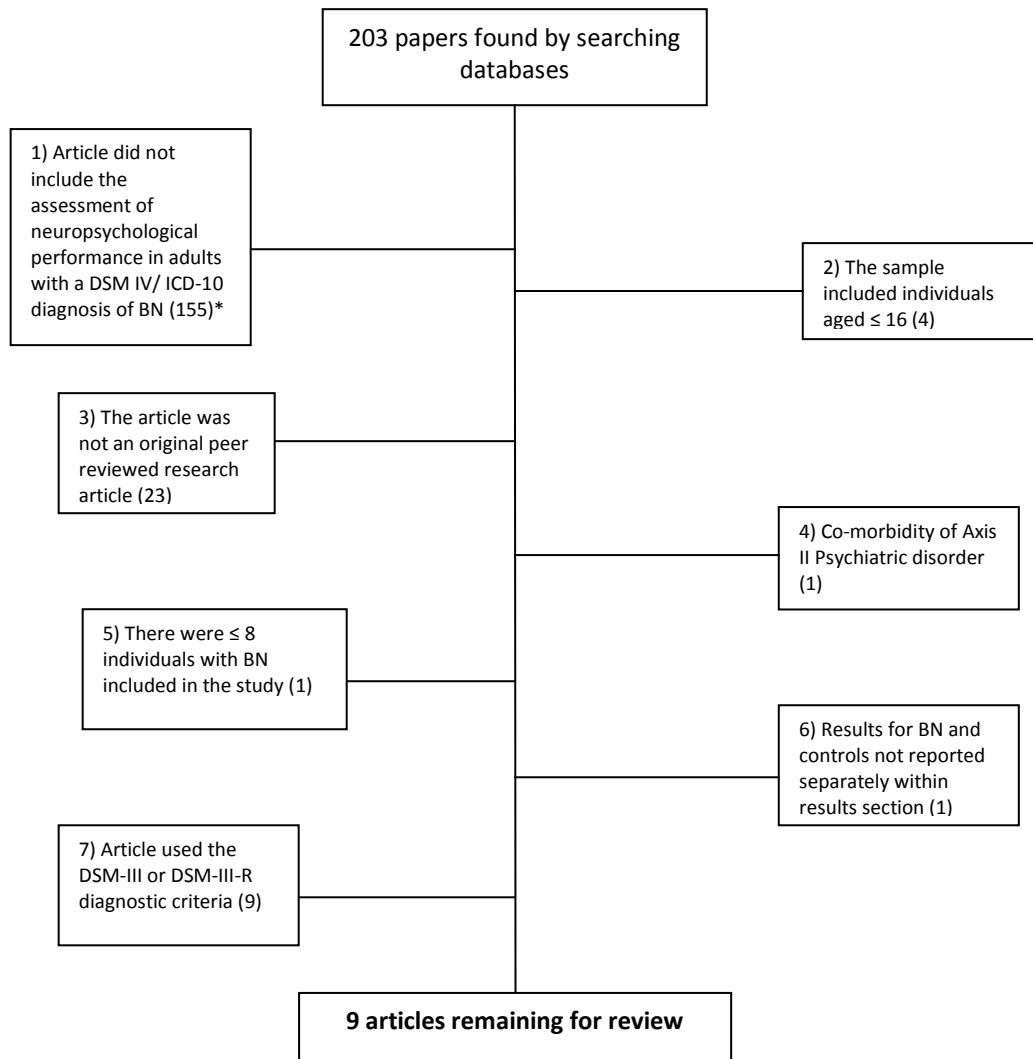
*Only those articles passing exclusion criteria 1 were considered for exclusion

criteria 2, 3, 4 etc

Fig 1: Flowchart summarising the number of articles found and reasons for excluding

Table 2 shows the ratings of the included articles on the six areas of methodological quality. Table 3 shows a summary of the main characteristics of the studies included in the review.

Table 2: *Methodological quality of papers*

Paper	Valid and reliable neuro-psychological measure	Measures assessed relevant areas of neuro-psychological functioning	Adequate sample size	Control / comparison group or normative data	Sufficient data to calculate Effect Size	Appropriate statistics	Total score (max score = 18)
Alvarez-Moya *et al*. 2009	Excellent	Limited	Limited	Excellent	Excellent	Excellent	14
Bosanac *et al*. 2007	Excellent	Good	Limited	Excellent	Excellent	Excellent	15
Brand *et al*. 2007	Excellent	Excellent	Limited	Excellent	Excellent	Excellent	16
Liao *et al.* 2008	Limited	Limited	Limited	Excellent	Limited	Excellent	10
Lopez *et al*. 2008a	Excellent	Excellent	Good	Excellent	Excellent	Excellent	17
Murphy *et al*. 2002	Excellent	Limited	Limited	Excellent	Good	Excellent	13
Murphy *et al.* 2004	Excellent	Limited	Limited	Excellent	Good	Excellent	13
Southgate *et al*. (2008)	Limited	Limited	Limited	Excellent	Excellent	Excellent	12
Tchanturia *et al*. 2004	Excellent	Excellent	Limited	Excellent	Excellent	Excellent	16

Ratings: Excellent = 3; Good = 2; Limited = 1

Table 3: *Summary table of articles reviewed*

Authors, Year	Aim	Sample	Measures *	Conclusions
Alvarez-Moya *et al*. (2009)	To compare executive functioning of pathological gamblers (PGs) and individuals with BN	**15 BN** **15 PG** **15 Controls**	**WCST, SCWT**	BN showed highest percentage of non-perseverative errors. BN demonstrated executive dysfunction relative to controls. This suggests that BN females exhibit difficulty in maintaining the ongoing set and are more vulnerable to distraction than controls.
Bosanac *et al*. (2007)	To compare executive, memory and visuo-spatial functioning of people with AN, BN and controls	**16 AN** (BMI ≤17.5) **12 AN** (BMI >18.5) **13 BN** **16 Controls**	**BT, CDR**	BN showed impairments in attention in comparison to controls. BN were also impaired on morse tapping, immediate word-recall delayed word-recall and motor tasks.
Brand *et al.* (2007)	To investigate decision making, relating to impulsivity, in people with BN	**14 BN** **14 Controls**	**GDT, CWIT, TMT, NMCST, TH, DS, BS, COWA, SAT, RCFT, VMLT**	In comparison to controls, BN show decision making deficits. Although the BN group scores on some attentional and executive tests were significantly lower than that of controls, attention and executive functions were not clinically impaired in the BN group.
Liao *et al*. (2008)	To investigate decision making in bulimia nervosa using the IGT.	**26 BN** **51 Controls** **29 AN**	**IGT**	BN performed poorly on the IGT. Impaired decision making was associated with obsessive-compulsive traits.
Lopez, Tchanturia, Stahl and Treasure (2008)	To examine central coherence in BN and AN	**42 BN** **42 Controls**	**RCFT, EFT, BD, HRT, SCT**	BN group showed superiority in local processing and difficulties in global processing indicative of weak central coherence.

Murphy *et al*. (2002)	To examine the acquisition of conditional -associations in people with eating disorders	**16 AN** **16 BN** **16 Controls**	**Buschke SRT, COWA, RCFT SDMT, TMT, CAL**	There were no significant differences between the BN and control group on the CAL task. There was no significant difference between the BN and NC groups on all other neuropsychological measures.
Murphy *et al*. (2004)	To examine the acquisition of conditional associations in AN, BN and OCD.	**16 AN** **16 BN** **16 OCD** **16 Controls**	**BSRT, COWA, SDMT**, **RCFT, TMT CAL**	There were no significant differences between the BN and control groups on the CAL task. There was no significant difference between the BN and control groups on all other neuropsychological measures.
Southgate, Tchanturia and Treasure (2008)	To investigate information processing style in ED	**14 BN** **20 AN** **26 Controls**	**MFFT**	There was no significant difference between the controls and BN groups in the visual field task. BN displayed the least impulsivity between the three groups.
Tchanturia, Anderluh *et al*. (2004)	To examine differences in cognitive flexibility in AN, BN and controls	**34 AN** **19 BN** **35 Controls**	**TMT, BrixT, VF, HAT, CatBat , PST**	BN showed impairment on the CatBat and HIT tasks. The BN group showed deficits in mental flexibility and perceptual shift.

Sample: AN = anorexia nervosa; BN = bulimia nervosa; ED = Eating disorders; PG = pathological gamblers; OCD = obsessive compulsive

disorder**. Measures***: Wisconsin Card Sorting Test (WCST); Stroop Colour-Word Test (SCWT); Bechara Social Decision-Making Task (BT);

Cognitive Drug Research Battery (CDR); Game of Dice Task (GDT); Colour-Word Interference Test (CWIT); Trail Making Test (TMT); Nelsons

Modified Card Sorting Test (NMCST); Tower of Hanoi (TH); Digit span (DS); Block Span (BS); Controlled Oral Word Association Test (COWA);

Selective Attention Test (SAT); Rey-Osterrieth Complex Figure (RCFT); Auditory Verbal Learning Test (RAVLT); Matching Familiar Figures

Test (MFFT); Brixton Test (BrixT); Verbal Fluency (VF); Haptic Illusion Test (HIT); The Cat Bat Task (CatBat); Picture Set Test (PST); Iowa

Gambling Task (IGT); Embedded Figures Test (EFT); Block Design (BD); Homograph Reading Test (HRT); Sentence Completion Task (SCT);

Buschke Selective Reminding Test (BuschkeSRT); Symbol –Digit Modalities Test (SDMT); Conditional-Associative Learning task (CAL);

Babcock Story Recall test (BSRT). * See Lezak, Howieson and Loring (2004) and Spreen and Straus (1991) for references for these tests.

Attention

According to Lezak et al. (2006), attentional defects can be defined as distractibility or an impaired ability for focused behaviour. Four studies in this review investigated attention (Murphy *et al*. 2002; 2004; Bosanac *et al*. 2007; Brand *et al*. 2007). The results show limited evidence of attentional deficits in BN.

Three papers reported no significant difference in attentional ability between people with BN and controls (Brand *et al*. 2007; Murphy *et al*. 2002; 2004) using the Selective Attention Test (SAT) and Trail Making Test - Part A (TMT - A). However, this may be as a result of all three papers being limited by small sample sizes (N=14; 16; and 16 respectively). Retrospective power calculations for these studies indicate that both Brand *et al*. (2007) and Murphy *et al*. (2002; 2004) would have required 50 individuals in each group in order to be sufficiently powered (with power at 0.8). Murphy *et al*. (2002; 2004) were also limited by their only having used a small range of neuropsychological measures to assess this domain.

Bosanac *et al*. (2007) used a composite score based upon three subtests within the Cognitive Drug Research Battery (CDR) to assess attention. They found attention to be significantly impaired in people with BN in comparison to controls. Despite being rated 15/18 on methodological quality (see Table 2), the study was based on a sample of only 13 individuals with BN and all three measures of attention were speed related. As other researchers have noted, these impairments may reflect psychomotor slowing rather than executive or attentional dysfunction (Tchanturia *et al*. 2004).

Memory and learning

Four articles investigated memory and learning in individuals with BN (Bosanac *et al*. 2007; Brand *et al*. 2007; Murphy *et al*. 2002; 2004). Although some findings were indicative of memory dysfunction, limitations within these studies reduce the evidence for memory and learning deficits in BN.

Bosanac *et al*. (2007) reported immediate and delayed word recall to be impaired in individuals with BN in comparison to controls. However, the sample size was small (N=13) and there was some incongruence between the terminology used to describe the neuropsychological domains being examined in the abstract and the factors investigated in the results. Therefore, it was not clear from the article exactly what neuropsychological domain was being examined.

Brand *et al*. (2007) investigated anterograde memory using the RCFT (delayed recall) and the AVLT and found that the BN group performed significantly worse than controls on both measures (Cohen's d = 1.15 for RCFT; Cohen's d = .82 for AVLT). Despite performing worse than controls, the BN group performed within the normal range. As the BN group still scored within the normal range, this paper does not show evidence of significant memory and learning dysfunction in BN; only that BN performance was may be at the lower end of normal expectations. This paper scored highly (16/18) on the six areas of methodological quality due to the study's use of valid and reliable neuropsychological measures and excellent assessment of the relevant areas of neuropsychological functioning. However, the limited sample size

(N=14) would warrant some caution in the interpretation of these results prior to the study being replicated.

Murphy *et al*. (2002; 2004) investigated the acquisition of conditional-associations in BN and controls using the Conditional-Associative Learning Task (CAL task). Despite a trend for better performance in the BN group, no significant difference was found between the groups.

Executive functioning

According to Lezak *et al*. (2006), executive functions form the basis of many cognitive, emotional and social skills. Lezak *et al.* (2006) described the four main components to executive functions as volition; planning; purposive action; and effective performance. Cognitive flexibility and decision making can both be defined as executive functions, and will be described below.

Cognitive flexibility

Cognitive flexibility, also referred to as set shifting, is the ability to shift between two competing stimuli simultaneously. Five studies measured cognitive flexibility using six different measures (Murphy *et al*. 2002; 2004; Tchanturia *et al*. 2004; Brand *et al*. 2007; Alvarez-Moya *et al.* 2009). Of those papers, three found evidence of some deficits in cognitive flexibility in individuals with BN relative to controls (Tchanturia *et al*. 2004; Brand *et al*. 2007; Alvarez-Moya *et al.* 2009). These three papers were rated more highly on methodological quality than those that did not find significant

differences and thus there appears to be some robust evidence of deficits in cognitive flexibility in BN.

Tchanturia et al. (2004) examined four factors of cognitive flexibility: simple alteration, mental flexibility, perseveration and perceptual shift. The BN group was found to be more impaired than controls on the factors 'mental flexibility' and 'perceptual shift', indicative of deficits in specific elements of cognitive inflexibility. Studies have found mixed results on comparisons between BN and control groups on the Trail Making Test - Part B (TMT - B) performance, a test traditionally used as a measure of cognitive flexibility. Tchanturia et al. (2004) and Murphy et al. (2002; 2004) reported non-significant differences on this measure in contrast to Brand et al. (2007), who found a significant difference between the groups using this task, with a large effect size (0.77). It is possible that the variation in findings on TMT - B performance may be due to the sampling methods used by these studies.

Alvarez-Moya et al. (2009) investigated cognitive flexibility using the Stroop Colour-Word Test (SCWT). No significant difference was found between the groups on this task. Alvarez-Moya et al. (2009) also used the Wisconsin Card Sorting Test (WCST), a measure of abstract thinking, problem solving, concept attainment and perseveration (Spreen & Strauss, 1991). The BN group had significantly higher rates of non-perseverative errors than controls. Alvarez-Moya et al. (2009) postulated that this was suggestive of people with BN having difficulty maintaining information about ongoing rules and being more vulnerable to distraction.

Impulsivity / Decision making

Three papers examined decision making in BN and provided some evidence of decision making deficits in BN relative to controls (Brand *et al.* 2007; Southgate *et al*. 2008; Liao *et al*. 2008). However, these papers would warrant replication using larger sample sizes and additional valid and reliable neuropsychological measures in order to strengthen the findings.

Brand *et al.* (2007) investigated decision making using the Game of Dice Task (GDT) and found that individuals with BN made disadvantageous decisions significantly more frequently than controls. This study had a high standard of methodology (score=16/18) due to the study's use of valid and reliable assessment measures and excellent statistical analysis. However, the study was based on a fairly small sample and the GDT had not previously been used with people with BN. Therefore, it would seem necessary to show some caution regarding the generalisability of the findings prior to the study being replicated.

Southgate *et al*. (2008) generated an 'impulsivity' score using the Matching Familiar Figures Test (MFFT). Although the BN group displayed less 'impulsivity' than controls, this difference was not statistically significant. As with most of the studies in this review, it seems likely that this study was underpowered. It was also limited in that it only employed one measure. Despite the MFFT having previously been used in the assessment of cognitive style in individuals with eating disorders (Kaye *et al*. 1995; Toner *et al*. 1987), there is insufficient evidence to determine the measure's validity and reliability with an eating disorder population.

Liao *et al*. (2008) investigated decision making using the Iowa Gambling Task (IGT), which measures whether individuals can prioritise immediate gratification over long-term gain. They reported that the BN group were significantly poorer on this task in comparison to controls, with the BN group making more disadvantageous decisions. However, similar to Southgate *et al*. (2008), no assessment was carried out of other neuropsychological domains which may have impacted on performance on the task. This limitation means that it is not possible to ascertain whether the poorer performance in the BN group represented a decision making deficit *per se*, or whether it was a consequence of another cognitive deficit e.g. attention.

Central coherence

Lopez *et al*. (2008a) defined weak central coherence as the tendency to process information in parts rather than the whole, with a relative difficulty in global or integrative thinking. Only two studies investigated central coherence in BN (Lopez *et al*. 2008a; Southgate *et al*. 2008). Despite one very good quality paper showing robust evidence of weak central coherence in BN, there is insufficient evidence as yet to conclude that individuals with BN possess a deficit on this domain.

Lopez *et al*. (2008a) examined central coherence (verbal, visual, speed and accuracy) in individuals with BN using the Rey Complex Figure Test (RCFT), Sentence Completion Task (SCT), Homograph Reading Task (HRT), Embedded Figures Test (EFT) and the Un-segmented / segmented Block Design Test (BD). With the exception of the BD task, all results were indicative of a pattern of weak central coherence in BN. In comparison to controls, the BN group showed weaker performance in tasks that

required a global processing style (RCFT, SCT, HRT), and a superior detailed-level processing style. This paper was of a high methodological standard (score = 17/18) and was the only paper to be rated 'good' in terms of sample size. This paper scored 'excellent' on five out of six areas of methodological quality.

Southgate *et al*. (2008) investigated information processing biases (impulsivity and efficiency) in individuals with AN, BN and controls using the Matching Familiar Figures Test (MFFT). This paper did not find a significant difference between the BN and controls on this measure. However, this study did have three out of six methodological limitations. The main limitation was its use of only one measure, which is not a valid and reliable measure of central coherence. Furthermore, as with many research studies, the study had a small sample size. Taken alone, this study cannot be taken as a reliable assessment of central coherence.

Visuo-spatial functioning

Four studies investigated visuo-spatial functioning (Murphy *et al*. 2002; 2004; Bosanac *et al*. 2007; Lopez *et al*. 2008a). The results of this review suggest limited evidence of visuo-spatial functioning deficits in BN relative to controls.

Murphy *et al*. (2002; 2004) investigated visuo-spatial functioning (constructional ability and memory) in people with BN and controls using the RCFT. These studies did not find any significant difference between BN and controls on either the immediate or delayed component of the RCFT. These findings are in contrast to those of Lopez *et al*. (2008a), who reported that the BN group obtained significantly

lower accuracy scores on both the copy and recall trials of the RCFT and on the percentage of recall. Lopez *et al*. (2008a) was rated more highly on methodological quality than Murphy *et al*. (2002; 2004), scoring 17/18 as opposed to 13/18. The higher score was achieved by carrying out an excellent assessment of the relevant areas of neuropsychological functioning and also by presenting sufficient data to enable the calculation of effect sizes. However, as this is the only paper that reported a significant difference between the groups, this study would warrant replication.

Bosanac *et al*. (2007) investigated visuo-spatial functioning in people with BN using subtests within the CDR. However, it was not clear from the article exactly which subtests were used to assess this domain. Despite this, Bosanac *et al*. (2007) did not report any difference in visuo-spatial functioning between the groups.

DISCUSSION

The aim of this review was to examine the evidence for neuropsychological dysfunction in individuals with BN relative to controls in the context of the growing interest in the neuropsychological functioning of individuals with eating disorders.

There was limited robust evidence of attentional, visuo-spatial and memory deficits in individuals with BN. These findings are in contrast to previous research not included in this review (e.g. Jones *et al*. 1991; Ferraro *et al*. 1997). However, the papers included in this review improve upon previous research in several ways. The participant sample in the included papers all had a formal DSM-IV diagnosis of BN (i.e. not including atypical BN), no co-morbid Axis II psychiatric disorders, and were all over the age of 16. Furthermore, all articles were published in peer reviewed journals and involved the comparison of BN with non-eating disordered controls. Despite these methodological improvements which increase the robustness of this review's findings, there continued to be limitations inherent in many of the included papers. Thus, it is not necessarily the case that individuals with BN do not have attentional, visuo-spatial and memory deficits. It would be useful for future research to take account of the limitations detailed in this review and replicate existing robust studies to increase the evidence base.

The current review found only one methodologically robust study showing evidence of weak central coherence in individuals with BN relative to controls (Lopez *et al*. 2008a). However, the assessment of central coherence in BN is a relatively new area

of interest, having been more frequently the focus of research in AN. The literature would benefit from more studies of a similar standard to Lopez *et al.* (2008a) in order to increase the evidence base. Future studies could achieve this methodological standard by using reliable and valid assessment measures; having a participant sample of a sufficient size to detect effects in the study; and by comparing the BN sample to a control sample.

There were consistent reports of executive dysfunction in BN relative to controls. This was in the areas of cognitive flexibility and decision making. The presence of executive dysfunction in BN, including poor decision making, has been reported previously (e.g. Boeke & Lokken, 2006; Duchesne *et al.* 2004). These findings have clinical implications in terms of the assessment and treatment of individuals with BN. For example, it has been proposed that deficits in decision making and other executive functions can have a negative impact on an individual's ability to engage with or benefit from cognitive behavioural therapy (CBT), which is the treatment of choice for people with BN (Agras *et al.* 2000; Wilson & Fairburn, 2002).

There were limitations in all included studies. The primary limitation was the small sample size, which often resulted in the studies having insufficient statistical power to detect any effects (Clark-Carter, 2006). This has resulted in the findings of the present review remaining somewhat tentative. Although recruitment is often problematic in clinical settings, some other areas of methodological quality could be improved. For example, studies would be strengthened by using more valid and reliable neuropsychological measures. Another limitation within the included papers

was having only examined one neuropsychological function using one measure. As Duchesne *et al*. (2004) and Brand *et al*. (2007) pointed out, it is important for researchers to assess a range of neuropsychological functions, as one neuropsychological function can impact on another.

This is currently the only systematic review to have been conducted on the neuropsychological functioning of individuals with BN. In addition to increasing the evidence base in an area which only infrequently is the focus of research, this review included the assessment of the quality of included papers, adding confidence in the findings. However, this review is not without limitations. Some evidence of neuropsychological findings in BN may have been overlooked as key researchers were not contacted. Secondly, there were a number of exclusion criteria applied and the findings may have been different if a broader definition of BN was used. However, focusing upon well defined groups can be beneficial as it highlights how findings can differ (e.g. between current DSM-IV diagnoses and earlier ones). Furthermore, it was decided that including some of the earliest papers of neuropsychological findings in BN (many of which were of a poorer quality) was not appropriate. For example, many papers not included in this review used measures of varying quality, which would leave difficulties in determining the validity of these findings or in comparing them to other studies. The aim was to be more exclusive, reducing the lack of clarity in the area.

In summary, the review highlights some consistent evidence of neuropsychological dysfunction in cognitive flexibility and decision making tasks in individuals with BN

relative to controls. These are likely to reflect limitations in specific areas of executive functioning. An assessment of decision making and cognitive flexibility would be a useful addition to the assessment process in order for therapists to adapt the treatment approach to the needs of the individual. There is only limited evidence of attentional, visuo-spatial, memory and central coherence deficits in BN. The current literature is limited by small sample size and variability in the type, quality and number of measures used to rate ability in specific cognitive areas. Many of the studies would warrant replication with larger sample sizes, using a range of valid and reliable assessment measures which examine a range of neuropsychological domains.

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<u>Empirical Study</u>

A Comparison of Neuropsychological Test Performance on the

Ravello Profile between Bulimia Nervosa and Anorexia

Nervosa

1.1: INTRODUCTION TO STUDY

The investigation of neuropsychological functioning in individuals with eating disorders has primarily focused on Anorexia Nervosa (AN), and there is now a general consensus that AN is associated with some neuropsychological dysfunction (Lena *et al*. 2004). However, the neuropsychological functioning of individuals with Bulimia Nervosa (BN) is less understood. Although BN has been associated with neuropsychological dysfunction, there are fewer robust studies available and many have used a variety of non-standardised tests or have not used a robust experimental design. Overall, there is no clear understanding regarding the neuropsychological strengths and weaknesses in people with BN.

Frampton *et al*. (2009) are currently investigating the neuropsychological profile of people with AN using the Ravello Profile. The Ravello Profile is a battery of validated, easily accessible and standardised neuropsychological tests which have been proposed to cover the key neuropsychological deficits found in AN: executive functioning, central coherence and visuo-spatial memory. It is anticipated that the results of this large scale study (Frampton *et al*. 2009) will provide a reliable neuropsychological profile for AN, aiding in future assessment and treatment.

The literature on the neuropsychological functioning in BN is less developed than that for AN. Without a consistent profile of strengths and weaknesses for people with BN, it is not possible to develop a unique battery of neuropsychological tests, such as the Ravello Profile for AN. However, there is some literature to suggest that

the areas of cognition assessed within the Ravello Profile also apply to BN; namely central coherence and executive dysfunction. Therefore, it seems appropriate to use the Ravello Profile to examine the neuropsychological profile of people with BN. This will be achieved by comparing an AN, BN and a non-eating disordered control group on the neuropsychological measures contained within the Ravello Profile. Any differences between the groups may denote the need for possible adaptations to the Ravello Profile for use with BN in the future.

1.2: HYPOTHESES

Hypothesis 1: The AN group will perform worse than the BN group and control group on measures of visuo-spatial functioning

Hypothesis 2: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on a measure of central coherence

Hypothesis 3: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on measures of executive functioning

Hypothesis 4: The BN group will perform worse than both the AN group and the control group on measures of error rates

CHAPTER 2: METHODOLOGY

2.1 DESIGN

This is a between subjects design, comparing scores on the Ravello Profile between three groups: Anorexia Nervosa (AN), Bulimia Nervosa (BN) and a non eating disordered control group (controls). To examine possible confounding variables, participants were screened for symptoms of low mood, anxiety, eating disorder symptomatology, IQ, age and BMI. There were significant differences found between the control group and both eating disordered groups on all of the above variables. As expected, the AN and BN groups differed from each other in terms of age and BMI but not on the other variables.

2.1.1 Ethics

Ethical approval was granted by the University of Edinburgh (Appendix 4). This study was also reviewed and approved by NHS Lothian's Research Ethics Committee (Appendix 5) and both NHS Highland and NHS Tayside gave management approval for the research to be carried out (Appendix 6 and 7 respectively). The Research and Development Department in NHS Highland acted as sponsor for this study (Appendix 8). The University of Edinburgh provided Indemnity (Appendix 9).

2.1.2 Ethical Issues

The research involved individuals with a formal diagnosis of BN undergoing a battery of neuropsychological assessments lasting up to two hours. It was acknowledged that this was a potentially vulnerable group of patients, and all care was taken to

address ethical issues in relation to their requirements. The current study collected data from BN participants and controls. Each participant was informed that they were not obliged to participate. If they chose to participate, they were asked to provide consent (Appendix 2) and were informed that they could opt out if they did not wish to continue. They were informed that their routine treatment would not be affected by their participation or by their declining to participate

People with eating disorders (EDs) may become distressed when completing screening measures relating to their eating disorder. It was decided in advance that the assessment would not continue should this occur and that the researcher would provide support to the participant.

The researcher was a clinical member of NHS Highland's Eating Disorder Service. Therefore, potential participants were recruited from this service. On occasion, the researcher asked an individual who was being seen clinically whether they wished to participate. Specific care was taken to ensure that these individuals did not feel obliged to participate.

2.2 PARTICIPANTS

The present study involved a comparison of scores on the Ravello Profile (Frampton *et al*. 2009; Davis *et al*. in press) between three groups. Group A consisted of the anonymised data of 60 participants from an existing database of individuals with a formal diagnosis of AN (American Psychiatric Association, 1994) collected for an

ongoing study (Frampton *et al*. 2009). This study is entitled 'the neuro-cognitive profile of Anorexia Nervosa' (REC ref: 07/H0803/195). The 60 participants were all over the age of 16 and consented for their data to be used for the purposes of Ravello Profile research.

Group B consists of those with a formal DSM-IV diagnosis of BN (American Psychiatric Association, 1994). The BN group (N=22) comprised participants from outpatient eating disorder clinics in NHS Highland and NHS Tayside. These individuals gave consent to take part in the study (Appendix 2). The 22 BN sample included two individuals from the anonymised Ravello Profile database who had subsequently been diagnosed as having BN rather than AN.

Group C was a control group (N=20) recruited to enable a comparison between eating disordered and non-eating disordered populations. Participation was entirely voluntary. The control group comprised NHS staff, acquaintances of the researcher, and people who showed an interest in participating after having seen a poster. All controls were given an adapted participant information sheet (Appendix 11) and consent form (Appendix 12) in advance and were given an opportunity to ask any questions before deciding whether they wished to participate.

A power analysis was undertaken in order to calculate how many participants would be required to detect any effects in the study (see section 3.1. for further details). A moderate to large effect size (0.65) was estimated, based upon two studies using similar measures to compare neuropsychological performance in BN and AN (Mobbs

et al. 2008; Lopez *et al*. 2008a). Both papers were deemed to be of an appropriate quality of design. Using a significance level of 0.05 and power at 0.8, Cohen (1992) estimates that thirty participants would be required per group.

In total, 27 individuals with BN were approached. Six individuals declined to participate and one had been invited to participate by another therapist but did not meet diagnostic criteria for BN. Therefore, of those 27 who were approached, 20 (74%) consented to participate. Including the two participants recruited by Frampton *et al*. (2009), this resulted in a sample of 22 in the BN group (see 3.1 for further details). For the control group, 20 potential participants were approached and all agreed to participate in the study after having read the participant information sheet (Appendix 11) and consent form (Appendix 12).

2.2.1 Inclusion and Exclusion Criteria

For the recruitment of Group B (BN), potential participants were included if they met diagnostic criteria for BN (American Psychiatric Association, 1994). Potential participants were excluded if: they had an IQ of less than eighty five (as an IQ of less than eighty five can confound performance on neuropsychological tests). IQ was assessed for all potential participants using two subtests included on the Ravello Profile. No participant was excluded on the basis of IQ. Potential participants were also excluded if they were not fluent in English (as the neuropsychological tests in the Ravello Profile were developed and validated in English speaking populations) or had previously undergone neuropsychological testing (as practice effects can impact on an individual's performance). No participants were excluded on these bases.

Finally, participants were excluded if they were under the age of seventeen or not attending adult services. No maximum age limit was set. For the recruitment of Group C (control group), participants were excluded if: they had an eating disorder (as measured by the clinical cut-off score on the Eating Disorder Examination – Questionnaire, EDE-Q); they had an IQ of less than eighty five; they were not fluent in English; they had previously undergone neuropsychological testing; and if they were under the age of seventeen or not attending adult services.

2.3 MEASURES

The Ravello Profile was developed by a group of specialist eating disorder researchers and clinicians who aimed to produce a global standard cognitive profile for AN (Frampton *et al*, 2009; Davis *et al*. in press). The Ravello Profile has been proposed to cover the key neuropsychological deficits found in AN; executive functioning, central coherence and visuo-spatial memory. Some measures in the Ravello Profile also included error rate analyses, an area of interest in the present study. Due to the lack of clarity with regards to the key neuropsychological deficits found in BN, it was decided that a comparison on all tests within the Ravello Profile would be conducted. However, rather than comparing group scores on all outcome measures within each test (which would increase the likelihood of finding type 1 errors), particular outcome measures were chosen based upon previous research. It was anticipated that any differences or similarities found between the groups on these measures would increase the evidence base for neuropsychological findings in eating disorders and guide future researchers who aim to utilise or develop another profile of measures for use in BN.

The Ravello Profile consists of the following measures: Hayling Sentence Completion Test (Burgess & Shallice, 1997); Brixton Spatial Anticipation Test (Burgess & Shallice, 1997); two subtests from the Wechsler Abbreviated Scale of Intelligence (WASI, Wechsler, 1999) (Vocabulary and Matrix Reasoning); Rey Complex Figure Task (RCFT, Meyers & Meyers, 1995); and four subtests from within the Delis-Kaplan Executive Function System (D-KEFS; Delis *et al*. 2001a): namely the Colour-Word Interference Task; Trail Making Task; Verbal Fluency Task and the Tower Task. See Table 2.1 for the order of tests administered. Specific outcome measures within each of these subtests were compared across the groups, as described below and in the hypotheses section.

The following measures were used to screen for eating disorder symptomatology and co-morbid mental health problems: The Beck Depression Inventory (BDI-II, Beck, Steer & Brown, 1996), State/Trait Anxiety Inventory (STAI, Spielberger *et al*. 1983), Beck Anxiety Inventory (BAI; Beck & Steer, 1990) and the Eating Disorders Examination - Questionnaire (EDE-Q, Fairburn & Beglin, 1994).

Measures of Executive Functioning

Executive functions refer to a group of neuropsychological domains. For example, planning, rule formation, self monitoring, cognitive flexibility and inhibition are all specific executive functions (Lezak *et al*. 2004). A number of measures included in the Ravello Profile assess these specific domains. Therefore, they were chosen in order to reflect as many domains of executive function a possible.

The Hayling Sentence Completion Test (Burgess & Shallice, 1997) is primarily a measure of verbal inhibition. The test consists of two sections; the first asks the participant to complete sentences with a congruent verbal response, which assesses response initiation and initiation speed. The second part asks the participant to complete sentences with an incongruent verbal response, which assesses verbal inhibition and response suppression. The second part also records the participant's time to respond, allowing the examiner to assess for impulsivity. Three separate scaled scores are then combined which generates an overall total scaled score. This was the outcome measure used in the present study.

In terms of internal consistency, Burgess and Shallice (1997) found split-half reliability coefficients to be lower than desirable for healthy adults. Coefficients were low for Hayling 1 time (.35, at $p<.001$) and error score (0.41, $p<.001$), but good for Hayling 2 time (0.83, $p<.001$). The total score comprises all three of these outcome measures. Test–retest reliability was found to be adequate for total score (.76, at $p<.001$), which is the outcome measure used for comparisons between groups in the present study. The task has been shown to have moderate correlations (.64) with other measures of executive dysfunction, including the Tower of London test (Marczewski *et al*. 2001).

The Brixton Spatial Anticipation Test (Burgess & Shallice, 1997) is used to measure flexibility and rule formation. This test asks the participant to predict the next location of a blue circle from a choice of ten, based on previous presentations. According to Burgess and Shallice (1997), there are three broad classes of error;

perseverations; the misapplication of a strategy; or guessing or bizarre responses. Thus, this test measures idiosyncratic and maladaptive behaviour, in addition to measuring an individual's ability to detect and follow a rule. An overall total error score is calculated, which is converted into a scaled score. The total number of errors (raw score) was used for group comparisons in the present study as raw scores render more of a range of scores than scaled scores.

This test has been validated and used in previous studies within the field of eating disorders (e.g. Tchanturia, *et al*. 2004; Tchanturia, Morris, *et al*. 2004; Holliday *et al.* 2005). In terms of internal consistency, Burgess & Shallice (1997) reported that split-half reliability coefficients for total score was moderate 0.62, p<.001) among a healthy sample (N=121). Test-retest reliability for total score on the Brixton Test was 0.71 (p<.001) among a healthy sample (N=31).

The following section details four subtests which are contained within the Delis-Kaplan Executive Function System (DKEFS; Delis *et al*. 2001): the Trail Making Test, Colour-Word Interference Test, Verbal Fluency Test and Tower Task. The D-KEFS is a set of nine stand alone executive tests co-normed on a large (N=1750) and representative sample. Some of the nine subtests are relatively new, whereas others are modifications of pre-existing clinical or experimental tests. All four subtests used within the Ravello Profile are modifications of pre-existing tests. As a result, there is a large body of literature regarding the validity of these four measures. Raw scores rather than scaled scores were used for group comparisons for the same reasons as was described previously.

All nine subtests have been examined for validity and reliability using analyses of internal consistency (split-half coefficients) and test-retest reliability. A test-retest reliability coefficient of 0.77 was reported for the Trail Making Test - Motor Speed; 0.80 for the Verbal Fluency - Category Fluency; and 0.80 for the Tower Task – Achievement Score (Homack *et al*. 2005). For the Colour-Word Interference Test, test-retest correlations ranged between .62 to .76. However, other scores within the same four subtests demonstrated lower correlations, indicating that some outcome scores within the four measures are more reliable than others. Moderate to high split-half reliabilities were reported for the Verbal Fluency – Letter Fluency condition (.68-.90) and Colour-Word Interference Test (.62-.86). Moderate to good split-half reliabilities were also reported for the Trail Making Test and Tower Test (ranging from .50-.80 depending on the specific outcome measure being examined). Low to moderate split-half reliabilities were reported for the Verbal-Fluency – Category Switching total correct (.37-.68).

The Colour–Word Interference Task was used to measure cognitive inhibition. This is based on the Stroop (1935) procedure, which requires participants to inhibit an over learned verbal response in order to generate a conflicting response. In addition to looking at verbal inhibition, this task also assesses cognitive flexibility.

The Trail Making Task is a measure of switching ability, first developed by U.S. Army psychologists as part of the Army Individual Test Battery (1944). This task has five conditions, all of which involve the participant completing a 'connect the circle' task. The primary executive function task is the Number-Letter Switching condition

(condition 4), a visuo-motor sequencing procedure which measures flexibility of thinking. The other conditions measure visual scanning, number sequencing, letter sequencing, and motor speed in drawing lines.

The Verbal Fluency Task was used as a measure of verbal fluency. Verbal fluency examines an individual's ability to generate lists of words fluently in an effortful, phonetic format. The task is composed of three conditions: letter fluency (generating a list of words which begin with particular letters), category fluency (generating a list of words within particular categories, condition 2) and category switching (generating two lists of words from different semantic categories, then alternating between them). For the purpose of the current study, only verbal fluency - total raw score was used within the analysis.

The Tower Task was used to measure cognitive inhibition. This test requires participants to move disks of varying size across three pegs to build a target tower in the fewest number of moves possible, whilst following two rules. According to Delis *et al*. (2001a), the Tower Task measures several key executive functions, including spatial planning, rule learning, inhibition of impulsive responding, inhibition of perseverative responding, and establishing and maintaining the instructional set.

Measures of Visuo-spatial Memory

The Rey Complex Figure Test (Meyers & Meyers, 1995) was used as a measure of visuo–spatial memory. This test consists of three conditions. The copy trial asks participants to copy a complex visual stimuli or 'complex figure'. This measures

visuo-spatial constructional ability. This task is also timed. The immediate recall condition asks participants to recall the same visual stimuli from memory three minutes after the copy trial is completed. The delayed recall condition asks participants to recall the same visual stimuli by memory thirty minutes after the end of the copy trial. Both conditions two and three measure visuo-spatial recall memory. Four scores were compared in the present study: copy raw score; time to copy raw score; immediate recall raw score; and delayed recall raw score.

Meyers and Meyers (1995) described the validation of the RCFT. Inter-rater reliability coefficients for total score was excellent, ranging from .93 - .99 (median coefficient of .94). It has good test-retest reliability coefficients of .76-.89. The discriminant validity of the RCFT was examined by correlating the RCFT raw scores from a normative participant sample (N=601 adults) with a heterogeneous sample of patients with brain dysfunction (N=100). For the normative sample, moderate correlations were found between copy (raw score) and immediate recall (.329) and delayed recall (.378). Immediate and delayed recall trials were highly correlated at .88. The RCFT was found to have good construct validity. Significant correlations were found between the RCFT and the Benton Visual Retention Test (BVRT; Sivan, 1992) and Trail Making Test (TMT; Army Individual Test Battery, 1944).

Measure of Central Coherence

The concept of central coherence refers to the ability to achieve a balance between efficiency and attention to detail. Lopez *et al*. (2008a) defined weak central coherence as the tendency to process information in parts rather than the whole,

with a relative difficulty in global or integrative thinking. To measure central coherence, an additional method of scoring the copy condition of the **Rey Complex Figure Test** was applied (see Appendix 10 for further details). This scoring system, known as the Central Coherence Index (CCI) has been used in other studies of central coherence in eating disorders (Lopez *et al*. 2008; Lopez *et al*. 2008a). The scoring system has also been applied by Frampton *et al*. (2009). The outcome measure for the current study was the overall central coherence index score (CCI). This score is calculated by adding the style index score and order index score, as described more fully in Appendix 10. A higher score in the CCI means a more coherent drawing style.

A strong correlation for the CCI index was found by Lopez *et al*. (2008) at .97. Inter-rater reliability was found to be .89 in their study, with an average Kappa co-efficient of .89.

Measure of Error Rates

Increased error rates are indicative of impulsivity, and some research suggests that individuals with BN show more errors in comparison to controls and individuals with AN (Meyers & Meyers, 1995; Burgess & Shallice, 1997). To examine this concept, error rates on four subtests on the D-KEFS (Delis *et al*. 2001) were examined and compared across the two groups. Error rates were based on: set loss and repetition raw scores on the **Verbal Fluency Test**; total corrected and uncorrected error raw scores on the **Colour-Word Interference Test** (condition 3); rule violation raw score on the **Tower Test**; mean time to first move raw score on the **Tower Test** (with a

significantly quicker time being indicative of impulsivity); and total error raw score

for the **Trail Making Task**.

According to Delis *et al*. (2001), set loss errors can be an indication of poor verbal

skills, a developmental verbal learning disability or relatively low intellectual skills;

repetition errors can be an indication of perseverative tendencies or a memory

problem; corrected and uncorrected errors can be an indication of perseverative

tendencies, the inability to self monitor, or a deficit in verbal inhibition / cognitive

flexibility; rule violation can be an indication of an impairment in establishing and

maintaining cognitive set; a significantly faster or significantly slower mean time to

first move can be an indication of either impulsivity (for faster mean first move time)

or activation problems and / or obsessive tendencies (for slower mean first move

time).

Measure of IQ

Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Two subtests

from the WASI were used as a measure of IQ; Vocabulary and Matrix Reasoning. An

overall IQ scored is generated based upon performance on both of these measures,

and this was the score used to compare the groups in the present study. This

method was consistent with that employed by Frampton *et al*. (2009). The WASI

Vocabulary subtest is a 42 item task which asks the examinee to orally define visually

presented words. It is a measure of expressive vocabulary and verbal knowledge.

The WASI Matrix Reasoning subtest involves visually presenting 35 incomplete

gridded patterns to the examinee, one by one. For each one, the examinee must

complete the grid by picking a correct response from a choice of five. It is a measure of nonverbal fluid reasoning and general intellectual ability.

Reliability coefficients for the Vocabulary subtest ranged between .90 - .98 (Fisher's *z*) and between 88-.96 for the Matrix Reasoning subtest. The reliability coefficients of the full scale IQ using both the Vocabulary and Matrix Reasoning subtests were higher still, with an average of .96. Test-retest reliability for a sample of 60 participants was good; .88 for the adult sample. Inter-rater reliability was also good; .98 for vocabulary.

Measures included for Background Information / Screening

The Beck Depression Inventory (BDI-II; Beck *et al*. 1996) is a widely used and easily accessible tool for detecting depression, and was used to measure presence and severity of depression for the current study. Several studies have examined the tool's validity and reliability in different populations (e.g. Moran & Mohr, 2005; Osman *et al*. 2004; Sprinkle *et al*, 2002), although the tool does not appear to have demonstrated validity and reliability with an eating disorder population. Despite that, this tool has been used in studies examining eating disorders (e.g. Boeke & Lokken, 2006; Mobbs *et al*. 2008). This measure was also used by Frampton *et al*. (2009).

The State / Trait Anxiety Inventory (STAI; Spielberger *et al*. 1983) was used to measure presence and severity of state and trait anxiety. The STAI comprises two separate self-report scales; STAI-T (Trait) and STAI-S (State). Evidence of the

construct validity of the STAI-T (Trait) and STAI-S (State) anxiety components is strong. When comparing controls and different psychiatric groups, the STAI-T was able to accurately discriminate between those with and without an anxiety symptom in all but one psychiatric group. The STAI-S was able to discriminate between individuals who were and were not in an immediate stressful event. The STAI-S and STAI-T have also been correlated with other measures of anxiety. For example, the STAI-T was correlated with the IPAT Anxiety scale (Cattell & Scheier, 1963) and the Taylor Manifest Anxiety Scale (TMAS; Taylor, 1953), with correlations noted to be relatively high (ranging between .73 - .85). There does not appear to be evidence demonstrating the tool's validity and reliability in eating disorder populations specifically. However, the measure has been used in studies of eating disorders (e.g. Grave *et al*. 2009).

The researcher had been informed that the STAI had been used by Frampton *et al*. (2009). It was deemed appropriate to use this measure in the present study to allow the groups to be matched. However, when examining the database, it transpired that Frampton *et al*. (2009) only started using the STAI at the end of 2009. Therefore, a sizeable proportion of the AN data for this measure was missing (N=38). Rather, Frampton *et al*. (2009) had made a late change to some of the screening measures used and opted instead for the Beck Anxiety Inventory (BAI; Beck, 1990). The BAI is a widely used measure of anxiety. There is much available research on the tool's reliability and validity in discriminating people with and without anxiety problems. Test-retest correlation coefficient was also high for a group of patients with anxiety problems (.75).

The Eating Disorders Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994) is

a self-report version of the Eating Disorders Examination (EDE; Fairburn & Cooper,

1993). Both the EDE and the EDE-Q are used to assess the cognitive and behavioural

symptoms of eating disorders. The EDE-Q is routinely gathered in eating disorder

services across the United Kingdom, and is used to aid in the diagnosis of individuals

with eating disorders. This measure was used by Frampton *et al*. (2009). The EDE-Q

involves the participant answering twenty eight questions relating to various aspects

of their eating cognitions and behaviour. Participants receive scores on four

subscales (Restraint, Eating Concern, Shape Concern and Weight Concern) and a

Global score. Fairburn and Beglin (1994) reported that correlations between scores

on the EDE and EDE-Q range between .78 and .85. The EDE-Q subscales are internally

consistent, with reported Cronbach's Alphas ranging from 0.78 to 0.93.

2.4 PROCEDURE

2.4.1.1 AN GROUP The AN group comprised participants from an existing

anonymised database (Frampton *et al*. 2009). Data for the AN group was collected by

Frampton *et al*. (2009) and not by the researcher of this study. Although the

neuropsychological and screening measures were collected in the same way for both

groups (see 2.4.1.2), there were differences in where and how participants were

approached and in how consent was given. Participants meeting DSM-IV (American

Psychiatric Association, 1994) diagnostic criteria for AN initially completed the

Ravello Profile and screening measures as part of their routine assessment on

admission to an in-patient setting. Thus, the Ravello Profile was used to aid in the

clinical assessment and treatment of the AN sample in addition to being used as a

research tool. Written consent was only obtained (and their anonymised data included on the database) for those individuals who consented for their data to be used for research purposes. Another difference between the recruitment of the AN and BN groups was in relation to where participants were recruited from. The AN group comprised participants from in-patient eating disorder settings as opposed to out-patients settings. Thus, participants may have varied in terms of severity of eating disorder. With the exception of these differences, the procedure for undertaking the Ravello Profile and screening measures was followed in the same way for both groups as is described below, allowing the groups to be comparable.

2.4.1.2 BN GROUP Participants meeting DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for BN were approached by the main researcher and / or by the therapist conducting the initial routine assessment following the patient's referral to the service. Existing patients meeting diagnostic criteria for BN were also eligible to take part in the study, and were approached by the patient's individual therapist. A verbal explanation of the study was provided when potential participants were identified. If the participant agreed in principle to taking part in the study, they were provided with the participant information sheet (PIS) (Appendix 3) and consent form (Appendix 2). They were informed that they could take the time to read the information sheet and consent form at home and that they would be contacted by the main researcher within two weeks, either by telephone or during their next routine appointment. This allowed the participant an opportunity to discuss the study with the researcher and ask questions. If they still wished to

participate in the study, they were offered an appointment to complete the Ravello Profile and screening measures in their normal eating disorder outpatient clinic.

For the two BN participants recruited by Frampton *et al*. (2009), the Ravello Profile was first carried out to aid in the clinical assessment and treatment of their eating disorder. Consent for this data to be included on the anonymised Ravello database for research purposes was obtained retrospectively. No other alterations to the procedure were applied.

2.4.1.3 CONTROL GROUP

The control group comprised colleagues and acquaintances of the researcher and people who showed an interest in participating after having seen a poster. Participation in this study was entirely voluntary. A verbal explanation of the study was provided when potential participants were identified. If the potential participant agreed in principle to taking part in the study, they were provided with the PIS (Appendix 11) and consent form (Appendix 12). If they still wished to participate after reading the PIS and consent form, they were offered an appointment to complete the Ravello Profile and screening measures in an out-patient clinic. The procedure was then followed in the same way as for the BN group.

2.4.2 Neuropsychological Assessment

For the BN group recruited by the researcher, written consent was obtained (Appendix 2) prior to completing the Ravello Profile and screening measures. Consent was only obtained after the participant had read the PIS and consent form,

had an opportunity to think about whether they wished to take part, and had an opportunity to ask any questions. The main researcher discussed all points on the consent form prior to the participant and main researcher signing it. A signed record of the consent form was given to the participant, and a copy kept in a separate filing cabinet away from their Ravello Profile data to ensure neuropsychological scores were anonymous.

All AN patients who had completed the Ravello Profile for clinical purposes were asked whether they consented for their anonymised data to be used for research purposes. Therefore, written consent was obtained retrospectively for the AN group and the two BN participants recruited by Frampton *et al*. (2009). Although Ravello Profile scores were available to the therapists involved in their patients care because it was used as a clinical tool, it was only those who consented for their scores to be used for research purposes whose anonymised data was put on the database. This was the only data that was available to the researcher of this study.

Following consent being obtained, the screening measures (i.e. BDI-II, STAI and EDE-Q) were completed. It is routine in most outpatient and inpatient eating disorder services to complete the EDE-Q (Fairburn & Beglin, 1994) at the time of assessment. Therefore, for participants who had completed this measure within twenty eight days, it was not necessary that this measure was repeated. These individuals only needed to complete the STAI and BDI-II. For individuals who had not completed the EDE-Q, all screening measures were completed. Following this, the Ravello Profile

was completed. See Table 2.1 below for the order of the tests (taken from

http://www.ravelloprofile.org/home.asp).

Table 2.1 Order of tests

NAME AND ORDER OF TEST
1) Rey Complex Figure Test (copy and immediate recall
2) Verbal Fluency Test
3) Wechsler Vocabulary Test
4) Rey Delayed Recall
5) Wechsler Matrix Reasoning Test
6) Colour Word Interference Test
7) Trail Making Test
8) Brixton Spatial Anticipation Test
9) Hayling Sentence Completion Test
10) Tower of London Test

Table 2.1 shows the order of administration of the Ravello Profile. Completing the

measures with the participant took up to two hours, with a 30 minute break at mid-

point. Frampton *et al*. (2009) proposed that clinical judgment could be applied

should the examiner feel a change is warranted to the order of the tests. For

example, if the examiner were to believe an individual's IQ was less than 85, the

Vocabulary and Matrix Reasoning subtests could be undertaken first to exclude the

participant. For the BN sample, this did not occur on any occasion and the order of

tests was followed as per the guidelines. It was not possible to ascertain whether the

order of the tests was altered for the AN sample and it was therefore not possible to

ascertain the reason(s) for any change in order if they occurred.

All participants were offered a 30 minute break at mid-point. However, the researcher also asked participants whether they wished a break at any natural end-point. Following the completion of the Ravello Profile, the participant had an opportunity to ask questions relating to the study and their performance on specific tasks. At this point, the researcher asked whether the participant wished for oral or written feedback of the assessment. The majority of participants accepted this offer, and were provided with oral feedback at a time of convenience for them. At a later stage, the researcher scored the participant's Ravello Profile and entered this data onto an anonymised database. Scoring each profile took up to two hours.

2.5 Statistical analyses

Age, IQ, Body Mass Index (BMI), eating disorder symptomatology (EDE-Q), low mood (BDI) and anxiety (STAI-S and STAI-T) were compared across the AN, BN and control groups to determine if differences on these factors required statistical controlling. Due to the differences in symptomatology between AN and BN, a significant difference was found between the AN and BN groups on age and BMI. The difference in age is to be expected given that the year of onset in AN is generally in early adolescence. As expected, a significant difference was also found between the control groups and both eating disorder groups on age, IQ, BMI, EDE-Q, BDI, STAI-S and STAI-T. To ensure that any differences between the groups were not as a result of any of the demographic and clinical variables, Pearson Correlations were conducted to determine which of these variables were associated with performance on outcome measures. For the outcome measures significantly correlated with any demographic / clinical variables (i.e. CCI, CWIT, TT, HSCT, RCFT, BT, TMT and VF),

Analyses of Covariance (ANCOVA) were conducted to measure whether there was a significant difference between the groups. Otherwise, Analyses of Variance (ANOVA) were conducted to measure differences. As ANOVA and ANCOVA only reveal whether there is a significant difference between the three groups, a priori pairwise comparisons were then conducted to examine specific predicted differences between the groups as detailed in the hypotheses section (see section 1.2).

CHAPTER 3: RESULTS

An analysis of the participant sample is presented first. This is followed by the inferential statistical analyses of the sample data, to determine if the data support the experimental hypotheses. The data was analysed using SPSS for Windows (Version 17).

3.1 Sample size and power

As described in section 2.2, the power calculation established that 30 participants would be required per group assuming equivalent sample sizes. As the current project had a large AN sample and limitations in recruiting participants for the BN group, options for non-equivalent sample sizes were explored. The case control literature has developed formulae for statistical power using non-equivalent sample sizes (e.g. Hulley *et al*. 2007; Rosenberg, 1983). For example, Hulley *et al*. (2007) advise that if the control group is double the size which power calculations suggest would be needed for equivalent sample sizes, the case group can be 25 percent smaller than would be needed if there were equivalent sample sizes. The statistical benefits of increasing the control sample size reduce substantially with size, such that some authors recommend not extending the control sample beyond three times the number that would be required for equivalent sample sizes.

Due to the large AN database, the application of multiple controls per case was possible. The following formula was applied (Hulley *et al*. 2007) to calculate the number of participants required in the case (BN) group when more participants were

available in the control (AN) group. If *n* represents the number of cases that would have been required for one control per case and c = controls per case, then the approximate number of cases that would be required (N), where N=30 and c=2 is:

$$N = [(c+1) \div 2c] \text{ x n.}$$

$$[(2+1) \div 2x2] \text{ x } 30 = \underline{N = 22}$$

Thus for an anticipated effect size of 0.65, power at 0.8 and a significance level of 0.05, the required sample would be 30 participants per group assuming equal sample sizes. Applying the above equation for non-equivalent groups, the same level of power could be achieved with a sample of 22 in the BN group and 60 in the AN group.

BN GROUP

As mentioned in section 2.4.1.2, a sample of 22 BN were included in the study; 20 recruited by the researcher and 2 recruited by Frampton *et al*. (2009). Demographic and clinical information for this sample can be found in Table 3.1.

AN GROUP

Sixty participants were drawn from the anonymised Ravello database (see 2.4.1.1 for further details). It was initially intended that the BN group would be matched to the available AN data on the key demographic and clinical variables (i.e. age). However, due to a large amount of missing data for particular variables in the AN group, those with the least amount of missing data were taken from the database (see section

3.2.1 below for further details of missing data). This resulted in an AN sample that was significantly younger than both the BN and control group. Demographic and clinical information for this sample can be found in Table 3.1.

CONTROL GROUP

Twenty participants were included as controls (see 2.4.1.3, 20 for further details). Demographic and clinical information for this sample can be found in Table 3.1.

3.2 Exploratory Data Analysis

3.2.1 Missing data

AN GROUP The Ravello Profile AN data collection (Frampton *et al*. 2009) was carried out across several sites in the United Kingdom and Norway, over a period of three years. Some data collected in 2008 and early 2009 had large amounts of missing data for particular variables. To examine the seriousness of the problem, patterns of missing data were investigated by the researcher of the present study. This was achieved by comparing all variables with missing data with 'dummy variables'. Dummy variables were created by duplicating the variable with missing data and then substituting the missing value with an overall mean. The statistical analysis was then repeated for both the variable with missing values and the dummy variable with mean substitutions. If there was no significant difference between the two means, the variable was retained and there were more options available as to how to manage the missing data, as described below. For variables where there was a

significant difference between the means, those variables were excluded. Two variables were excluded on this basis; 'omission errors' and 'commission errors' on the Trail Making Test of the D-KEFS. These variables had initially been intended for error analysis. Although there were other variables with missing data, no significant differences were found between the means. Thus, all other variables were included for analysis after applying the following procedure for dealing with missing data.

Although there are no firm guidelines for how much missing data can be tolerated for a sample of a given size (Tabachnick & Fidell, 2001), cases were excluded from the analysis where over 50 percent of the data was missing. However, as Tabachnick and Fidell (2001) point out, distortions of the sample can occur if too many cases are deleted, and important relationships between variables can be missed. Therefore, it is important to retain as many cases as possible. For variables with no more than five percent of missing data, mean (group) substitution was applied using transformations. This method was chosen as it does not cause the distribution to change and there is no researcher bias. However, the variance of a given variable is reduced because the mean is closer to itself than to the missing value it has replaced (Tabachnick & Fidell, 2001).

3.2.2 Distribution

Parametric tests are more robust and have more power than non-parametric tests (Clark-Carter, 2004). However, some conditions should be met in order for parametric tests to be used. Firstly, the population of scores from which the sample

came must be normally distributed. Secondly, the data should be interval or ratio level. Finally, the variances cannot be significantly different (Clark-Carter, 2004). The data was analysed to ascertain whether it departed significantly from the assumptions of normality and equal variance. Normality was assessed for each measure, for all three groups, using the Kolmogorov-Smirnov test. The presence of outliers, skew (symmetry of the distribution) and kurtosis (peakedness of a distribution) were also examined for all three groups using boxplots. According to Field (2005), data is significantly skewed or kurtic if the z scores are greater than 2.58. Ten variables were found to have significant levels of skew and kurtosis (p<.001). The presence of outliers was examined for these variables, and any significant outliers (falling below the 5th percentile) were removed. Tests of skew and kurtosis were then re-run. If the variable still produced skew or kurtosis, outliers were re-instated. All outliers were re-instated as all ten variables still produced skew and kurtosis. The inclusion of the outliers also reduced the possible bias in the analysis. Instead, logarithmic (LG10) transformations were conducted for the ten variables. Some of the variables were skewed positively (LG10, variable + 1) and some were skewed negatively (reflect and LG10, highest score in variable + 1 – variable). In all ten variables, the logarithmic transformations reduced skew and kurtosis whereby they were no longer significant.

Homogeneity of variance was assessed using Levene's test. If the Levene's test is significant (p<.05), this is indicative of a violation of equal variances. In this case, it can be corrected by reporting the test statistic which does not assume equal

variance. Unless stated otherwise, all data met the assumption of homogeneity of variance.

3.3 Descriptive statistical analysis

Table 3.1 Differences in mean demographic and clinical characteristics of the samples

	MEAN (SD)			ANOVA			A PRIORI		
	BN (N=22)	AN (N=60)	Controls (N=20)	F	df	p	AN v BN	AN v C	BN v C
Age (years)	28.50 (8.68)	22.55 (7.18)	29.65 (8.62)	8.66	2, 101	*p<.001*	*.008*	*.002*	.883
IQ	107.14 (8.58)	105.82 (14.76)	116.45 (8.78)	5.38	2, 101	*.006*	.908	*.004*	*.050*
BMI	23.44 (3.93)	15.23 (2.50)	23.65 (3.72)	88.10	2, 101	*p<.001*	*p<.001*	*p<.001*	.973
EDE-Q	4.27 (0.99)	3.97 (1.11)	1.01 (0.69)	72.23	2, 101	*p<.001*	.480	*p<.001*	*p<.001*
BDI	31.50 (12.57)	36.80 (11.88)	5.00 (6.79)	60.40	2, 101	*p<.001*	.147	*p<.001*	*p<.001*
	MEAN (SD)			ANOVA			A PRIORI		
	BN (N=22)	AN (N=22)	Controls (N=20)	F	df	p	AN v BN	AN vs C	BN v C
STAI – S	59.45 (14.22)	60.55 (13.11)	45.95 (12.41)	7.71	2, 63	*p<.001*	.960	*.002*	*.005*
STAI – T	72.95 (14.67)	68.77 (13.16)	51.20 (12.38)	15.16	2, 63	*p<.001*	.561	*p<.001*	*p<.001*

Note. Means and standard deviations are presented, with significant p values shown in italics (p<.05). N = number of participants, AN = Anorexia Nervosa, BN = Bulimia

Nervosa, C = Controls, SD = Standard Deviation, BMI = Body mass index, EDE-Q = Eating Disorder Examination – Questionnaire (global score), BDI = Beck Depression Inventory, STAI = State-Trait Anxiety Inventory.

Demographic and clinical variables are presented in Table 3.1. Comparisons between the groups on STAI (STAI-S and STAI-T) were conducted on smaller numbers (BN = 22; AN = 22) (see section 2.3 for further details). It was decided that this was preferable to comparing the available STAI data for the BN group (N=22) with the available BAI data (N=38) and STAI data (N=22) for the AN group. Firstly, the available data for both the AN and BN groups for the STAI were equal in size. Secondly, this method was deemed preferable to recoding the STAI and BAI variables into categories to enable the comparison of the AN and BN groups, which would require non-parametric analyses.

Table 3.1 demonstrates that there was a significant difference between the three groups on all demographic variables, as measured by Analysis of Variance (ANOVA). To examine where the differences lay between the three groups, a priori pairwise comparisons were conducted using Tukey. As expected, the AN group had a significantly lower BMI than both the BN group ($p<.001$) and control group ($p<.001$). It was anticipated that the AN group would have lower BMI as this is a symptom of AN (see section 4.4.4). Therefore, this variable was not controlled for during the statistical analyses as this would be controlling for the eating disorder itself. As anticipated, the AN group were significantly younger than both the control group ($p=.002$) and BN group ($p=.008$). Although this is typical of an AN population, this is

not itself a symptom of AN and thus subsequent comparisons between the groups controlled for age where age was correlated with the outcome measure.

There was a significant difference between the AN group and control group on IQ (p=.004), EDE-Q (p<.001), BDI (p<.001) and STAI-S (p=.002) and STAI-T (p<.001). There was also a significant difference between the BN group and control group on IQ (p=.050), EDE-Q (p<.001), BDI (p<.001) and STAI-S (p=.005) and STAI-T (p<.001). These differences are to be expected given that the control group was not a clinical population. However, it is important to examine whether any of the above variables were significantly correlated to any of the outcome measures. As BMI and higher EDE-Q scores are symptomatic of eating disorders these do not require statistical controlling. For the demographic and clinical variables: age, IQ, BDI and STAI, Pearson Correlations were conducted with all of the 16 outcome measures. Of the 16 outcome measures, three were significantly correlated with age at p < .05 (CCI, Central Coherence Index; CWIT total errors, Colour-Word interference Test; TT mean time to first move, Tower Test). One measure was also nearing significance at p = .060 (HSCT, Hayling Sentence Completion Test). Thus, the cut-off for controlling for age was p < 0.1. For these four measures, an Analysis of Covariance (ANCOVA) with age as covariate was carried out as opposed to ANOVA.

There were nine variables that significantly correlated with IQ. The cut-off for controlling for IQ was p<0.1 to capture those nearing significance. The nine measures were: all four outcome measures for RCFT, Rey Complex Figure Test; BT, Brixton Test, TMT, Trail Making Test; VF, Verbal Fluency; CWIT, Colour-Word interference

Test; TT mean time to first move, Tower Test. Four were significantly correlated with BDI at p<0.1 (HSCT, Hayling Sentence Completion Test; BT, Brixton Test; CWIT, Colour-Word interference Test; TT mean time to first move, Tower Test). One measures was significantly correlated with STAI – S at p<0.1 (TT mean time to first move, Tower Test). No measures were significantly correlated with STAI – T at p<0.1. For these measures, ANCOVA with age, IQ, BDI and STAI-S as covariates were carried out as opposed to ANOVA.

3.4 Inferential statistical analysis

As all experimental hypotheses were directional (one tailed), all p values based on two tailed tests were halved, as recommended by Clark-Carter (2004).

3.4.1 Hypothesis 1: *The AN group will perform worse than the BN group and control group on measures of visuo-spatial functioning*

Visuo-spatial functioning was assessed using the RCFT (as measured by the Rey Complex Figure Test - immediate recall and delayed recall raw scores, time to copy raw score and copy raw score). Means and standard deviations can be found in Table 3.2.

Table 3.2 Means and Standard Deviations of raw scores for RCFT performance.

TEST	MEAN (SD)			ANCOVA			A PRIORI	
	AN (N=57)	BN (N=22)	Controls (N=20)	F	df	p	AN v BN	AN v C
Copy	32.03 (4.59)	32.47 (2.34)	35.30 (1.17)	.322	2, 99	.359	-	-
Time to copy	138.10 (55.12)	101.00 (49.08)	115.15 (38.89)	7.18	2, 99	*p<.001*	*.003*	*.009*
Immediate Recall	18.71 (5.67)	17.63 (6.17)	19.85 (4.58)	.492	2, 99	.306	-	-
Delayed Recall	17.95 (6.07)	17.50 (6.99)	19.75 (4.69)	.315	2, 99	.365	-	-

Note. RCFT = Rey Complex Figure Test, *df* = degrees of freedom, t = t-test, F = F ratio.

The variable IQ was significantly correlated with RCFT copy raw score (r=-.355, p<.001), 'time to copy' raw score (r=-.266, p.008), immediate recall raw score (r = .189, p = .057) and delayed recall raw score (r=-.228, p<.021). Therefore, an ANCOVA with IQ as covariate was conducted. As seen in Table 3.2, there was no statistically significant difference between the groups on copy raw score, immediate recall raw score or delayed recall raw score as measured by ANCOVA. However, there was a statistically significant difference between the groups on 'time to copy' raw score (F = 7.18, df = 2, 99, p<.001). A priori pairwise comparisons were then conducted to examine the predicted differences between the groups. The pairwise comparisons revealed that the AN group was significantly slower than the BN group on 'time to copy' (p = .003), representing a large effect size of d = .71. The AN group was also significantly slower than the control group, with a moderate effect size of d = .48.

These results support the experimental hypothesis. To examine whether the increased 'time to copy' in the AN group confounded performance on the visuo-spatial memory trials, time to copy was added as covariate through ANCOVA. The increased time spent on time to copy did not impact on copy (F = 2.207, df = 2, 98, p = .116), immediate recall (F = .835, df = 2, 98, p = .437) or delayed recall of the figure (F = .875, df = 2, 98, p = .420).

3.4.2 Hypothesis 2: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on a measure of central coherence

Central coherence was assessed using the patterns of completion on the Rey Complex Figure Test (copy trial). An overall Central Coherence Index (CCI) score was calculated based upon the 'order of construction' and 'style of construction' scores on the copy trail of the RCFT (see appendix 10). A Levene's test revealed that the group variances were not significantly different on the CCI score, (F = .646, p = .526), therefore equal variances were assumed. As age was significantly correlated with CCI (r = .227, p = .021), ANCOVA was carried out to control for the possible influence of age on CCI performance. With a mean (SD) for the AN group of 1.25 (0.31), a mean (SD) for the BN group of 1.46 (0.25) and a mean for the control group of 1.40 (0.94) a statistically significant difference was found between the three groups on the CCI (F = 2.68, df= 2, 102, p = .036). A priori pairwise comparisons revealed that the AN group performed significantly worse than the BN group (p=.043), representing a small effect size of d = .21. However, the BN group did not perform worse than the control group.

3.4.3 Hypothesis 3: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on measures of executive functioning

The Ravello Profile includes measures of separate areas of executive functioning (cognitive inhibition, switching, flexibility and rule formation, verbal inhibition, planning and verbal fluency). Executive functioning was assessed objectively using the Hayling Sentence Completion Test (HSCT), Brixton Test (BT), Colour-Word Interference Test (condition 3) (CWIT), Trail Making Task (condition 4) (TMT), Tower Task (TT) (achievement score) and Verbal Fluency (condition 3) (VF).

Table 3.3 Means and Standard Deviations of raw scores for measures of executive functioning

TEST (s)	MEAN (SD)			ANCOVA			A PRIORI		
	AN (N=57)	BN (N=22)	Controls (N=20)	*F*	*df*	*p*	AN v BN	BN v C	AN v C
BT	13.56 (4.65)	14.38 (6.77)	11.00 (3.78)	1.47	2, 102	.117	-	-	-
HSCT	18.21 (2.37)	19.90 (2.06)	20.50 (1.10)	8.90	2, 102	*p<.001*	*.005*	-	*p<.001*
TMT	77.07 (28.75)	58.82 (14.78)	65.00 (14.71)	4.68	2, 102	*.005*	*.007*	-	
VF	39.97 (12.74)	39.45 (10.02)	43.90 (11.19)	0.85	2, 102	.459	-	-	-
CWIT	55.15 (17.47)	42.59 (7.18)	46.20 (9.44)	8.32	2, 102	*p<.001*	*p<.001*	-	-
TT	16.15 (3.75)	16.86 (3.99)	17.10 (3.80)	0.270	2, 102	.382	-	-	-

Note. HSCT, Hayling Sentence Completion Test (verbal inhibition and set shifting); BT, Brixton Test (rule formation and flexibility); TMT; Trail Making Test (cognitive flexibility); VF, Verbal Fluency Test (verbal fluency); CWIT, Colour-Word Interference Test (cognitive inhibition and set shifting); TT, Tower Test (spatial planning).

The demographic variable IQ was significantly correlated with the BT (r = -.261, p = .008), HSCT (r=-.281, p <.001), TMT (r = -.361, p <.001), VF (r = .464, p <.001), CWIT (r = -.304, p = .002) and TT (r = .360, p <.001). Therefore, ANCOVA with IQ as covariate was carried out as opposed to ANOVA. A Levene's test revealed that the group variances were not significantly different on any of the measures of executive

functioning. Therefore, equal variances were assumed. ANCOVA revealed no significant difference between the groups on the BT, VF and TT. There was a significant difference found between the groups on the HSCT (F = 8.89, df = 2, 102, p<.001), TMT (F = 4.68, df = 2, 102, p = .005) and CWIT (F = 8.32, df = 2, 102, p<.001). A priori pairwise comparisons revealed that the AN group performed significantly worse than the BN group on the HSCT (p = .005), TMT (p <.001) and CWIT (p = .001), and these represented large effect sizes of d = .53, d = .79 and d = .91 respectively. However, although there was a trend for better performance in the control group in comparison to the BN group in some measures of executive functioning, the BN group did not perform significantly worse than the control group.

3.4.4 Hypothesis 4: The BN group will perform worse than both the AN group and control group on measures of error rates

Error rates were measured using raw error scores on the VF (set loss and sequencing errors), CWIT (corrected and uncorrected errors on condition 3), TT (mean first move time and rule violation) and TMT (total errors on condition 4).

Table 3.4 Means and Standard Deviations of raw error scores

TEST	MEAN (SD)			ANCOVA			A PRIORI	
	AN	BN	Controls					
	(N=60)	(N=22)	(N=20)	*F*	*df*	*p*	BN v AN	BN v C
TT Mean first move	2.75 (1.81)	3.64 (3.50)	4.65 (3.14)	.334	2, 102	.359	-	-

TEST	MEAN (SD)			ANOVA			A PRIORI	
	AN	BN	Controls					
	(N=57)	(N=22)	(N=20)	*F*	*df*	*p*	BN v AN	BN v C
VF Set loss	.570 (.35)	.700 (.93)	.700 (.80)	.297	2, 102	.372		
VF Repetition	1.00 (.63)	1.56 (1.36)	1.50 (1.46)	3.23	2, 102	*.023*	*.015*	-
TT Rule violation	.660 (1.71)	1.45 (2.90)	.750 (1.55)	.963	2, 102	.194	-	-
CWIT errors	.850 (1.16)	1.78 (1.79)	.250 (.44)	6.49	2, 102	*.002*	*.030*	-

Note. VF, Verbal Fluency; CWIT, Colour-Word Interference Test; TT, Tower Test.

Age was significantly correlated with mean time to first move on the TT ($r = .317$, p<.001). Therefore, ANCOVA with age as covariate was conducted as opposed to ANOVA to ensure that any difference between the groups was not as a result of age. There were no other confounding variables identified using Pearson Correlations. Therefore, ANOVA was used for comparisons between the groups on the remaining outcome measures. A Levene's test revealed that the group variances were significantly different on set-loss error raw score on the VF (f = 15.33, p <.001) and rule violation on the TT (F = 4.75, p =.012). The violation of the assumption of

homogeneity of variance was corrected by reporting the test statistic which did not assume equal variances.

Table 3.4 shows that there was a significant difference between the groups on VF repetition error score (F = 3.23, df = 2, 102 p = .015), representing a large effect size of r = .64. There was also a significant difference between the groups on CWIT corrected and uncorrected error score (F = 6.49, df = 2, 102 p = .002), representing a large effect size of r = .54. There were no other statistically significant differences found between the groups. A priori pairwise comparisons revealed that the BN group performed significantly worse than the AN group on the VF repetition error score (p = .015) and this represented a medium effect size of d = 52. The BN group also performed significantly worse than the AN group on CWIT corrected and uncorrected error score (p = .030), and this represented a medium effect size of d = .61. Although the BN group made more set-loss errors on the VF Test than the AN group and made more rule violations on the TT than both the AN and control groups, these differences were not statistically significant. Contrary to prediction, the BN group did not respond significantly faster than the AN group or control group on mean time to first move.

CHAPTER 4: DISCUSSION

4.1 Summary of results

This study examined differences between individuals with AN, BN and controls on four areas of neuropsychological functioning: visuo-spatial functioning, executive functioning, central coherence and error rates. The results found that the AN group did not perform worse than the BN and control groups on three measures of visuo-spatial functioning. Despite this, the AN group were significantly slower than both the BN and control groups on time to copy the RCFT figure, showing some support for the experimental hypothesis. The results confirmed the prediction that the AN group would perform worse than the BN group on a measure of central coherence, but not that the BN group would perform worse than controls. The results found that the AN group performed worse than the BN group on commonly used measures of executive functioning, but not that the BN group performed worse than controls. The study found some evidence of increased error rates amongst the BN sample in comparison to the AN sample, potentially indicative of greater impulsivity in BN. However, the BN group did not make more errors than the control group.

4.2 Discussion of results

4.2.1 Hypothesis 1: The AN group will perform worse than the BN group and control group on measures of visuo-spatial functioning

The AN group did not perform worse than the BN and control groups on the RCFT (copy, immediate and delayed recall). The copy trial is a measure of visuo-spatial constructional ability and the immediate and delayed recall trials are measures of visuo-spatial memory. These results do not support the experimental hypothesis. However, the AN group was significantly slower than the BN and control groups on 'time to copy' the RCFT figure and thus had longer to process the figure. Furthermore, the BN group were significantly faster than both the AN and control groups. One may assume that longer time spent copying the figure would mean more accurate recall of the figure. However, this has not been found. To examine whether the increased time copying the figure confounded performance on the visuo-spatial memory trials, time to copy was added as covariate through ANCOVA. The increased time spent on copying the RCFT figure in the AN group did not impact on copy, immediate or delayed recall. This indicates that individuals with AN performed to the same level in terms of accuracy of visual memory recall as people with BN and controls; they simply took significantly more time to complete the initial copying of the task. This finding is consistent with the often reported tendency towards perfectionist traits in AN (Braun, Sunday & Halmi, 1994; Halmi *et al*. 2000; Fairburn, 2008), whereby they apply extreme standards to all aspects of life that they value, including treatment.

4.2.2 Hypothesis 2: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on a measure of central coherence

The AN group performed significantly worse than the BN group on a measure of central coherence (CCI), supporting the experimental hypothesis. This result indicates that the

BN group had a more coherent drawing style in comparison to the AN group, as reflected by their method of copying the RCFT figure. Overall, the AN group focused more on the smaller elements of the figure whilst copying the figure and did not start by focusing on the main elements. This less strategic style makes recalling the figure after a delay more difficult, as was found in this study. Their poorer performance on this task was despite the AN group taking significantly longer to copy the figure (see 4.2.1). The longer completion time may reflect the less strategic approach to copying, which may also explain why the increased copy time was not associated with an enhanced accuracy of recall relative to the BN group. These findings are supported by the growing body of literature which demonstrates that individuals with AN show a cognitive style characterised by a focus on detail rather than the 'bigger picture', similar to that seen in individuals with Autism Spectrum Disorder (Southgate *et al*. 2007).

Although there was a trend for better performance in the BN group in comparison to the control group (i.e. a more global processing style), there was no significant difference found between the BN and control groups. Lopez *et al*. (2008ab) reported that people with BN display less difficulty in global processing than people with AN, but that people with BN perform more poorly than controls. Therefore, the finding of the present study does not support the experimental hypothesis or the finding by Lopez *et al*. (2008a).

4.2.3 Hypothesis 3: The AN group will perform worse than the BN group and the BN group will perform worse than the control group on measures of executive functioning

As predicted, the AN group performed significantly worse than the BN group on the HSCT, TMT (condition 4), and CWIT (condition 3). This supports similar findings by previous studies using these measures (Lena *et al*. 2004; Duchesne *et al*. 2004). Previous research has found deficits primarily in the area of set shifting (or cognitive flexibility), as measured by the TMT and CWIT. The present study was able to build upon this research with a larger ED sample size. The AN group were significantly slower to complete the TMT (condition 4) and CWIT (condition 3) than the BN group. In fact, they were slower to complete all tasks of executive functioning that were speed related. Thus, deficits may be due to slower processing speed rather than executive dysfunction. This is consistent with previous findings by Tchanturia *et al*. (2004), who proposed that impairments amongst AN on some executive tasks may be reflective of psychomotor slowing rather than executive dysfunction.

Although there was a trend for worse performance in the BN group in comparison to the control group (more errors on the BT; lower score on the HSCT; faster completion time which is indicative of impulsivity on the TMT, VF CWIT; and lower achievement score on the TT), no statistically significant differences were found.

No significant differences were found between the AN and BN groups on the BT (Brixton Test), VF Test (Verbal Fluency Test, condition 1) and TT (Tower Test, achievement). There are several possible explanations for this. Firstly, fewer research studies have used the BT, VF Test and TT to measure executive functioning in eating disorder populations. This is particularly the case for the TT. It may be that more 'traditional' and widely known tests, such as the TMT and CWIT (i.e. Stroop), are more sensitive to executive

dysfunction than their more modern counterparts. It may also be that both the TMT and CWIT measure a particular construct (i.e. set shifting) and that the difference between the groups is specifically in relation to this deficit. This finding also implies that people with AN do not show deficits on the constructs measured by the BT, VF Test and TT. For example, it may be that people with AN and BN do not show deficits in rule formation and flexibility (as measured by the BT), verbal fluency (as measured by the VF test) or spatial planning (as measured by the TT). This would imply that the pattern of differences found between the groups on HSCT, CWIT and TMT is indicative of deficits in verbal inhibition, cognitive inhibition and set shifting ability in AN relative to BN. The assessment of set shifting in AN has been of particular interest within the literature, with a growing number of research studies investigating the concept in AN (Tchanturia *et al*. 2004; Swanson, 2009; Wheeler, 2009).

The pattern of deficits found in the area of executive function merits further consideration. The most notable pattern is that the total score generated for the HSCT, TMT (condition 4) and CWIT (condition 3) comprises the time taken to complete the task. Therefore, the finding that individuals with AN performed more poorly than BN on these tasks may reflect the fact that people with AN perform tasks more slowly than BN, rather than them having a deficit in executive functioning per se (Tchanturia *et al*. 2004). Nevertheless, there is consistent evidence of executive dysfunction in AN relative to BN and controls. Furthermore, there was no significant difference between the AN and BN groups on other timed measures of executive function (i.e. the VF Test and TT). There was also no significant difference in performance between the AN and BN groups on a measure of executive function which was not timed (Brixton Test). Therefore, it is

possible that observed deficits across executive function tasks in AN may involve a combination of particular processing speed deficits and specific executive function deficits, such as deficits in set shifting.

4.2.4 Hypothesis 4: The BN group will perform worse than both the AN group and the control group on measures of error rates

This study found some evidence of increased error rates in the BN group relative to the AN group. However, despite a trend for increased errors in the BN group relative to controls, no significant differences were found. The BN group made significantly more repetition errors than the AN group on the VF Test. According to Delis *et al*. (2001a), an elevated number of repetition errors can signal at least two types of cognitive difficulty. If the repeated responses are given in relative temporal proximity, then the examinee may be exhibiting perseverative tendencies. By examining the responses given by the BN group, this was not found to be the pattern displayed. A second explanation put forward by Delis *et al*. (2001a) is if the repeated responses are temporally distal to the initial response, then it is more reflective of a memory problem. This would seem to be the more likely explanation for the pattern of repetitions observed in the current BN data and thus potentially suggests short term memory deficits. Memory deficits have not been indicated widely in previous literature and consequently the current battery of measures had relatively few memory tasks. However, this finding may suggest that it would be worth exploring short term memory in future neuropsychological studies with BN participants.

The BN group made significantly more errors than the AN group on the CWIT (corrected and uncorrected errors). There are a number of explanations for this pattern. According to Delis-Kaplan (2001a), increased uncorrected errors may be indicative of problems in self-monitoring, although there is limited evidence to either support or refute this claim. Another explanation is in relation to impulsivity. Individuals with BN as a group are considered to be more impulsive than either individuals with AN or controls (Braun *et al.* 1994; Halmi *et al.* 2000). Although impulsivity was not examined in depth in the current study, one may hypothesise that increased impulsivity is at the expense of accuracy. The pattern of increased errors on both the VF Test (repetition errors) and CWIT (condition 3 errors) in the BN group relative to the AN group shows some support for the experimental hypothesis relating to increased error rates in BN.

Although the BN group made more set-loss errors on the VF Test and more rule violations on the TT than both the AN and control groups, these differences were not statistically significant. Furthermore, the BN group did not demonstrate quicker 'time to first move' scores on the TT than both the AN group and control groups. It has been proposed that individuals with BN are more impulsive than individuals with AN and controls (Meyers & Meyers, 1995; Burgess & Shallice, 1997) and this has been measured previously by examining response times (Braun, Sunday & Halmi, 1994; Halmi *et al.* 2000). Therefore, the finding that the BN group did not respond faster than both AN and control groups may imply that the BN group were not more impulsive. However, given the BN group's faster speed in other measures examined in this study (e.g. see 3.4.1 and 3.4.3) further research would be warranted to investigate this concept more thoroughly.

4.3 Implications for clinical practice and future research

There are many clinical implications that emerge from this and other studies which have reported neuropsychological deficits in eating disorders. For example, it has been suggested that within treatment, individuals with cognitive deficits may be unable to reflect on the nature and seriousness of their problems and may have difficulty generating solutions to problems, impacting on engagement and motivation (Rourke *et al*. 1989). It would therefore seem reasonable to ask all therapists working with people with eating disorders to be aware of the types of neuropsychological deficits typically associated with individuals with eating disorders. Individual neuropsychological testing would enable staff working with eating disorder patients to tailor their intervention to suit the cognitive abilities of the individual. However, as yet, neuropsychological testing is not often part of the routine assessment process (Fairburn, 2008).

It has been proposed that specific elements of treatments may not be suitable for some individuals wishing to engage in treatment due to their neuropsychological profile. For example, research has shown that the treatment of choice for BN, Cognitive-Behavioural therapy (CBT), often does not work for those who are highly impulsive (Agras *et al*. 2000; Duchesne *et al*. 2004; Wilson & Fairburn, 2002). It has been suggested that impulsivity reduces the likelihood of the intervention being helpful as impulsive individuals are less able to decrease the focus on their eating control / dietary restriction. Instead, Duchesne *et al*. (2004) proposed that therapists should focus on the anticipation and inhibiting of binge eating episodes (i.e. the client's deficient control of inhibitory responses). Whilst the current study adds to the current understanding of the neuropsychological profile of

BN, it is unlikely that this will become integrated into routine clinical practice until further research is conducted.

For AN, there are further advances and clearer implications for clinical practice (Baldock & Tchanturia, 2007). The current study adds to the evidence of set shifting deficits (rigidity), weak central coherence, and other executive dysfunction in people with AN (Duchesne *et al*. 2004; Lena *et al*. 2004). Neuropsychological findings have shown that rigidity is one of the maintaining factors in AN (Davies & Tchanturia, 2005). Whereas the development of recommendations for the adaptation of existing treatments for BN are ongoing, recommendations for the adaptation of treatments for AN have already been used to develop a new clinical intervention (Cognitive Remediation Therapy for Anorexia Nervosa, CRT-AN).

CRT-AN was developed by Davies & Tchanturia (2005) and Tchanturia *et al*. (2007) as an alternative treatment for people with AN presenting with set shifting deficits. The intervention uses set shifting exercises to improve cognitive flexibility, exercises to promote 'bigger picture' thinking rather than the detail, and explores alternative strategies in cognitive tasks (i.e. problem solving). Preliminary findings are encouraging, with researchers proposing that it can be an effective tool in improving flexibility in AN. The development of CRT-AN demonstrates how clinically relevant neuropsychological findings are to the assessment and treatment outcome of people with eating disorders. Given that some neuropsychological differences have been found in both AN and BN, it would be helpful for future research to focus on adapting and developing treatment approaches for the benefit of treatment resistant cases in all of the eating disorders.

In terms of the utility of the Ravello Profile, there are many clinical implications in that this study primarily found differences between AN and BN and not BN and controls. The Ravello Profile was developed for an AN population. Therefore, it would be expected that the primary deficits would be found in the AN group. However, previous research would suggest that there would also be differences between the BN and control group on measures of executive functioning and on a measure of central coherence as measured by the Ravello Profile. This was not found in the present study. Although it may simply be that the BN group are not impaired on these domains, it may also be possible that some areas of functioning not measured by the Ravello Profile are impaired in BN. Therefore, based on the current study, it would be appropriate to continue examining neuropsychological deficits in BN samples using standardised tests not contained within the Ravello Profile to examine whether there are differences between BN and control populations.

The finding that the AN group performed significantly worse than the BN group only on a measure of central coherence, 3 out of 6 measures of executive functioning, and on 1 out of 4 measures of visuo-spatial functioning suggests that not all neuropsychological domains are more poorly affected in AN than in BN. It also suggests that the AN sample do not show impairment in all measures examined in the Ravello Profile. One can be more confident in these findings given the large sample size used for the AN group, which is more likely to be representative of the AN population more generally. Therefore, it may be appropriate to adapt the Ravello profile by reducing the number of measures used to take into account the findings of the present study.

4.4 Limitations and strengths of study

4.4.1 Type 1 errors

Due to the number of statistical tests and measures used in this study, the study was at risk of finding type 1 errors (Tabachnick & Fidell, 2001). This risk was always a possibility given the objectives of this study i.e. to compare three groups on the neuropsychological domains: visuo-spatial functioning, executive functioning, central coherence and error rates. Attempts were made to reduce the number of variables measured and past literature was used to provide a rationale for choosing only some variables for analysis. Furthermore, caution was used in the interpretation of individual significant results. However, the pattern of significant results found in this study was consistent with existing research. Thus, it did not appear that any significant results found were due to chance as a result of the number of outcome variables measured in the present study.

4.4.2 Sample size and power

It would have been preferable to have had a sample size of 30 in both the BN and AN groups, as recommended by Cohen (1992). However, it was not possible to recruit 30 individuals with BN. Many potential cases in NHS Highland and NHS Tayside out-patient clinics did not meet the inclusion criteria. For example, many individuals presenting to the eating disorder services met diagnostic criteria for atypical BN. Fortunately, one of the strengths of this study was its access to the large AN database, which made it possible to increase the number of AN data sets included in the analysis to compensate for the lower number of BN participants, thus increasing power.

4.4.3 Missing data

It is widely accepted that missing data is a pervasive problem in data analysis (Tabachnick & Fidell, 2001). A limitation of the study was the extent of missing data in the AN database. Due to the number of variables which had five percent of missing data, group means were inserted. Whilst this was not ideal, there are a number of benefits of retaining cases with group means rather than simply excluding cases (Tabachnick & Fidell, 2001).

4.4.4 Characteristics of groups

There were no males recruited for this study. Therefore, the results cannot be generalised to the male population. However, eating disorders are more often found in the female population (Fairburn, 2008), and the study would not have been able to recruit sufficient males with BN to enable any comparisons. It is possible that there would be gender differences and thus it was thought preferable to confine the study to females rather than introduce a potential confound by including a small number of males.

The current study was limited by the groups being significantly different in terms of age, IQ, BMI, eating disorder severity (as measured by EDE-Q), low mood (as measured by BDI-II), and anxiety (as measured by STAI-s and STAI-T). It was to be expected that the groups would differ in terms of BMI, eating disorder severity, low mood and anxiety given that the control group was not a clinical sample. Therefore, relevant demographic and clinical variables were controlled for during the statistical analysis of the data to

ensure that any differences were as a result of differences on outcome measures and not as a result of clinical or demographic variables.

The finding that the AN group had a significantly lower BMI than both the BN and control groups was not surprising as low BMI is part of the symptomatology of AN (Fairburn, 2008; Halmi *et al*. 2000). Thus, BMI was not controlled for during statistical analyses as controlling for BMI would essentially be controlling for the AN itself. The finding that the AN group were significantly younger than the BN group may be related to the younger year of onset in AN (Fairburn, 2008) and also due to limitations in the AN database. It had been anticipated that the AN and BN groups could be matched using the older participants from the AN database. However, this was not possible. Thus, age was taken into account during the statistical analysis of the data. It was not expected that the groups would differ on IQ. This may be as a result of the control group largely comprising of NHS staff who are more likely to have a higher than average IQ. This is therefore a limitation of this study. However, all differences were taken into account during statistical analyses to ensure that any differences were not as a result of differences in demographic and clinical variables.

Finally, those in the BN group were mostly treated in out-patient settings whereas those in the AN group were all treated in in-patients settings. The potential for this to introduce a confound due to differences in eating disorder severity was considered and consequently eating disorder symptomatology and severity was assessed using the EDE-Q to ensure that there was no significant difference on this domain between the groups.

4.4.5 Measures

One of the strengths of this study is that only ecologically valid, standardised and easily accessible measures were used to examine neuropsychological functioning in eating disorders. The systematic review carried out as part of this research (Chapter 1) highlighted that much of the neuropsychological literature in eating disorders, particularly in BN, is limited by their use of measures of varying validity and reliability and small sample sizes. Therefore, this study has acted to improve upon previous research and outline additional limitations that can be taken into account in future research.

4.5 Conclusions

The findings of this study support previous research which has found evidence of executive dysfunction and weak central coherence in AN in comparison to BN. The AN sample were also significantly slower than individuals with BN and controls on a task of visuo-spatial functioning, indicating an accuracy over speed bias in comparison to the BN sample. Despite a trend for better performance in the control group in comparison to the BN group, no statistically significant differences were found. Therefore, this study only found AN to be associated with specific neuropsychological dysfunction.

There are many implications of these findings for clinical and research practice. It may be beneficial to adapt the Ravello Profile for AN as not all measures were found to be more poorly affected in AN in comparison to BN and controls. There were very few measures more poorly affected in the BN sample. Therefore, the Ravello Profile as it stands may not be the most suitable battery of tests to use with this group. For example, it would be

useful for a battery of tests for BN to take into account increased errors in BN relative to AN and increased speed of processing in BN relative to AN (possibly reflecting impulsivity). Those working with individuals with AN or BN should take into consideration possible effects of their respective cognitive limitations and adapt interventions accordingly. AN has already developed a specific treatment (CRT-AN) which targets the areas of neuropsychological weakness most commonly found in AN. The development of a specific treatment for BN is yet to have occurred. Given the increasing evidence of neuropsychological deficits in BN relative to controls found in this and other studies (i.e. increased impulsivity), treatments for BN (e.g. CBT-BN) may also require adaptation. It is important that future research builds upon these treatment developments in order for services to better tailor treatments for individuals with eating disorders.

A Comparison of Neuropsychological Test Performance on the Ravello Profile between Bulimia Nervosa and Anorexia Nervosa

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Running Head: Review of Neuropsychological Functioning in Bulimia

This report has been written following the *Psychological Medicine* author guidelines

(see Appendix 1)

A Comparison of Neuropsychological Performance on the Ravello

Profile between Bulimia Nervosa and Anorexia Nervosa

ABSTRACT

Background The Ravello Profile is a battery of standardised neuropsychological measures of areas of functioning that evidence indicates are impaired in Anorexia Nervosa (AN), namely visuo-spatial functioning, central coherence and executive functioning. The neuropsychological profile of individuals with Bulimia Nervosa (BN) is less well established. The current study aimed to examine differences in cognitive performance between people with BN, AN and controls on the Ravello Profile.

Methods The AN group (N=60) comprised participants from an existing database (Frampton *et al*. 2009. The BN group (N=22) largely comprised of participants from NHS adult out-patient services. The non-eating disordered control group (N=20) comprised of colleagues and acquaintances of the researcher. Differences between AN, BN and control samples on visuo-spatial functioning, central coherence, executive functioning and error rates were examined.

Results The AN group performed significantly worse than the BN group on a measure of central coherence and on some measures of executive function, but the BN group did not perform worse than the control group. There was no significant difference between the groups on three measures of visuo-spatial functioning. However, the AN group was significantly slower than both the BN and control group to copy the

figure. The results showed some evidence of increased error rates in BN relative to AN, which may reflect greater impulsivity in BN.

Conclusions The results indicate separate patterns of neuropsychological performance between AN, BN and controls, with AN demonstrating poorer performance on measures of executive function and central coherence, whilst BN participants showed higher rates of errors. The BN group were also generally faster to complete some tasks, indicative of a preference for speed over accuracy or impulsivity. Those working with individuals with AN or BN should take into consideration possible effects of their respective cognitive limitations and adapt interventions accordingly.

INTRODUCTION

There is a general consensus that anorexia nervosa (AN) is associated with some

neuropsychological dysfunction, with AN consistently associated with deficits in

three areas of functioning, namely visuo-spatial functioning, central coherence and

executive functioning (Lena *et al*. 2004; Tchanturia *et al*. 2004; Duchesne *et al*. 2004).

Recently, the 'Ravello Profile' has been developed which assesses these three areas

of neuropsychological functioning using existing standardised and validated

neuropsychological tests (Frampton et al. 2009; Davis *et al*. in press). Frampton *et al*.

(2009) aim to establish a neuropsychological profile for AN by collecting data from a

large sample of AN participants using the Ravello Profile.

The presence of neuropsychological dysfunction in bulimia nervosa (BN) is less well

established. There is some evidence of neuropsychological deficits relative to non-

eating disordered controls in BN, including deficits in attention and executive

function (Ferraro *et al*. 1997; Jones *et al*. 1991; Laessle *et al*. 1992), decision making

(Brand *et al.* 2007; Liao *et al*. 2008), central coherence (Lopez, Tchanturia, Stahl,

Booth *et al*. 2008; Tokley & Kemps, 2007), visuo-spatial functioning (e.g. Ferraro *et

al*. 1997; Jones *et al*. 1991) and memory (e.g. Ferraro *et al*. 1997; Beatty *et al*. 1990).

However, due to inconsistencies and methodological limitations within the

literature, the neuropsychological profile for BN remains less clear. There is currently

no set of standardised and validated measures known to reliably examine

neuropsychological dysfunction in BN in the manner that the Ravello Profile has

been developed for AN.

The aim of this study was to compare individuals with AN and BN and controls on

measures of visuo-spatial functioning, central coherence, executive functioning and

error rates contained within the Ravello Profile.

METHODS

Design

This is a between subjects design, comparing scores on the Ravello Profile between three groups: Anorexia Nervosa (AN), Bulimia Nervosa (BN) and non-eating disordered controls. To examine possible confounding variables, participants were screened for low mood, anxiety, Body Mass Index (BMI), eating disorder symptomatology and IQ.

Participants

The AN group (N=60) comprised participants from an already existing database (Frampton *et al*. 2009). The BN group (N=22) comprised participants from adult NHS out-patient eating disorder services, plus two from the Frampton *et al*. (2009) database. A sample of healthy adults (N=20) acted as controls. They comprised NHS staff, acquaintances of the researcher, and people who showed an interest in participating after having seen a poster.

Inclusion and Exclusion Criteria

BN participants were included if they met diagnostic criteria for BN (American Psychiatric Association, 1994); had an IQ of at least eighty five (as an IQ of less than eighty five can confound performance on neuropsychological tests); were fluent in English and had not previously undergone neuropsychological testing. Participants were excluded if they were under the age of seventeen or not attending adult services. For the AN group previously recruited by Frampton *et al*. (2009), participants were included if they met diagnostic criteria for AN (American Psychiatric Association, 1994); had an IQ of at least eighty five; were fluent in English

and had not previously undergone neuropsychological testing. For the control group, participants were included if they were female, did not have an eating disorder, had an IQ of at least eighty five; were fluent in English and had not previously undergone neuropsychological testing.

Procedure

AN GROUP The AN group comprised participants from an existing anonymised database (Frampton *et al*. 2009) and was not recruited by the researcher of this study. Although the neuropsychological and screening measures were collected in the same way for both groups, there were differences in where and how participants were approached and in how consent was given. Participants meeting DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for AN initially completed the Ravello Profile and screening measures as part of their routine assessment on admission to an in-patient setting. Thus, the Ravello Profile was used to aid in the clinical assessment of the AN sample in addition to being used as a research tool. Written consent was only obtained (and their anonymised data included on the database) for those individuals who consented for their data to be used for research purposes. Another difference was that the AN group comprised participants from in-patient eating disorder settings. Thus, participants may have varied in terms of severity of eating disorder. With the exception of these differences, the procedure for undertaking the Ravello Profile and screening measures was followed in the same way for both groups as is described below, allowing the groups to be comparable.

BN GROUP Participants meeting DSM-IV (American Psychiatric Association, 1994) diagnostic criteria for BN were approached by the main researcher and / or by the therapist conducting the initial routine assessment following the patient's referral to the service. Existing patients meeting diagnostic criteria for BN were also eligible to take part in the study. A verbal explanation of the study was provided when potential participants were identified. If the participant agreed in principle to taking part, they were provided with a participant information sheet and consent form and informed that they would be contacted by the main researcher within two weeks. At that point they were offered an appointment to complete the Ravello Profile and screening measures in their normal eating disorder outpatient clinic.

CONTROL GROUP

The control group comprised colleagues, acquaintances of the researcher, and people who showed an interest in participating after having read a poster. Participation in this study was entirely voluntary. A verbal explanation of the study was provided when potential participants were identified. If the potential participant agreed in principle to taking part in the study, they were provided with the participant information sheet and consent form. If they still wished to participate, they were offered an appointment to complete the Ravello Profile and screening measures in an out-patient clinic. The procedure was then followed in the same way as for the BN group.

Measures

The Ravello Profile comprises of existing standardised, validated and easily accessible neuropsychological tests. All measures have evidence of adequate - good inter-rater reliability, test-retest reliability and construct validity.

Measures of executive functioning

The Hayling Sentence Completion Test (Burgess & Shallice, 1997) is primarily a measure of verbal inhibition. The first section asks the participant to complete sentences with a congruent verbal response, which assesses response initiation and initiation speed. The second part asks the participant to complete sentences with an incongruent verbal response, which assesses verbal inhibition and response suppression. The second part also records the participant's time to respond. Three separate scaled scores are combined which generates an overall total scaled score.

The Brixton Spatial Anticipation Test (Burgess & Shallice, 1997) measures cognitive flexibility (also referred to as set shifting) and rule formation. The participant is asked to predict the next location of a blue circle from a choice of ten, based on previous presentations. According to Burgess and Shallice (1997), there are three broad classes of error; perseverations; the misapplication of a strategy; or guessing or bizarre responses. The total number of raw errors was used for group comparisons.

Four subtests from the Delis-Kaplan Executive Function System (DKEFS; Delis *et al*. 2001) were also used as measures of executive function. Raw scores were used for group comparisons.

The Colour–Word Interference Task was used to measure cognitive inhibition. This is based on the Stroop (1935) procedure, which asks participants to inhibit an over learned verbal response in order to generate a conflicting response. This task examines verbal inhibition and cognitive flexibility.

The Trail Making Task is a measure of switching ability, first developed by U.S. Army psychologists as part of the Army Individual Test Battery (1944). This task has five conditions, all of which involve the participant completing a 'connect the circle' task. The primary executive function task is the Number-Letter Switching condition (condition 4), a visuo-motor sequencing procedure which measures flexibility of thinking.

The Verbal Fluency Task was used as a measure of verbal fluency. Verbal fluency examines an individual's ability to generate lists of words fluently in an effortful, phonetic format. The task is composed of three conditions: letter fluency, category fluency and category switching. For the purpose of the current study, only verbal fluency - total raw score was used within the analysis.

The Tower Task was used to measure cognitive inhibition. This test asks participants to move disks of varying size across three pegs to build a target tower in the fewest number of moves possible, whilst following two rules. According to Delis *et al*. (2001), the Tower Task measures several key executive functions, including spatial planning, rule learning, inhibition of impulsive responding, inhibition of perseverative responding, and establishing and maintaining the instructional set.

Measures of Visuo-spatial Memory

The Rey Complex Figure Test (Meyers & Meyers, 1995) was used as a measure of visuo-spatial memory. Four scores were compared in the present study: copy raw score; time to copy raw score; immediate recall raw score; and delayed recall raw score. The copy trial asks participants to copy a complex visual stimuli or 'complex figure'. This measures visuo-spatial constructional ability and is timed. The immediate recall condition asks participants to recall the figure from memory three minutes after the copy trial is completed. The delayed recall condition asks participants to recall the figure thirty minutes after the end of the copy trial.

Measure of Central Coherence

The concept of central coherence refers to the ability to achieve a balance between efficiency and attention to detail. To measure central coherence, an additional method of scoring the copy condition of the **Rey Complex Figure Test** was applied. This scoring system, known as the **Central Coherence Index (CCI)** has been used in other studies of central coherence in eating disorders (e.g. Lopez, Tchanturia, Stahl, Booth *et al*. 2008). A higher CCI score indicates a more coherent drawing style.

Measure of Error Rates

Increased error rates are indicative of impulsivity and research suggests that individuals with BN show more errors in comparison to AN and controls (Meyers & Meyers, 1995; Burgess & Shallice, 1997). Error rates on four subtests on the D-KEFS were compared across the two groups. Error rates were based on: **set loss** and **repetition** raw scores on the Verbal Fluency Test; **corrected** and **uncorrected** error

raw scores on the Colour-Word Interference Test (condition 3); **rule violation** raw score on the Tower Test; **mean time to first move** raw score on the Tower Test; and total error raw score for the Trail Making Task.

Measure of IQ

Two subtests from the **Wechsler Abbreviated Scale of Intelligence** (WASI; Wechsler, 1999) were used as an estimate of IQ: Vocabulary and Matrix Reasoning. The Vocabulary subtest is a 42 item task which asks the examinee to orally define visually presented words. The Matrix Reasoning subtest involves visually presenting thirty five incomplete gridded patterns to the examinee who must then complete the grid by choosing a correct response from a choice of five.

Measures included for Background Information / Screening

The Beck Depression Inventory (BDI-II; Beck *et al*. 1996) is a widely used and easily accessible tool for detecting and measuring the severity of depression. This measures was used by Frampton *et al*. (2009).

The Eating Disorders Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994) is a 28-item self-report version of the Eating Disorders Examination (EDE; Fairburn & Cooper, 1993) and is used to assess severity of cognitive and behavioural symptoms of eating disorders. This data is routinely gathered in eating disorder services across the United Kingdom to aid in the diagnosis of eating disorders. The global score was used to match the AN and BN participants.

Statistical methods

The AN and BN groups were found to be well matched in terms of eating disorder symptomatology, IQ and low mood, but they significantly differed in age and BMI. As expected, the control group significantly differed from both eating disorder groups in BMI, eating disorder symptomatology, low mood and IQ. To examine whether any differences found between the groups were as a result of these variables, correlations were conducted between the possible confounds and the outcome measures. When any significant correlations were found, Analyses of Covariance (ANCOVA) were used controlling for the potential confounding variable rather than using Analysis of Variance (ANOVA). A priori pairwise comparisons were performed following ANCOVA to examine specific predicted differences between the groups, as outlined in the hypotheses.

Ethics

This study was granted ethical approval by the University of Edinburgh and by NHS Lothian's Research Ethics Committee.

RESULTS

Missing data

The Ravello Profile AN data collection (Frampton *et al*. 2009) was carried out across several sites over a period of three years. Some data collected in 2008 and early 2009 had large amounts of missing data for particular variables. Patterns of missing data were investigated by comparing all variables with missing data with 'dummy variables'. Dummy variables were created by duplicating the variable with missing data and then substituting the missing value with an overall mean. The statistical analysis was then repeated for both the variable with missing values and the dummy variable with mean substitutions. If there was no significant difference between the two means, the variable was retained and there were more options available as to how to manage the missing data. For variables where there was a significant difference between the means, those variables were excluded. Two variables initially intended for error analysis were excluded on this basis; 'omission errors' and 'commission errors' on the Trail Making Test of the D-KEFS. All other variables with no more than five percent of missing data were included for analysis by applying mean (group) substitution using transformations (as recommended by Tabachnick and Fidell, 2001).

Distribution

The data was analysed to ascertain whether it departed significantly from the assumptions of normality and equal variance. Normality was assessed for each measure using the Kolmogorov-Smirnov test. The presence of outliers, skew and kurtosis were also examined using boxplots. Ten variables were found to have

significant levels of skew and kurtosis (p<.001). The presence of outliers was

examined for these variables, and any significant outliers (falling below the 5th

percentile) were removed. Tests of skew and kurtosis were then re-run. If the

variable still produced skew or kurtosis, outliers were re-instated. All outliers were

re-instated as all ten variables still produced skew and kurtosis. Instead, logarithmic

(LG10) transformations were conducted for the ten variables. Some of the variables

were skewed positively (LG10, variable + 1) and some were skewed negatively

(reflect and LG10, highest score in variable + 1 – variable). In all ten variables, the

logarithmic transformations reduced skew and kurtosis whereby they were no longer

significant.

Demographic and clinical variables

Table 1 shows a summary of the demographic and clinical characteristics of the

sample. Means and standard deviations are presented together with the results of

ANOVA and a priori pairwise comparisons comparing the AN, BN and control groups.

Table 1 Differences in mean demographic and clinical characteristics of the samples

	MEAN (SD)			ANOVA			A PRIORI		
	BN (N=22)	AN (N=60)	Controls (N=20)	F	df	p	AN v BN	AN v C	BN v C
Age (years)	28.50 (8.68)	22.55 (7.18)	29.65 (8.62)	8.66	2, 101	*p<.001*	*.008*	*.002*	.883
IQ	107.14 (8.58)	105.82 (14.76)	116.45 (8.78)	5.38	2, 101	*.006*	.908	*.004*	*.050*
BMI	23.44 (3.93)	15.23 (2.50)	23.65 (3.72)	88.10	2, 101	*p<.001*	*p<.001*	*p<.001*	.973
EDE-Q	4.27 (0.99)	3.97 (1.11)	1.01 (0.69)	72.23	2, 101	*p<.001*	.480	*p<.001*	*p<.001*
BDI	31.50 (12.57)	36.80 (11.88)	5.00 (6.79)	60.40	2, 101	*p<.001*	.147	*p<.001*	*p<.001*

Note. Means and standard deviations are presented, with significant p values shown in italics (p<.05). N = number of participants, AN = Anorexia Nervosa, BN = Bulimia Nervosa, C = Controls, SD = Standard Deviation, BMI = Body mass index, EDE-Q = Eating Disorder Examination – Questionnaire (global score), BDI = Beck Depression Inventory.

A significant difference was found between the three groups on all demographic variables, as measured by ANOVA. Therefore, a priori pairwise comparisons were conducted using Tukey. As expected, BMI was significantly lower in the AN group than both the BN group (p<.001) and controls (p<.001). As this is a symptom of AN, this variable was not controlled for during the statistical analyses. The AN group were significantly younger than both the controls (p=.002) and BN group (p=.008).

Thus, subsequent comparisons between the groups controlled for age where age was correlated with the outcome measure.

There was a significant difference between the AN group and control group on IQ (p=.004), EDE-Q (p<.001) and BDI (p<.001). There was also a significant difference between the BN group and controls on IQ (p=.050), EDE-Q (p<.001) and BDI (p<.001). As BMI and higher EDE-Q scores are symptomatic of eating disorders these do not require statistical controlling. For the demographic variables: age, IQ and BDI, Pearson Correlations were conducted with all of the 16 outcome measures. Three measures were significantly correlated with age at $p < .05$ and one was nearing significance at $p = .060$. There were nine variables that significantly correlated with IQ. There were four significantly correlated with BDI at $p<0.1$. For these measures, ANCOVA with age as covariate was carried out as opposed to ANOVA.

Visuo-spatial functioning

Visuo-spatial functioning was assessed using the Rey Complex Figure Test (RCFT) (time to copy, copy raw score, immediate recall and delayed recall raw scores). Means and standard deviations of the raw scores are presented in Table 2.

Table 2 Means and Standard Deviations of raw scores for RCFT performance.

TEST	MEAN (SD)			ANCOVA			A PRIORI	
	AN (N=57)	BN (N=22)	Controls (N=20)	*F*	*df*	*p*	AN v BN	AN v C
Copy	32.03 (4.59)	32.47 (2.34)	35.30 (1.17)	.322	2, 99	.359	-	-
Time to copy	138.10 (55.12)	101.00 (49.08)	115.15 (38.89)	7.18	2, 99	*p<.001*	*.003*	*.009*
Immediate Recall	18.71 (5.67)	17.63 (6.17)	19.85 (4.58)	.492	2, 99	.306	-	-
Delayed Recall	17.95 (6.07)	17.50 (6.99)	19.75 (4.69)	.315	2, 99	.365	-	-

Note. RCFT = Rey Complex Figure Test, *df* = degrees of freedom, t = t-test, F = F ratio.

The variable IQ was significantly correlated with RCFT copy raw score (r=-.355, p<.001), 'time to copy' raw score (r=-.266, p.008), immediate recall raw score (r = .189, p = .057) and delayed recall raw score (r=-.228, p<.021). Therefore, an ANCOVA with IQ as covariate was conducted. As seen in Table 2, there was no statistically significant difference between the groups on copy raw score, immediate recall raw score or delayed recall raw score as measured by ANCOVA. However, there was a statistically significant difference between the groups on 'time to copy' raw score (F = 7.18, df = 2, 99, p<.001). A priori pairwise comparisons were then conducted to examine the predicted differences between the groups. The pairwise comparisons revealed that the AN group was significantly slower than the BN group on 'time to copy' (p = .003), representing a large effect size of .71. The AN group was also significantly slower than the control group, with a moderate effect size of d = .48.

These results support the experimental hypothesis. To examine whether the increased 'time to copy' in the AN group confounded performance on the visuo-spatial memory trials, time to copy was added as covariate through ANCOVA. The increased time spent on time to copy did not impact on copy (F = 2.207, df = 2, 98, p = .116), immediate recall (F = .835, df = 2, 98, p = .437) or delayed recall of the figure (F = .875, df = 2, 98, p = .420).

Central coherence

Central coherence was assessed using the patterns of completion on the Rey Complex Figure Test (copy trial). An overall Central Coherence Index (CCI) score was calculated based upon the 'order of construction' and 'style of construction' scores on the copy trail of the RCFT. A Levene's test revealed that the group variances were not significantly different on the CCI score, (F = .646, p = .526), therefore equal variances were assumed. As age was significantly correlated with CCI (r = .227, p = .021), ANCOVA was carried out to control for the possible influence of age on CCI performance. With a mean (SD) for the AN group of 1.25 (0.31), a mean (SD) for the BN group of 1.46 (0.25) and a mean for the control group of 1.40 (0.94) a statistically significant difference was found between the three groups on the CCI (F = 2.68, df= 2, 102, p = .036). A priori pairwise comparisons revealed that the AN group performed significantly worse than the BN group (p=.043), representing a small effect size of d = .21. However, the BN group did not perform worse than the control group.

Executive functioning

Executive functioning was measured using the Hayling Sentence Completion Test (HSCT), Brixton Test (BT), Trail Making Test (TMT), Verbal Fluency Test (VF), Colour-Word Interference Test (CWIT), and Tower Test (TT).

Table 3 Means and Standard Deviations of raw scores for measures of executive functioning

TEST (s)	MEAN (SD)			ANCOVA			A PRIORI		
	AN (N=57)	BN (N=22)	Controls (N=20)	*F*	*df*	*p*	AN v BN	BN v C	AN v C
BT	13.56 (4.65)	14.38 (6.77)	11.00 (3.78)	1.47	2, 102	.117	-	-	-
HSCT	18.21 (2.37)	19.90 (2.06)	20.50 (1.10)	8.90	2, 102	*p<.001*	*.005*	-	*p<.001*
TMT	77.07 (28.75)	58.82 (14.78)	65.00 (14.71)	4.68	2, 102	*.005*	*.007*	-	
VF	39.97 (12.74)	39.45 (10.02)	43.90 (11.19)	0.85	2, 102	.459	-	-	-
CWIT	55.15 (17.47)	42.59 (7.18)	46.20 (9.44)	8.32	2, 102	*p<.001*	*p<.001*	-	-
TT	16.15 (3.75)	16.86 (3.99)	17.10 (3.80)	0.27	2, 102	.382	-	-	-

Note. HSCT, Hayling Sentence Completion Test (verbal inhibition and set shifting); BT, Brixton Test (rule formation and flexibility); TMT; Trail Making Test (cognitive flexibility); VF, Verbal Fluency Test (verbal fluency); CWIT, Colour-Word Interference Test (cognitive inhibition and set shifting); TT, Tower Test (spatial planning).

The demographic variable IQ was significantly correlated with the BT ($r = -.261$, $p = .008$), HSCT ($r = -.281$, $p < .001$), TMT ($r = -.361$, $p < .001$), VF ($r = .464$, $p < .001$), CWIT ($r = -.304$, $p = .002$) and TT ($r = .360$, $p < .001$). Therefore, ANCOVA with IQ as covariate was carried out. Table 3 revealed no significant difference between the groups on the BT, VF and TT. There was a significant difference found between the groups on the HSCT ($F = 8.89$, $df = 2, 102$, $p < .001$), TMT ($F = 4.68$, $df = 2, 102$, $p = .005$) and CWIT ($F = 8.32$, $df = 2, 102$, $p < .001$). A priori pairwise comparisons revealed that the AN group performed significantly worse than the BN group on the HSCT ($p = .005$), TMT ($p < .001$) and CWIT ($p = .001$), and these represented large effect sizes of $d = .53$, $d = .79$ and $d = .91$ respectively. Although there was a trend for better performance in the control group in comparison to the BN group in some measures of executive functioning, no significant differences were found.

Error rates

Error rates were measured using set loss and repetition raw error scores on the Verbal Fluency Test (VF), a total corrected and uncorrected raw error score on the Colour Word Interference Test (CWIT, condition 3) and rule violation and time to first move raw scores on the Tower Test (TT).

Table 4 Means and Standard Deviations of raw error scores

TEST	MEAN (SD)			ANCOVA			A PRIORI	
	AN	BN	Controls				BN v AN	BN v C
	(N=60)	(N=22)	(N=20)	*F*	*df*	*p*		
TT Mean first move	2.75 (1.81)	3.64 (3.50)	4.65 (3.14)	.334	2, 102	.359	-	-

TEST	MEAN (SD)			ANOVA			A PRIORI	
	AN	BN	Controls				BN v AN	BN v C
	(N=57)	(N=22)	(N=20)	*F*	*df*	*p*		
VF Set loss	.570 (.35)	.700 (.93)	.700 (.80)	.297	2, 102	.372		
VF Repetition	1.00 (.63)	1.56 (1.36)	1.50 (1.46)	3.23	2, 102	*.023*	*.015*	-
TT Rule violation	.660 (1.71)	1.45 (2.90)	.750 (1.55)	.963	2, 102	.194	-	-
CWIT errors	.850 (1.16)	1.78 (1.79)	.250 (.44)	6.49	2, 102	*.002*	*.030*	-

Note. VF, Verbal Fluency; CWIT, Colour-Word Interference Test; TT, Tower Test.

Age was significantly correlated with mean time to first move on the TT ($r = .317$, p<.001). Therefore, ANCOVA with age as covariate was conducted for this measure and ANOVA was used for all other comparisons between groups. A Levene's test revealed that the group variances were significantly different on set-loss error raw score on the VF (f = 15.33, p <.001) and rule violation on the TT (F = 4.75, p =.012). The violation of the assumption of homogeneity of variance was corrected by reporting the test statistic which did not assume equal variances.

Table 4 shows that there was a significant difference between the groups on VF repetitions (F = 3.23, df = 2, 102 p = .015), representing a large effect size of r = .64. There was also a significant difference between the groups on the CWIT (F = 6.49, df = 2, 102 p = .002), representing a large effect size of r = .54. There were no other statistically significant differences found between the groups. A priori pairwise comparisons revealed that the BN group performed significantly worse than the AN group on VF repetitions (p = .015) and this represented a medium effect size of d = 52. The BN group also performed significantly worse than the AN group on CWIT corrected and uncorrected error score (p = .030), and this represented a medium effect size of d = .61. Although the BN group made more set-loss errors on the VF Test than the AN group and made more rule violations on the TT than both the AN and control groups, these differences were not statistically significant. Contrary to prediction, the BN group did not respond significantly faster than the AN or control group on mean time to first move.

Visuo-spatial functioning

The AN group did not perform worse than the BN and control groups on the RCFT (copy, immediate and delayed recall). These results do not support the experimental hypothesis. However, the AN group was significantly slower than the BN and control groups on 'time to copy' the RCFT figure and thus had longer to process the figure. Furthermore, the BN group were significantly faster than both the AN and control groups. One may assume that longer time spent copying the figure would mean more accurate recall of the figure. However, this was not found. To examine whether increased time copying the figure confounded performance on the visuo-spatial memory trials, time to copy was added as covariate through ANCOVA. The increased time spent copying the RCFT figure did not impact on copy, immediate or delayed recall. This indicates that individuals with AN performed to the same level in terms of accuracy of visual memory recall as people with BN and controls; they simply took significantly more time to complete the initial copying. This finding is consistent with the often reported tendency towards perfectionist traits in AN (Braun, Sunday & Halmi, 1994; Halmi *et al*. 2000; Fairburn, 2008), whereby they apply extreme standards to all aspects of life that they value, including treatment.

Central coherence

The AN group performed significantly worse than the BN group on a measure of central coherence (CCI), supporting the experimental hypothesis. This result indicates that the BN group had a more coherent drawing style in comparison to the AN group, as

reflected by their method of copying the RCFT figure. Overall, the AN group focused more on the smaller elements of the figure whilst copying the figure and did not start by focusing on the main elements. This less strategic style makes recalling the figure after a delay more difficult, as was found in this study. Their poorer performance on this task was despite the AN group taking significantly longer to copy the figure. The longer completion time may reflect the less strategic approach to copying, which may also explain why the increased copy time was not associated with an enhanced accuracy of recall relative to the BN group. These findings are supported by the growing body of literature which demonstrates that individuals with AN show a cognitive style characterised by a focus on detail rather than the 'bigger picture', similar to that seen in individuals with Autism Spectrum Disorder (Southgate *et al*. 2007).

Although there was a trend for better performance in the BN group in comparison to controls, there was no significant difference found between the BN and control groups. Lopez *et al*. (2008ab) reported that people with BN display less difficulty in global processing than people with AN, but that people with BN perform more poorly than controls. Therefore, the finding of the present study does not support the experimental hypothesis or the finding by Lopez *et al*. (2008a).

Executive function

As predicted, the AN group performed significantly worse than the BN group on the HSCT, TMT, and CWIT. This supports similar findings by previous studies using these measures (Lena *et al*. 2004; Duchesne *et al*. 2004). The AN group were significantly slower than the BN group to complete the TMT and CWIT. In fact, they were slower to

complete all tasks of executive functioning that were speed related. Thus, deficits may be due to slower processing speed rather than executive dysfunction. This is consistent with previous findings by Tchanturia *et al*. (2004), who proposed that impairments amongst AN on some executive tasks may be reflective of psychomotor slowing rather than executive dysfunction.

Although there was a trend for worse performance in the BN group than in the control group (more errors on the BT; lower score on the HSCT; faster completion time which is indicative of impulsivity on the TMT, VF CWIT; and lower achievement score on the TT), no statistically significant differences were found.

No significant differences were found between the AN and BN groups on the BT, VF Test and TT. There are several possible explanations for this. Firstly, fewer research studies have used the BT, VF Test and TT to measure executive functioning in eating disorder populations. It may be that more widely known tests, such as the TMT and CWIT (i.e. Stroop), are more sensitive to executive dysfunction than their more modern counterparts. It may also be that both the TMT and CWIT measure a particular construct (i.e. set shifting) and that the difference between the groups is specifically in relation to this deficit. This finding also implies that people with AN do not show deficits on the constructs measured by the BT, VF Test and TT. For example, it may be that people with AN and BN do not show deficits in rule formation and flexibility (as measured by the BT), verbal fluency (as measured by the VF test) or spatial planning (as measured by the TT). This would imply that the pattern of differences found between the groups on HSCT, CWIT and TMT is indicative of deficits in verbal inhibition, cognitive inhibition and set

shifting ability in AN relative to BN. The assessment of set shifting in AN has been of particular interest within the literature, with a growing number of research studies investigating the concept in AN (Tchanturia *et al*. 2004; Swanson, 2009; Wheeler, 2009).

It is also of interest to note that the total score generated for the HSCT, TMT (condition 4) and CWIT (condition 3) comprises the time taken to complete the task. Therefore, poorer performance in the AN group may reflect slower processing speed rather than executive functioning (Tchanturia *et al*. 2004). Nevertheless, there is consistent evidence of executive dysfunction in AN relative to BN and controls. Furthermore, there was no significant difference between the AN and BN groups on other timed measures of executive function. There was also no significant difference in performance between the AN and BN groups on a measure of executive function which was not timed (Brixton Test). Therefore, it is possible that observed deficits across executive function tasks in AN may involve a combination of particular processing speed deficits and specific executive function deficits, such as deficits in set shifting.

Error rates

This study found some evidence of increased error rates in BN relative to AN. However, despite a trend for increased errors in BN relative to controls, no significant differences were found. The BN group made significantly more repetition errors than the AN group on the VF Test. According to Delis *et al*. (2001a), an elevated number of repetition errors can signal at least two types of cognitive difficulty. If the repeated responses are given in relative temporal proximity, then the examinee may be exhibiting perseverative tendencies. By examining the responses given by the BN group, this was not found to be

the pattern displayed. Delis *et al*. (2001a) also suggested that if the repeated responses are temporally distal to the initial response, then it is more reflective of a memory problem. This would seem to be the more likely explanation for the pattern of repetitions observed in the BN group and potentially suggests short term memory deficits. Memory deficits have not been indicated widely in previous literature and consequently the current battery of measures had relatively few memory tasks. However, this finding may suggest that it would be worth exploring short term memory in future neuropsychological studies with BN participants.

The BN group made significantly more errors than the AN group on the CWIT (corrected and uncorrected errors). There are a number of explanations for this pattern. According to Delis-Kaplan (2001a), increased uncorrected errors may be indicative of problems in self-monitoring. Another explanation is in relation to impulsivity. Individuals with BN as a group are considered to be more impulsive than either individuals with AN or controls (Braun *et al*. 1994; Halmi *et al*. 2000). Although impulsivity was not examined in depth in the current study, one may hypothesise that increased impulsivity is at the expense of accuracy. The pattern of increased errors on both the VF Test (repetition errors) and CWIT (condition 3 errors) in the BN group shows some support for this hypothesis.

Although the BN group made more set-loss errors on the VF Test and more rule violations on the TT than both the AN and control groups, these differences were not significant. Furthermore, the BN group did not demonstrate quicker 'time to first move' on the TT. It has been proposed that individuals with BN are more impulsive than individuals with AN and controls (Meyers & Meyers, 1995; Burgess & Shallice, 1997) and

this has been measured previously by examining response times (Braun, Sunday & Halmi, 1994; Halmi *et al*. 2000). Therefore, the finding that the BN group did not respond faster may imply that the BN group were not more impulsive. However, given the BN group's faster speed in other measures examined in this study, further research would be warranted to investigate this concept more thoroughly.

There are many clinical implications based upon the findings of this study and other studies which have reported neuropsychological deficits in eating disorders. In terms of treatment, it has been suggested that individuals with cognitive deficits may be unable to reflect on the nature and seriousness of their problems, and may have difficulty generating solutions to problems, impacting on engagement and motivation (Rourke,*et al*. 1989). Therefore, it would seem reasonable to ensure that all therapists be aware of the types of neuropsychological deficits typically associated with individuals with eating disorders. Some elements of psychological treatments may also not be suitable for some individuals with eating disorders due to their neuropsychological weaknesses. For example, research has shown that Cognitive-Behavioural therapy (CBT) may not be as effective for those who are highly impulsive (Agras *et al*. 2000; Duchesne *et al*. 2004) because they are less able to decrease the focus on their eating control / dietary restriction. The increased errors found in BN relative to AN in this study and previous studies which have found evidence of decision making deficits in BN would support this proposal.

AN has seen further advances for clinical practice; for instance, there is now consistent evidence of set shifting deficits, weak central coherence, and other executive

dysfunction in people with AN, as supported by this study (Duchesne *et al*. 2004; Lena *et al*. 2004). Neuropsychological findings have shown that deficits in set shifting are one of the maintaining factors in AN (Davies & Tchanturia, 2005). To target these deficits, Cognitive-Remediation Therapy for Anorexia Nervosa (CRT-AN) was developed. This has been proposed to be an alternative treatment for people with AN, with encouraging preliminary findings (Davies & Tchanturia, 2005; Tchanturia *et al*. 2007). The development of CRT-AN demonstrates how clinically relevant neuropsychological findings are to the assessment and treatment of people with eating disorders (Baldock & Tchanturia, 2007).

In terms of the utility of the Ravello Profile, there are many clinical implications in that this study primarily found differences between AN and BN and not BN and controls. The Ravello Profile was developed for an AN population. Therefore, it would be expected that the primary deficits would be found in the AN group. However, previous research would suggest that there would also be differences between the BN and controls on measures of executive functioning and central coherence as measured by the Ravello Profile. However, this was not found. Although it may be that the BN group are not impaired on these domains, it may also be possible that some areas of functioning not measured by the Ravello Profile are impaired in BN. Therefore, based on the findings of the current study, it would be beneficial to continue examining neuropsychological deficits in BN using standardised tests not contained within the Ravello Profile.

Some limitations of this study deserve discussion. Due to the number of variables which had missing data in the AN group, group means were inserted. Whilst this is not ideal,

there are a number of benefits of retaining cases with group means rather than simply

excluding cases. Secondly, the study would have been strengthened by having a wider

range of symptom severity, as those in the BN group were mostly treated as out-

patients whereas those in the AN group were treated as in-patients. It may also have

been useful to have controlled for other variables such as medication, time of

undertaking the neuropsychological assessment, and years in education as these may

have been confounds to neuropsychological performance.

Conclusions

The findings of this study support previous research which has found evidence of

executive dysfunction and weak central coherence in AN in comparison to BN. The AN

sample were also significantly slower than individuals with BN and controls on a task of

visuo-spatial functioning, indicating an accuracy over speed bias in comparison to the BN

sample. Despite a trend for better performance in control group in comparison to the

BN group, no significant differences were found. Therefore, this study only found AN to

be associated with specific neuropsychological dysfunction.

There are many implications of these findings for clinical and research practice. It may be

beneficial to adapt the Ravello Profile for AN as not all measures were found to be more

poorly affected in AN. There were very few measures more poorly affected in BN sample.

Therefore, the Ravello Profile may not be the most suitable battery of tests to use with

this group. It would be useful for a battery of tests for BN to take into account increased

errors in BN relative to AN and increased speed of processing in BN relative to AN

(possibly reflecting impulsivity). Those working with individuals with AN or BN should take

into consideration possible effects of their respective cognitive limitations and adapt interventions accordingly. It is important that future research builds upon these treatment developments in order for services to better tailor treatments for individuals with eating disorders.

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APPENDICES

Appendix 1: Author guidelines for *Psychological Medicine*

Psychological Medicine

Editorial Policy

Psychological Medicine is a journal aimed primarily for the publication of original research in clinical psychiatry and the basic sciences related to it. These include relevant fields of biological, psychological and social sciences. Review articles, editorials and letters to the Editor discussing published papers are also published. Contributions must be in English.

Submission of manuscripts

Papers for publication from Europe and Australasia, except those on genetic topics, should be addressed to the UK Editor, Professor Robin Murray, C/O Lynet Smith, Psychological Medicine Editorial Office, Cambridge University Press, UPH Building, Shaftesbury Road, Cambridge, CB2 8BS, Email: lsmith@cambridge.org.

Papers from the Americas, Asia, Africa and the Middle East, and all papers dealing with genetic topics, irrespective of country, should be sent to the US Editor, Professor Kenneth S. Kendler, MCV, PO Box 980126, Richmond, VA, 23298-0126, USA (Street address: Virginia Biotechnology Center One, Room 1-123, 800E Leigh Street, Richmond, VA, 23219, USA), Email: bherrmann@vcu.edu.

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Submissions by email attachments are preferred. Alternatively contributors who wish may send one hard copy of the text, tables and figures, plus an identical copy on computer disk, giving details of format used (e.g. MS Word etc.). All files should be editable, e.g. Microsoft Word format. Please do not attach pdf files. Authors should also accompany their submission with a list of 5 or more suggested suitable referees to aid the peer review process.

A covering letter signed by all authors should confirm agreement to submission. The letter should also give full mailing, fax and email contact details of the author who will handle correspondence. Submission of a paper will be held to imply that it contains original work that has not been previously published and that it is not being submitted for publication elsewhere. This should be confirmed in the letter of submission. When an article has been accepted for publication, the authors should email their final version or send a copy on computer disk (indicating format used, e.g. Mac/PC, MS Word/Word Perfect, etc.) together with one hard copy of the typescript and good quality copies of all tables, figures, etc. However, the publisher reserves the right to typeset the material by conventional means if an author's disk proves unsatisfactory.

The following information must be given on the first page (title sheet): (1) title and short title for running head (not more than 60 characters): (2) authors' names, (3) department in which the work was done, (4) word count of text excluding abstract, tables/figures and reference list. Generally papers should not have text more than 4500 words in length (excluding these sections) and should not have more than a combined total of 5 tables and/or figures. Papers shorter than these limits are encouraged. For papers of unusual importance the editors may waive these requirements. A structured abstract of no more than 250 words should be given at the beginning of the article using the headings: Background; Methods; Results; Conclusions. The name of an author to whom correspondence should be sent must be indicated and a full postal address given in the footnote. Any acknowledgements should be placed at the end of the text (before the References section). Declaration of Interest: A statement must be provided in the acknowledgements listing all financial support received for the work and, for all authors, any financial involvement (including employment, fees, share ownership) or affiliation with any organisation whose financial interests may be affected by material in the manuscript, or which might potentially bias it. This applies to all papers including editorials and letters to the editor.

Contributors should also note the following:

1. S.I. units should be used throughout in text, figures and tables.

2. Authors should spell out in full any abbreviations used in their manuscripts.

3. Foreign quotations and phrases should be followed by a translation.

4. If necessary, guidelines for statistical presentation may be found in: **Altman, D. G., Gore, S. M., Gardner, M. J. & Pocock, S. J.** (1983). Statistical guidelines for contributors to medical journals. *British Medical Journal* **286**, 1489-1493.

References

(1) The Harvard (author-date) system should be used in the text and a complete list of References cited given at the end of the article. In a text citation of a work by more than two authors cite the first author's name followed by *et al*. (but the names of all of the authors should be given in the References section). Where several references are cited together they should be listed in rising date order.

(2) The References section should be typed in alphabetical order on a separate sheet. Examples follow:

Brown, G. W. (1974). Meaning, measurement and stress of life events. In *Stressful Life Events: Their Nature and Effects* (ed. B. S. Dohrenwend and B. P. Dohrenwend), pp. 217-244. John Wiley: New York.

Brown, J. (1970). *Psychiatric Research*. Smith: Glasgow.

Brown, J., Williams, E. & Wright, H. (1970). Treatment of heroin addiction. *Psychological Medicine* **1**, 134-136.

Note: authors names should be in **bold** font; journal titles should always be given in full.

(3) References to material published online should follow a similar style, with the URL included at the end of the reference, with the accession date, if known. Authors are requested to print out and keep a copy of any online-only information, in case the URL changes or is no longer maintained. Examples follow:

Acute Health Care, Rehabilitation and Disability Prevention Research – National Centre for Injury Prevention and Control.

(http://www.cdc.gov/ncipc/profiles/acutecare/default.htm). Accessed 7 June 2004.

British Psychological Society Research Digest, Issue 12.

(http://lists.bps.org.uk/read/messages?id=1423). Accessed 17 February 2004.

Figures and tables

Only essential figures and tables should be included. Further tables, figures, photographs and appendices, may be included with the online version on the journal website. *Photographs* Unmounted photographs on glossy paper should be provided. Magnification scales, if necessary, should be lettered on these. Where possible, prints should be trimmed to column width (i.e. 70 mm). *Diagrams* These should not be included in the text and should be submitted in a form suitable for direct reproduction. The printed version will normally be reduced to 70 mm wide, so care should be taken to ensure that lettering and symbols will remain clearly legible. All

photographs, graphs, and diagrams should be referred to as figures and should be numbered consecutively in Arabic numerals. Ensure that the figure number is marked on the back of the photograph or artwork together with the name of the author and paper title. Captions for figures should be typed double-spaced on separate sheets. *Tables* Tables should be numbered consecutively in the text in Arabic numerals and each typed on a separate sheet after the References section. Titles should be typed above the table.

Proofs and offprints

Page proofs will be sent to the author designated to receive correspondence. Corrections other than to printer's errors may be charged to the author. Fifty offprints of each paper are supplied free; additional offprints are available according to a scale of charges if they are ordered on the form supplied when the proof is returned. *(Revised 30/09/09)*

Appendix 2: Consent form for BN group (NHS Highland)

**Psychotherapy &
Eating Disorder
Services**
Greenfields House
New Craigs Hospital
6-16 Leachkin Road
Inverness
IV3 8NP
Tel: 01463 253667
Enquiries to:

Date

CONSENT FORM

Title of study: A comparison of neuropsychological test performance between anorexia nervosa and bulimia nervosa

Centre Name:
Name of researcher: Kirsty Macdonald
Participant Identification Number:

**Please
INITIAL**

1. I confirm that I have read and understand the information sheet
    concerning the above study. I have had the opportunity to consider the
    information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free
    to withdraw at any time, without giving any reason, and without my
    medical care, educational or legal rights being affected.

3. I understand that information from my original routine assessment will
    be looked at by the named local researcher where it is relevant
    to my taking part in this research. I give permission
    for this individual to have access to my records.

4. I agree to take part in the above research study.

5. I agree to my General Practitioner (GP) being informed of my

    participation in this research.

6. In the unlikely event that there is an underlying clinical problem identified
    during the course of this research, the researcher will inform me of this. I

give consent to the researcher providing me with this feedback.

7. In the unlikely event that there is an underlying clinical problem identified, I give consent to the researcher contacting my GP to inform them of this.

_____   _____   _____
Name of participant   Signature   Date

_____   _____   _____
Name of researcher   Signature   Date

Following completion of this consent form, one copy will be given to the participant and one will be kept in their medical records.

Appendix 3: Participant Information Sheet for BN group (NHS Highland)

**Psychotherapy &
Eating Disorder
Services**
Greenfields House
New Craigs Hospital
6-16 Leachkin Road
Inverness
IV3 8NP
Tel: 01463 253667
Enquiries to:

Participant Information Sheet

Study title: A comparison of neuropsychological test performance between

anorexia nervosa and bulimia nervosa

You are being invited to take part in a research study. It is important for you to

understand why the research is being done and what it will involve. Please take time

to read the following information carefully. Talk to others about the study if you wish

before you decide to take part. *Thank you for your time.*

Why are we doing this research?

This research project is investigating cognitive functioning in people with bulimia

nervosa. Cognitive functioning means the way our brain makes sense of information.

Our brain does this in lots of different ways within our everyday life. For example,

we use our memory (e.g. to remember an appointment), attention (e.g. to take

notice of what is going on around us), problem solving (e.g. to solve everyday dilemmas) and language (e.g. to communicate with others).

Everyone has their own cognitive strengths and weaknesses. For example, a person may have a good memory but may find it difficult to solve everyday problems.   The aim of this study is to explore whether people with bulimia nervosa have a particular set of cognitive strengths and difficulties compared to people with anorexia nervosa.

Why have I been invited to take part?

Anybody referred to this service with a formal diagnosis of bulimia nervosa will be invited to take part in this study.

Do I have to take part?

No, it is up to you whether you take part. If you do wish to take part, you will be asked to sign a consent form saying that you have agreed to take part in this research study. You will be given a copy of this consent form to keep for your information. You are free to change your mind at any time during the study without giving a reason. If you change your mind and withdraw from the study, any treatment you are having now or in the future will not be affected.

What is involved?

The research involves you completing some tasks and questionnaires. The tasks are set out like puzzles and require various responses from you, such as saying different

words or drawing diagrams. These will take up to two hours to complete. You will be

offered a thirty minute break in between this appointment.

Is there any harm to participating in this research?

The tasks and questionnaires used in this study will not cause you any harm.

However, if you were to have any concerns, the named researcher (Kirsty

Macdonald) would discuss these with you.

How is this research useful?

We cannot promise that the study will help you personally, although many people

find it helpful to have information on their cognitive strengths and difficulties. The

information we get from this study will help us to understand more about cognitive

functioning in bulimia nervosa. In the long term, this understanding may contribute

towards developing improved ways of treating those with bulimia nervosa.

What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the

named local researcher, Kirsty Macdonald, who will do her best to answer your

questions. If you would like to speak to an independent person about this study you

may also contact Dr Andrew MacDougall (Clinical Psychologist) who will answer any

queries you may have relating to this research. If you remain unhappy and wish to

complain formally, you can do this through the organisations Complaints Procedure.

Details can be obtained from the hospital.

In the unlikely event that something does go wrong and you are harmed during the research and this is due to someone's negligence then you may have grounds for a legal action for compensation against the organisation named on the consent form. Should this occur, you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

What will happen to the results of the research study?

The results of this study may be published in scientific journals and if so, will appear one to two years after the end of the research study.

If you wish to receive a summary of your own individual results (i.e. your own cognitive strengths and weaknesses), please indicate this on the consent form. This summary will be sent to your home address at the end of the study, which we will take from your medical records.

Will the information be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Only members of the research team and the staff involved in your treatment will have access to this information. Any information about you that leaves the hospital will have your name and address removed so that you cannot be recognised from it. If you do opt to receive a summary of the results, your name and address will be kept separate from all research information.

In the unlikely event that the assessment highlights an underlying clinical problem, then you will be informed of this through feedback of the assessment. You will then be advised to contact your General Practitioner (GP), and your data will be removed from the study. You must give consent for this feedback to be given to you. You must also give consent for us to contact your GP to inform them that you are participating in a research study.

Who is organising and funding the research?

This study is part of the researcher's Doctorate in Clinical Psychology (D.Clin.Psychol) qualification. This qualification is being completed through the National Health Service (NHS Highland), National Education for Scotland (NES), and the University of Edinburgh.

Who has reviewed the study?

All research is looked at by an independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. In addition to undergoing review by the National Health Service's ethics committee, this study has been reviewed by the University of Edinburgh's Research Ethics Committee.

Can I get further information?

If you would like any more information about this study, please contact Kirsty Macdonald (Trainee Clinical Psychologist) on 01463 253667. Alternatively, if you would like to speak to an independent person about this study, please contact Dr Andrew MacDougall (Clinical Psychologist) on 01463 253697.

Please contact Kirsty Macdonald (01463 253667) if you would like a written summary

of the main research findings. This can be provided to all participants at the end of

the study (September 2010).

Thank you for considering taking part in this study

Appendix 4: Ethical approval from The University of Edinburgh

UNIVERSITY OF EDINBURGH / NHS (SCOTLAND) CLINICAL PSYCHOLOGY TRAINING COURSE

Research Ethics Meeting 5th October 09

Present:

Ethel Quayle

David Gillanders

Ken Laidlaw

Paul Morris

Jill Cossar

Apologies:

Lindsey Murray

Kirsty Macdonald

This was felt to be an interesting but challenging proposal and some concern was expressed as to whether it will be possible to secure the population required. This should be further discussed with the academic supervisors. There is no requirement to resubmit but a School Research Ethics Form should be completed and sent to Evelyn Kelly.

Dear Miss Macdonald

Study Title: A comparison of neuropsychological test performance on the Ravello Profile between bulimia nervosa and anorexia nervosa.

REC reference number: *09/51103/46*

Protocol number: 1

Thank you for your letter of 29 November 2009, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information was considered by the acting chair on behalf of SESREC 3.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

The Committee has not yet been notified of the outcome of any site-specific assessment (SSA) for the non-NHS research site(s) taking part in this study. The favourable opinion does not therefore apply to any non-NHS site at present. I will write to you again as soon as one Research Ethics Committee has notified the outcome of a SSA In the meantime no study procedures should be initiated at non-NHS sites.

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement* of *the NHS organisation is* as a *Participant Identification Centre, management permission for research is not required but the R&D office should be notified* of *the study. Guidance should be sought from the R&D office where necessary.*

Sponsors are not required to notify the Committee of *approvals from host organisations.*

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows: *Document*	*Version*	*Date*
Covering Letter		25 October *2009*
REC application		25 October 2009
Confirmation that DclinPsychol student		27 October *2009*
Investigator CV		K Macdonald
Evidence of insurance or indemnity		27 July 2009
Letter from Sponsor		23 October *2009*
Investigator CV		Paul Morris (tutor)
Investigator CV		Andrew MacDougall
Univ of Edin-NHSScotland RES meeting notes		05 October 2009
• Protocol	1	27 October 2009 !
Questionnaire: Various		29 October 2009
Obsessional -Compulsive Complaints Paper / Maudsley MOC inventory		
Participant Information Sheet: PIS	2	30 November 2009
Participant Consent Form: PCF	2	30 November 2009
Response to Request for Further Information		29 November 2009

Appendix 6: Management approval (NHS Highland)

Prof David J Godden, MD, FRCP(Edin), FRCP(Glasg)
Research Director
NHS Highland Research Office
Room S101
The Centre for Health Science
Old Perth Road
Inverness, IV2 3JH

Tel: 01463 255823
Fax: Not available
E-mail: david.godden@.nhs.net

NHS
Highland

08 December 2009

NHS Highland R&D ID: **620**
NRSCC ID: **NRS09/CP11**

Miss Kirsty Macdonald
Trainee Clinical Psychologist
Psychotherapy Services
Greenfields House
6-16 Leachkin Road
New Craigs Hospital
Inverness
IV3 8NP

RECEIVED
1 4 DEC 2009

Dear Miss Macdonald,

Management Approval for Non-Commercial Research

I am pleased to tell you that you now have Management Approval for the research project entitled: **'A Comparison of Neuropsychological Test Performance on the Ravello Profile Between Bulimia Nervosa and Anorexia Nervosa'.** I acknowledge that:

- The project is sponsored by NHS Highland.
- The project does not require external funding.
- Research Ethics approval for the project has been obtained from the South East Scotland 03 Research Ethics Committee, (Reference Number: 09/S1103/46).
- The Site-Specific Information form for this site has been reviewed (completed on 04/12/09) and there is no objection to NHS Highland being included as a site for this project

The following conditions apply:

- The responsibility for monitoring and auditing this project lies with NHS Highland.

Working with you to make Highland the healthy place to be

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- This study will be subject to ongoing monitoring for Research Governance purposes and may be audited to ensure compliance with the Research Governance Framework for Health and Community Care in Scotland (2006, 2nd Edition), however prior written notice of audit will be given.
- All amendments (minor or substantial) to the protocol or to the REC application should be copied to the NHS Highland Research and Development Office together with a copy of the corresponding approval letter. All such amendments will be covered by the approval given by this letter, and it is therefore not necessary to seek amendment approval.
- The paperwork concerning all incidents, adverse events and serious adverse events, thought to be attributable to participant's involvement in this project should be copied to the NHS Highland R&D Office.

Please report the information detailed above, or any other changes in resources used, or staff involved in the project, to the NHS Highland Research and Development Manager, Frances Hines (01463 255822, frances.hines@nhs.net).

Yours sincerely,

Dr Ken Proctor
Associate Medical Director

cc   Frances Hines, R&D Manager, NHS Highland Research & Development Office, Room S101, The Centre for Health Science, Old Perth Road, Inverness, IV2 3JH
Pamela Shand, Senior Administrator, NHS Research Scotland Coordinating Centre, Research & Development Office, Foresterhill House Annexe, Foresterhill, Aberdeen, AB25 2ZB

Appendix 7: Management approval (NHS Tayside)

NHS
Tayside

EC/LH

18 January 2010

Miss Kirsty Macdonald
Trainee Clinical Psychologist
NHS Highland
Psychotherapy Services
Greenfields House
New Craigs Hospital
6-16 Leachkin Road
INVERNESS
IV2 8NP

Dear Miss Macdonald,

NHS TAYSIDE MANAGEMENT/GOVERNANCE APPROVAL

NRS Project ID: NRS09/CP11

Tayside R&D Project ID: 2009MH07

Title: A comparison of neuropsychological test performance on the Ravello Profile between bulimia nervosa and anorexia nervosa and anorexia nervosa.

Main REC Ref: 09/S1103/46   **Main REC Approval Date: 03/12/09**

Funder: Unfunded

Sponsor: NHS Highland

NHS Support Costs: £2,022

The above project has been registered on the NHS Tayside R&D database, as required by the Research Governance Framework. Full ethical approval has been obtained and there are £2,022 of local NHS Support Costs associated with this research project.

NHS Tayside has no objection to the project proceeding, provided all necessary approvals are in place and all amendments to the protocol, personnel involved and funding be notified to the R&D Office and all appropriate personnel.

It is important to note that all research must be carried out in compliance with the Research Governance Framework for Health & Community Care, GCP and the new EU Clinical Trials Directive (for clinical trials involving investigational medicinal products).

Kind Regards

Elizabeth Coote
R&D Manager

c.c.   NRSCC

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Appendix 8: Sponsorship Letter

Frances Hines
Research and Development Manager
NHS Highland Research Office
Centre for Health Science
Old Perth Road
Inverness
IV2 3JH

Tel: 01463 255822
Fax:
E-mail: Frances.Hines@haht.scot.nhs.uk

23 October 2009   NHS Highland R&D ID: **620**

Ms Kirsty Macdonald
Trainee Clinical Psychologist
Specialist (Adult and Child) Easting Disorder Placement
Greenfields
New Craigs
Leachkin Road
Inverness
IV3 8NP

Dear Ms Macdonald

Project Title: **A Comparison of Neuropsychological Test Performance on the Ravello Profile Between Bulimia Nervosa and Anorexia Nervosa.**
REC Number: **Unknown**
NHS Highland Project Number: **620**

NHS Highland agrees to be Sponsor for this project under the requirements of the Scottish Executive Health Department Research Governance Framework for Health and Community Care (Second Edition (2006)).

It is the sponsor's responsibility to be satisfied that;

- The research proposal respects the dignity, rights, safety and well-being of participants and the relationship with care professionals;
- An appropriate process of independent expert review has demonstrated that the research proposal is worthwhile, of high scientific quality and good value for money;
- An appropriate ethics committee has given a favourable opinion;
- The chief investigator and other key researchers have the necessary expertise and experience and have access to the resources needed to conduct the proposed research successfully;
- The arrangements and resources proposed will allow the collection of high quality, accurate data and the systems and resources proposed are those required to allow appropriate data analysis and data protection;

Working with you to make Highland the healthy place to be

Headquarters:
NHS Highland, Assynt House, Beechwood Park, Inverness

Chairman: Mr Garry Coutts
Chief Executive: Dr Roger Gibbins, BA, MBA, PhD

- There is written agreement about the arrangements for the management and monitoring of the study;
- Arrangements are in place for the sponsor and other stakeholder organisations to be alerted if significant developments occur as the study progresses, whether in relation to the safety of individuals or to scientific direction;
- Agreement has been reached about compensation in the event of harm to research participants and if any organisation, or the sponsor itself, offers compensation without proof of negligence, it has made the necessary financial arrangements;
- There are arrangements for the conclusion of the study including appropriate plans for disseminating the findings;
- Scientific judgements made by the sponsor in relation to these responsibilities should be based on independent and expert advice;
- The sponsor is expected to assist any enquiry, audit or investigation related to the work.

I would be grateful if you could respond in writing to the SIX items highlighted in the attached Sponsor checklist. The checklist will be used to monitor the project, fulfilling the obligations NHS Highland has as Sponsor.

Yours sincerely,

Frances Hines

Frances Hines
NHS Highland Research and Development Manager

Responsibilities of the Sponsor	Status	Action
The research proposal respects the dignity, rights, safety and well-being of participants and the relationship with care professionals	This will be confirmed by a favourable opinion from the REC.	Please send a copy of the Favourable Opinion letter to NHS Highland R&D Office
An appropriate process of independent expert review has demonstrated that the research proposal is worthwhile, of high scientific quality and good value for money	Academic reviews or other peer reviews will provide evidence of this.	Please ensure that such peer review evidence is available, for example, by completing the R&D IRAS form.
The chief investigator and other key researchers have the necessary expertise and experience and have access to the resources needed to conduct the proposed research successfully	Kirsty Macdonald is working in this area of knowledge and has the clinical and academic support available.	NA
The arrangements and resources proposed will allow the collection of high quality, accurate data and the systems and resources proposed are those required to allow appropriate data analysis and data protection	Kirsty Macdonald has the support of her work colleagues and of her academic supervisors, and full access to the patients she needs for effective data collection.	NA
There is written agreement about the arrangements for the management and monitoring of the study	This will be confirmed by the R&D IRAS form.	Please send a copy of the R&D IRAS form to the NHS Highland R&D Office when completed and signed.
Arrangements are in place for the sponsor and other stakeholder organisations to be alerted if significant developments occur as the study progresses, whether in relation to the safety of individuals or to scientific direction	If any such occurrences the CI should inform the NHS Highland R&D Office immediately.	Please ensure any such issues are brought to the attention of the NHS Highland R&D Office immediately.
Agreement has been reached about compensation in the event of harm to research participants and if any organisation, or the sponsor itself, offers compensation without proof of negligence, it has made the necessary financial arrangements	NHS will cover.	NA
There are arrangements for the conclusion of the study including appropriate plans for disseminating the findings	The R&D IRAS form will confirm that the outputs are appropriate to the level of the study.	Please send a copy of the R&D IRAS form to the NHS Highland R&D Office when completed and signed.
Scientific judgements made by the sponsor in relation to these responsibilities should be based on independent and expert advice	This will be confirmed by a favourable opinion from the REC.	Please send a copy of the Favourable Opinion letter to NHS Highland R&D Office
The sponsor is expected to assist any enquiry, audit or investigation related to the work	The NHS Highland R&D Office may audit this study as part of any annual audit for research governance purposes.	NA

Appendix 9: Indemnity

TO WHOM IT MAY CONCERN

27 July 2009

Dear Sir / Madam

The University of Edinburgh – Professional Indemnity Insurance

As Insurance Brokers to the above, we confirm details of their annual Professional Indemnity Insurance as follows:-

Professional Indemnity

Insurer   QBE Insurance
Policy Number   011800/01/2007/075
Renewal Date   01 August 2010
Limit of Indemnity   £10M any one claim and in all during the period

I trust that the above details are sufficient for your requirements, but please do not hesitate to contact us if you require further information.

Yours faithfully

A Parker

Alan Parker
Client Service Adviser – Commercial Insurance Division
For and on behalf of Aon Limited

Direct Dial : 0131 456 3074
E-Mail : alan.parker@aon.co.uk

Appendix 10: Central Coherence scoring system

Central coherence is the ability to achieve a balance between efficiency and attention to detail. Typically, individuals process incoming information on a gestalt level which enables them to see the "bigger picture" or general gist. This sort of processing style is known as strong, or high central coherence. On the other hand, weak central coherence refers to a processing bias towards featural or local information, usually at the expense of the overall gestalt. The Central Coherence Index (CCI) is a measure of this cognitive bias that entails focusing on the details rather than integrating information into an overall context.

Below are instructions on scoring central coherence from the Rey Complex Figure Test. The examiner should have documented the participant's drawing method on pages 4, 5 and 6 of the Rey Complex Figure Test and Recognition Trial Test Booklet for the Copy, Immediate Recall and Delayed Recall, respectively. Furthermore, a prerequisite for using the CCI is knowledge of the Meyers and Meyers Rey Complex Figure (1995) scoring system.

The Rey diagram consists of 18 elements, i.e. the first element is the vertical cross; the second element is the large rectangle and so on. Each element consists of a number of components, for instance the vertical cross consists of three components- the vertical component of the cross, the short horizontal component near the top of the vertical component and a short horizontal component midway down the vertical

line which connects the cross to the large rectangle. It is important to note that all components must be present for an element to be complete.

The Central Coherence Index is scored in three steps.

1) Order of Construction Index (OCI)

The first step focuses on the number of global features as opposed to local features which are drawn in the early stage of the each trial. Each element is assigned a weight reflecting it's importance in the overall gestalt of the figure which ranges from 0 to 4. The more important the element is to the overall figure i.e. global and external, the higher the weight. Firstly, work out the total number of *complete* elements the participant has copied, and then assign the first third of these elements a corresponding weight from Table 1. For instance, if all 18 elements of the Rey are complete and present, then the first 6 elements are scored for Order of Construction. If an element has a missing component, then move on until you come to the next complete element- it must be complete in order to receive a weight, even if it has been completed in a fragmented or piecemeal fashion. The mean weight is taken as the OCI, ranging from 0 to 3.3.

2) Style Index (SI)

The second step focuses on the degree of continuity the participant has employed in the drawing process. Six pre-selected elements are scored on the following three-point scale: Two points = the components of the element were drawn in a continuous stroke or drawn consecutively. One point = the components of the

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element were partially fragmented or drawn separately i.e. one interruption in drawing the components of the element. Zero points = the components of the element are clearly disjointed in appearance or drawn in a piecemeal manner i.e. two or more interruptions in drawing the components of the element. Ratings are made independent of accuracy, therefore if an element is partially drawn, i.e. one or more components of the element are missing, but the element is still recognisable, the rating should be based on the components that are present. If an element is absent or unrecognisable, no rating should be given. The mean rating is taken as the SI, ranging from 0 to 2.

3) Central Coherence Index (CCI)

The final step involves calculating the Central Coherence Index by adding the proportions of the total possible scores for order and style.

$$\text{CCI} = \left(\frac{OCI}{3.3} \right) + \left(\frac{SI}{2} \right)$$

OCI= Order of Construction Index

SI= Style Index

Possible CCI scores range from 0 to 2, a higher score suggesting a more coherent drawing style as reflected by use of global, external features (as oppose to finer, internal details) at the beginning of the figure construction and a continuous (versus fragmented) drawing style for the main elements of the figure.

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Order of Construction Index (OCI) scoring guidelines

Determine how many of the 18 elements of the Rey figure were drawn by the

participant. Take the first 1/3 of those elements (up to a total of 6).

Order	Scoring Element	Description	Type of Element	Score
e.g.	2	Large Rectangle	Global External	4
1st				
2nd				
3rd				
4th				
5th				
6th				

Total Score	OCI (divide total by no. of elements scored)	Proportion of Scores (divide OCI by 3.3)

Style Index (SI) scoring guidelines

Continuous or consecutive drawing of lines, 2 points; Fragmented drawing (1

interruption), 1 point; Separate drawing (2 or more interruptions), 0 points.

Scoring Element	Description	Style (Continuous, fragmented or separate	Score
e.g.	Large rectangle	Continuous	2
2	Large rectangle		
3	Diagonal Cross		
4+16	Extended horizontal line		
5+1	Extended vertical midline		
6	Small rectangle		
13+15	Large triangle + inside line		

Total Score	SI (divide total by no. of components present)	Proportion of Style Index (divide SI by 2)

Central Coherence Index (CCI)

Proportion of OCI		Proportion of SI		CCI
	+		=	

Psychotherapy & Eating Disorder Services
Greenfields House
New Craigs Hospital
6-16 Leachkin Road
Inverness
IV3 8NP

Tel: 01463 253667

Enquiries to: Kirsty Macdonald
Kirsty.macdonald@nhs.net
Date   03 May 2011

Participant Information Sheet

Study title: A comparison of neuropsychological test performance between anorexia nervosa, bulimia nervosa and healthy adults

You are being invited to take part in a research study. It is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Talk to others about the study if you wish before you decide to take part. *Thank you for your time.*

Why are we doing this research?

This research project is investigating cognitive functioning in people with anorexia nervosa, bulimia nervosa and healthy adults. Cognitive functioning means the way our brain makes sense of information. Our brain does this in lots of different ways within our everyday life. For example, we use our memory (e.g. to remember an appointment), attention (e.g. to take notice of what is going on around us), problem solving (e.g. to solve everyday dilemmas) and language (e.g. to communicate with others).

Everyone has their own cognitive strengths and weaknesses. For example, a person may have a good memory but may find it difficult to solve everyday problems. The aim of this study is to explore whether people with bulimia nervosa have a particular set of cognitive strengths and difficulties compared to people with anorexia nervosa.

Why have I been invited to take part?

You are being invited to take part as a healthy adult.

Do I have to take part?

No, it is up to you whether you take part. If you do wish to take part, you will be asked to sign a consent form saying that you have agreed to take part in this research study. You will be given a copy of this consent form to keep for your information. You are free to change your mind at any time during the study without giving a reason.   If you change your mind and withdraw from the study, any treatment you are having now or in the future will not be affected.

What is involved?

The research involves you completing some tasks and questionnaires. The tasks are set out like puzzles and require various responses from you, such as saying different words or drawing diagrams. These will take up to two hours to complete. You will be offered a thirty minute break in between this appointment.

Is there any harm to participating in this research?

The tasks and questionnaires used in this study will not cause you any harm. However, if you were to have any concerns, the named researcher (Kirsty Macdonald) would discuss these with you.

How is this research useful?

We cannot promise that the study will help you personally, although many people find it helpful to have information on their cognitive strengths and difficulties. The information we get from this study will help us to understand more about cognitive functioning in bulimia nervosa. In the long term, this understanding may contribute towards developing improved ways of treating those with bulimia nervosa.

What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the named local researcher, Kirsty Macdonald, who will do her best to answer your questions. If you would like to speak to an independent person about this study you may also contact Jessie Macdonald (Nurse Therapist) who will answer any queries you may have relating to this research. If you remain unhappy and wish to complain formally, you can do this through the organisations Complaints Procedure. Details can be obtained from the hospital.

In the unlikely event that something does go wrong and you are harmed during the research and this is due to someone's negligence then you may have grounds for a legal action for compensation against the organisation named on the consent form. Should this occur, you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

What will happen to the results of the research study?

The results of this study may be published in scientific journals and if so, will appear one to two years after the end of the research study.

If you wish to receive a summary of your own individual results (i.e. your own cognitive strengths and weaknesses), please indicate this on the consent form. This summary will be sent to your home address at the end of the study, which we will take from your medical records.

Will the information be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. Only members of the research team and the staff involved in your treatment will have access to this information. Any information about you that leaves the hospital will have your name and address removed so that you cannot be recognised from it. If you do opt to receive a summary of the results, your name and address will be kept separate from all research information.

In the unlikely event that the assessment highlights an underlying clinical problem, then you will be informed of this through feedback of the assessment. You will then be advised to contact your General Practitioner (GP), and your data will be removed from the study. You must give consent for this feedback to be given to you. You must also give consent for us to contact your GP to inform them that you are participating in a research study.

Who is organising and funding the research?

This study is part of the researcher's Doctorate in Clinical Psychology (D.Clin.Psychol) qualification. This qualification is being completed through the National Health Service (NHS Highland), National Education for Scotland (NES), and the University of Edinburgh.

Who has reviewed the study?

All research is looked at by an independent group of people, called a Research Ethics Committee to protect your safety, rights, wellbeing and dignity. In addition to undergoing review by the National Health Service's ethics committee, this study has been reviewed by the University of Edinburgh's Research Ethics Committee.

Can I get further information?

If you would like any more information about this study, please contact Kirsty Macdonald (Trainee Clinical Psychologist) on 01463 253667. Alternatively, if you would like to speak to an independent person about this study, please contact Jessie Macdonald (Nurse Therapist) on 01463 253667.

Please contact Kirsty Macdonald (01463 253667) if you would like a written summary of the main research findings. This can be provided to all participants at the end of the study (September 2010).

Thank you for considering taking part in this study

Appendix 12: Consent form for controls

**Psychotherapy & Eating Disorder
Services**
Greenfields House
New Craigs Hospital
6-16 Leachkin Road
Inverness
IV3 8NP

Tel: 01463 253667

Enquiries to
Kirsty.macdonald@nhs.net
Date   03 May 2011

CONSENT FORM

Title of study: A comparison of neuropsychological test performance between anorexia nervosa, bulimia nervosa and healthy adults

Centre Name:
Name of researcher: Kirsty Macdonald
Participant Identification Number:

**Please
INITIAL**

8. I confirm that I have read and understand the information sheet concerning the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

9. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without my medical care, educational or legal rights being affected.

10. I agree to take part in the above research study.

11. I agree to my General Practitioner (GP) being informed of my participation in this research.

12. In the unlikely event that there is an underlying clinical problem identified during the course of this research, the researcher will inform me of this. I give consent to the researcher providing me with this feedback.

13. In the unlikely event that there is an underlying clinical problem identified, I give consent to the researcher contacting my GP to inform them of this.

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_____   _____   _____

Name of participant   Signature   Date

_____   _____   _____

Name of researcher   Signature   Date

Following completion of this consent form, one copy will be given to the participant and one will be kept in their medical records.