Set shifting, central coherence and starvation in eating disorders

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Overview

The literature review evaluates previous research into set shifting in eating disorders and investigates the role of starvation. Overall, the review suggests evidence for set shifting impairments in Anorexia Nervosa (AN) and Bulimia Nervosa (BN) but no research has investigated this in Binge Eating Disorder (BED). The review suggests that starvation may have a mediating or maintaining role in set shifting impairments rather than causing them per se. Evidence from studies of genetic relatives and recovered AN participants suggests that set shifting difficulties may be an enduring trait predisposing individuals to eating disorders. However various methodological limitations limit the conclusions that can be drawn.

The empirical paper investigates set shifting, central coherence and starvation in AN, BN and a Healthy Control (HC) group. Findings provided some evidence to suggest a set shifting impairment in AN and BN, although it was not possible to remove the confounding effects of anxiety, depression and obsessive compulsive symptomatology. There was no evidence to suggest an impairment in central coherence in AN or BN, however it is possible that inadequate statistical power may have contributed towards non-significant findings. Results indicated that starvation was not significantly associated with set shifting or central coherence, however this may be because few impairments were actually detected and because of inadequate indices of starvation. It is important to replicate these findings with more accurate indices of starvation before conclusions can be drawn about whether impairments in set shifting and central coherence are a consequence of starvation or a risk factor for eating disorders.

The critical appraisal explores the decisions, difficulties and personal challenges throughout the research process. It also considers consistency with previous findings, limitations of the study and the role of a psychologist in research.

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Part 1: Literature Review

Set shifting in eating disorders: 1980-2011

ABSTRACT

Aims: This review aims to evaluate and synthesise previous research on set shifting in eating disorders in order to determine whether individuals with eating disorders have impaired set shifting. It also aims to determine whether set shifting difficulties are a risk factor for eating disorders or a consequence of starvation.

Method: A summary and critique of the 13 papers specifically exploring set shifting in eating disorders is presented and followed by a synthesis of the results.

Results: There is evidence for set shifting difficulties in Anorexia Nervosa (AN) and Bulimia Nervosa (BN) however no research has been conducted into Binge Eating Disorder (BED). This review suggests that starvation may have a mediating or maintaining role in neuropsychological impairments, rather than causing them per se. Increased set shifting impairments in recovered AN participants and genetic relatives suggest that set shifting difficulties may be a predisposing trait, increasing vulnerability to eating disorders. However, there are various methodological limitations (such as no power analyses to estimate required sample sizes) which are discussed and should be kept in mind.

Conclusions: Although there is evidence for set shifting difficulties in AN and BN, the evidence is still very mixed and there is a need for use of consistent measures and clear reporting of findings with equal importance given to non-significant results.

1. Introduction

1.1 Set shifting:

Set shifting is the ability to move back and forth between multiple tasks, operations or mental sets (Miyake, Friedman, Emerson, Witzki & Howerter, 2000). It requires consideration of whether a previous pattern of responding remains relevant to the goal and changing it if necessary. Roberts, Tchanturia, Stahl, Southgate and Treasure (2007) suggest that problems in set shifting may manifest as cognitive inflexibility (e.g. concrete and rigid approaches to problem solving and stimulus bound behaviour) or response inflexibility (e.g. perseverative or stereotyped behaviours).

Research has indicated that individuals with AN demonstrate more rigid and inflexible behaviour than Healthy Control's (HCs), giving the same responses repeatedly (Tchanturia, Serpell, Troop & Treasure, 2001) and has shown that individuals with AN struggle significantly more than HCs on tasks requiring cognitive and perceptual set shifting (Holliday, Tchanturia, Landau, Collier & Treasure, 2005; Tchanturia et al. 2004b). After systematically reviewing studies that had investigated set shifting in AN and BN, Roberts et al. (2007) concluded that a consistent set shifting deficit was present across the eating disorder population. Unfortunately, the majority of research on set shifting has focused on AN, with little investigating BN and none investigating BED. Hence the current review aims to examine studies of set shifting across the eating disorders.

1.2 The role of starvation:

As eating disorders and starvation typically occur at the same time, it is difficult to establish whether neuropsychological impairments are risk factors for

eating disorders or are a consequence of starvation. State and trait theories have been proposed to explain the role starvation might play in neuropsychological impairments such as set shifting.

The state argument proposes that a state of starvation *causes* neuropsychological impairments in set shifting. Research findings that participants who have gained weight and are in recovery from AN have an intermediate set shifting performance compared to AN and HC groups (Nakazato et al. 2009; Nakazato et al. 2010) and findings that cognitive impairments normalise with refeeding and weight gain (Hatch et al. 2010) suggest neuropsychological functioning is adversely affected by starvation and lend support to the state theory. Recent studies showing that short-term starvation in healthy participants has a detrimental effect on set shifting (Bolton, 2010 & Pender, 2011) also lend support to this argument.

If the state argument is correct we would expect to see a high correlation between degree of starvation and severity of set shifting impairments. We would also expect chronic starvation to be more detrimental to neuropsychological performance than acute starvation. Therefore we might expect those with AN to have the most difficulties set shifting (because they are likely to suffer the effects of long-term chronic fasting in addition to short-term acute fasting), followed by those with BN (because they are likely to suffer short-term acute fasting effects). Finally, we would expect participants with BED not to demonstrate any set shifting difficulties because they are, by definition eating regularly outside binges and thus not in a state of starvation.

The trait argument proposes that neuropsychological impairments are enduring traits that predispose individuals to develop eating disorders. Research findings that set shifting impairments persist after recovery and weight gain (Holliday et al. 2005; Tchanturia et al. 2004b; Tenconi et al. 2010) and are present in unaffected sisters of women with eating disorders (Holliday et al. 2005; Tenconi et

al. 2010) lend support to the trait theory. If the trait argument is correct we would expect to see a weak or nonexistent correlation between degree of starvation and severity of neuropsychological impairments.

Overall, findings thus far have been mixed and the role that starvation plays in eating disorders is not yet clear.

2. Previous reviews and limitations

The only systematic review and meta-analysis into set shifting in eating disorders by Roberts et al. (2007) concluded that there appeared to be a set shifting deficit across eating disorders and in recovered/weight restored individuals with AN. However, this review only included papers published up until 2005 and did not include any studies of BED. This paucity of research into BED is particularly striking and is particularly relevant at the current time when there is a proposal to make BED a standalone diagnosis separate from the Eating Disorders Not Otherwise Specified (EDNOS) category (Fairburn & Cooper, 2011).

Moreover, evidence about the role of starvation in set shifting has never been systematically reviewed. It is important to try and establish clarity about the role of starvation in order to improve treatment outcomes because if starvation is *causing* neuropsychological impairments such as set shifting difficulties, it would make sense for interventions to focus on weight restoration in the first instance.

3. Rationale for current review and research questions

Given increased interest in the idea that set shifting is a core difficulty in eating disorders and the fact that the only systematic review investigating set shifting in eating disorders (Roberts et al. 2007) only reviewed articles published up until 2005, it seems timely to conduct another review to investigate this. A new

review will also provide an opportunity to examine the role of starvation in set shifting. Therefore the current review will examine experimental studies that have investigated set shifting in individuals with eating disorders and attempt to answer the following questions:

- *Do participants with AN, BN and BED have significantly more difficulties set shifting than HCs?*

- *Does the evidence suggest that set shifting difficulties are a consequence of starvation (state argument) or does it suggest that set shifting difficulties are an enduring trait predisposing an individual to eating disorders (trait argument)?*

4. Methodology for current review

4.1 Literature search strategy

A computerised search was completed on two online databases – PsychINFO and MEDLINE to identify relevant papers published between 1980 and 05.11.2011. Two search strategies were employed. The first was to map key terms to subject headings and use the 'explode' function and the second was to search for key terms in a free text word search. As there is a wide proliferation of terms used by researchers investigating set shifting, various search terms were included in an attempt to incorporate a high percentage of studies examining set shifting. Set shifting key terms searched for included variations of set shift, set switch, perseveration, flexibility and rigidity. Eating disorder key terms searched for included variations of anorexia, bulimia, binge eating, eating disorder and eating disorder not otherwise specified.

Once the search terms for set shifting and eating disorder were combined to select studies that included both aspects, there were 200 results in MEDLINE and 272 results in PsychINFO. Results in both databases were restricted to articles written in English (as translation facilities were not available), using human samples, published between 1980 and 05.11.2011. In PsychINFO results were restricted to peer-reviewed journals and in MEDLINE, results were restricted to journal articles as it was not possible to limit to peer-reviewed journals. Once these limits had been applied there were a total of 304 articles (161 from PsychINFO and 143 from MEDLINE) to screen by hand to ensure they met the inclusion criteria.

4.2 Inclusion & exclusion criteria

In order to be included, articles needed to be experimental studies (not only questionnaires) investigating set shifting in at least one eating disordered group. There were no age limits and articles with adolescents and adults were included in the review in order to maximise the number of studies that could be included. Examination of set shifting in eating disorders needed to be the main focus of the study and studies where set shifting was only a minor part of a broader battery of cognitive, executive functioning or neuropsychological tasks were excluded. Studies that were predominantly biological in nature and imposed additional restrictions (e.g. the task needed to be completed in a fMRI scanner) were also excluded unless the information on the set shifting task could be easily extracted and compared to other studies. In cases where information on set shifting could be extracted, the biological aspects of the article were not discussed as these were beyond the scope of this review.

5. Findings

5.1 Studies included in the review

Many of the 304 studies were irrelevant or duplicates and once screened by hand to ensure that they met the inclusion criteria 13 studies remained. The ‘find citing articles’ and ‘find similar’ articles functions in the electronic databases were used on these 13 studies but did not lead to the addition of any extra articles. The 13 studies that met the criteria for inclusion in the literature review are summarised in table 5.1 below.

Table 5.1 – Articles included in the review

Authors (year)	Study design	Sample size	Set shifting tasks	Brief description of results
Tchanturia, Harrison, Davies, Roberts, Oldershaw, Nakazato, Stahl, Morris, Schmidt & Treasure (2011)	Cross-sectional Various studies combined	215 AN (96 IP & 119 OP) 69 BN 29 EDNOS 72 ANREC 216 HC	Brixton	Brixton: AN & EDNOS significantly more errors than HC; BN not significantly different to HC; ANREC not significantly different to HC or AN. Starvation: No significant relationship between BMI & Brixton.
McAnarney, Zarcone, Singh, Michels, Welsh, Litteer, Wang & Klein (2011)	Cross-sectional	24 AN-R 37 HC	WCST IED - CANTAB	WCST: No significant differences in perseverative errors between AN-R & HC. IED: No significant differences in number of errors between AN-R & HC. Starvation: No significant relationship between BMI & SS.
Roberts, Tchanturia, & Treasure (2010)	Cross-sectional	35 AN-R 33 AN-BP 30 BN 30 ANREC (18R & 12BP) 30 AN Sis 20 BN Sis 88 HC	TMT WCST Brixton Haptic	TMT: No significant differences in B-A difference or errors between HC & AN (both subtypes), ANREC & AN Sisters. BN significantly more errors & significantly higher B-A difference than HC. BN sisters' significantly higher B-A difference than HC but no significant differences in number of errors. WCST: AN-BP & BN significantly more perseverative errors & completed fewer categories than HC. AN-R & ANREC significantly fewer categories than HC but no significant differences in perseverative errors. AN sisters no significant differences in categories completed but significantly more perseverative errors than HC. BN sisters not significantly different to HC. Brixton: AN-BP & BN sisters had significantly more errors

				than HC. AN-R, BN, ANREC & AN sisters not significantly different to HC. Haptic: AN-R & BN significantly more illusions than HC. AN-BP, ANREC, AN sisters & BN sisters not significantly different to HC. Starvation: No significant relationship between BMI & SS.
Nakazato, Hashimoto, Schmidt, Tchanturia, Campbell, Collier, Iyo & Treasure (2010)	Cross-sectional	27 AN (20R & 7BP) 18 ANREC (R) 28 HC	WCST TMT	WCST: AN significantly more perseverative errors than HC. ANREC not significantly different to HC or AN. TMT: AN & ANREC no significant differences in shifting time or errors to HC. Starvation: No investigation of relationship between starvation & SS.
Nakazato, Tchanturia, Schmidt, Campbell, Treasure, Collier, Hashimoto & Iyo (2009)	Cross-sectional	29 AN (21R & 8BP) 18 ANREC (R) 28 HC	WCST	WCST: AN significantly more perseverative errors than HC. ANREC not significantly different to HC. Starvation: No investigation of relationship between starvation & SS.
Wilsdon & Wade (2006)	Cross-sectional	22 AN-R 20 High obsessionality 21 Low obsessionality	WCST UCOT	WCST: AN-R no significant differences in perseverative errors or categories completed compared to both obsessionality groups. UCOT: AN-R significantly more perseverative errors than low obsessionality group when influence of depression held constant. Starvation: No significant relationship between BMI & SS.
Steinglass, Walsh & Stern (2006)	Cross-sectional	15 AN (10 IP & 5OP)	WCST TMT	WCST: AN significantly more perseverative errors than HC but no differences in number of categories completed.

		11 HC		TMT: AN not significantly different to HC in B-A difference. Starvation: No significant relationship between BMI & SS tasks.
Holliday, Tchanturia, Landau, Collier & Treasure (2005)	Cross-sectional	47 AN (19R & 28BP) 47 AN sis 47 HCs	Haptic Brixton TMT CATBAT	Haptic: AN significantly more illusions than HC but fell below significance after adjustment for depression & obsessive compulsive symptoms. AN sisters had significantly more illusions than HC. Brixton: AN & AN sisters were not significantly different to HC in errors. TMT: AN & AN sisters not significantly different to HC in shifting time. CATBAT: AN & AN sisters had significantly longer BAT time & significantly higher CATBAT ratio than HC. Starvation: No significant relationship between BMI & SS.
Tchanturia, Morris, Brecelj Anderluh, Collier, Nikolaou & Treasure (2004b)	Cross-sectional and longitudinal	34 AN (14BP & 20R) 18 ANREC 36 HC 22 AN-WR (repeated measures)	TMT Brixton Picture set CATBAT Haptic Verbal fluency	Cross-sectional study: TMT: AN significantly longer shifting time than HC but no significant differences in shifting errors. ANREC not significantly different to HC in shifting time or errors. Brixton: AN more errors than HC but ANREC not significantly different to HC. Picture set: AN & ANREC significantly more errors than HC. CATBAT: AN significantly longer on BAT than HC, no significant differences in errors, unclear whether significant differences in CATBAT time. ANREC not significantly different to HC in BAT time, CATBAT time or errors. Haptic: AN & ANREC significantly more illusions than HC. Verbal fluency: AN & ANREC no significant differences in total performance or perseverative errors.

				Longitudinal study: No significant changes in any set shifting measures except improvement in CATBAT time. Starvation: No investigation of relationship between starvation & SS.
Tchanturia, Brecelj Anderluh, Morris, Rabe-Hesketh, Collier, Sanchez & Treasure (2004a)	Cross-sectional	34 AN (20R & 14BP) 19 BN 35 HC	TMT Brixton Picture set Verbal fluency CATBAT Haptic	TMT: AN significantly longer than HC on shifting but no significant differences in errors. BN no significant differences to HC. Brixton: AN significantly more errors than HC but BN not significantly different to HC. Picture set: AN & BN not significantly different to HC. Verbal fluency: AN & BN no significant differences to HC. CATBAT: AN no significant differences in CATBAT time, errors or BAT time. BN significantly longer to complete BAT & CATBAT than HC but no significant differences in errors. Haptic: AN & BN significantly more errors than HC. Starvation: No investigation of relationship between starvation & SS.
Tchanturia, Morris, Surguladze & Treasure (2002)	Cross-sectional	30 AN (15R & 15BP) 16 ANREC 23 HCs	Haptic CATBAT	Haptic: AN & ANREC significantly more illusions than HC after controlling for obsessive compulsive symptoms, anxiety and depression. CATBAT: AN & ANREC significantly more perseverations than HC but became non-significant when anxiety was controlled for. AN took significantly longer to complete than HC. ANREC no significant differences to HC in time to complete. Starvation: No investigation of relationship between starvation & SS.

Tchanturia, Serpell, Troop & Treasure (2001)	Cross-sectional	15 AN–R 15 BN 28 HC	Haptic	Haptic: AN & BN significantly more illusions than HC & remained significant after anxiety & depression controlled for. Starvation: No investigation of relationship between starvation & SS.
Tenconi, Santonastaso, Degortes, Bostello, Titton, Mapelli & Favaro (2010)	Cross-sectional	153 AN (60 acute AN, 63 weight restored but symptomatic & 30 fully recovered) 28 AN sis 120 HC	WCST TMT	WCST: AN & AN sisters significantly more perseverations & fewer categories completed than HC. TMT: AN & AN sisters significantly longer to complete shifting element. Starvation: No significant relationship between BMI & SS.

Note: TMT – Trail Making Test; WCST – Wisconsin Card Sorting Task; CANTAB - Cambridge Neuropsychological Test Automated Battery; IED - Intra-Extra Dimensional subtest of CANTAB; UCOT - Uses for Common Objects Test ; CATBAT – CATBAT task/paradigm of Eliava; Brixton – Brixton Spatial Anticipation test; Haptic – Haptic illusion task/Uznadze illusion task; Picture set – Picture set test; Verbal fluency – Verbal fluency task; AN – Anorexia nervosa; BN – Bulimia Nervosa; ANREC – Anorexia Nervosa recovered participant; EDNOS – Eating Disorder not Otherwise Specified; HC – Healthy Control; WR – Weight Restored; Sis – Sister; IP – Inpatient; OP – Outpatient; R – Restrictive Subtype; BP – Binge-Purge Subtype; SS – Set Shifting; BMI – Body Mass Index.

5.2 Neuropsychological measures used in studies

A brief summary of the neuropsychological measures used to examine set shifting is presented below.

5.2.1 Brixton Spatial Anticipation Test (Burgess & Shallice, 1997)

In the Brixton test, participants are presented with 10 circles in a 5x2 grid (on paper or on a computer screen) and are required to predict the movement of a blue circle based on patterns that change without warning over 56 trials. It is expected that difficulties in set shifting will lead to difficulties adapting to pattern change and consequently increased errors. Therefore the measure of set shifting is the total number of errors made by the participant.

5.2.2 Wisconsin Card Sorting Task (WCST; Heaton, Chelune, Talley, Kay & Curtiss, 1993)

The WCST (Heaton et al. 1993) is widely used to assess cognitive flexibility and set shifting (Steinglass, Walsh & Stern, 2006). In the WCST, participants are asked to match stimulus cards with one of four categories using changing rules about whether to sort by shape, colour or number. The participant is given brief feedback (stating whether they corrected matched the card with the category) and the rule changes unpredictably after 10 consecutive correct matches. Difficulties set shifting are understood to result in increased perseverative errors (based on a previous rule) and less correct responses because of difficulties flexibly adapting to rule changes. Therefore measures of set shifting are the number of perseverative errors made by the participant and total number of categories completed.

5.2.3 Trail Making Test (TMT; Reitan, 1958)

In the TMT (Reitan, 1958; Lezak, 1995) participants are required to draw lines between numbers in ascending numerical order (Trail A) and between numbers and letters in alternating ascending numerical and alphabetic order (Trail B). Trail B requires participants to switch between ordering numbers and letters and requires an ability to shift between them. Time taken to complete Trail B is the measure of set shifting. Alternatively, Trail B minus Trail A is taken as a measure of set shifting that controls for motor and visual difficulties. Alternative forms of the test with a motor control condition, letter sequencing condition and a set shifting condition have also been used but are essentially the same because the motor condition time is subtracted from the set shifting condition to control for motor speed.

5.2.4 Intra-Extra Dimensional (IED) subtest of Cambridge Neuropsychological Test Automated Battery (CANTAB; Luciana, 2003)

In the IED, participants are shown shapes and lines in rectangles on a computer screen and must learn which stimuli to select based on rules inferred from audio and visual feedback. These rules then change and participants are required to learn new rules. Difficulties shifting flexibly between rules indicate set shifting difficulties and therefore the measure of set shifting is number of errors in the task.

5.2.5 Haptic illusion task / Uznadze illusion task (Uznadze, 1966)

In the Haptic illusion task (Uznadze, 1966; Tchanturia et al. 2001; Tchanturia et al. 2004a) participants are required to judge the size of wooden balls placed in their hands while they have their eyes closed. In the first stage they are primed to

believe that there are two different sized balls but in the second stage they are given two balls of the same size. The number of illusions (that the two balls are different sizes) can be seen as a measure of perceptual inflexibility and so the number of illusions in the final stage is the measure of set shifting (with more illusions indicating difficulties set shifting).

5.2.6 Uses for Common Objects Test (UCOT; Getzels & Jackson, 1962; Guildford, Christensen, Merrifield & Wilson, 1978)

In the UCOT, participants are required to name as many uses for a bottle and a paperclip as possible in 90 seconds. A high number of perseverative responses (deemed too similar to previous answers) can be seen to indicate difficulties thinking flexibly and set shifting (Wilsdon & Wade, 2006). Therefore number of perseverative responses can be considered a measure of set shifting.

5.2.7 CATBAT task (Eliava, 1964)

In the CATBAT task (Eliava, 1964; Tchanturia, Morris, Surguladze & Treasure, 2002), participants are required to complete missing letters of words within a story using the context to guide response. In the first part of the story, the letter ‘c’ is required to make the word ‘cat’ and in the second part of the story, the letter ‘b’ is required to make the word ‘bat’. Completing the second word with a ‘c’ is thought to indicate difficulties shifting to the new context. The BAT (shifting) component completion time divided by the CAT (non-shifting) completion time (known as CATBAT ratio) has been used as a measure of set shifting that controls for overall processing time (Tchanturia et al. 2004b). The number of errors, perseverative errors, time taken to complete the BAT (shifting) component and time

taken to complete the whole task (CATBAT time) are additional measures of set shifting.

5.2.8 Picture set test (Surguladze, 1995)

In the Picture set test, participants are required to decide which one of four objects is the odd one out by using a sorting rule (such as ‘all are vegetables’). This rule then changes and there is an additional shift from looking at the properties of objects to their purpose or function (Tchanturia et al. 2004b). Difficulties switching between the subtasks and rules are thought to be indicative of difficulties set shifting and the number of errors can be considered a measure of set shifting.

5.2.9 Verbal fluency task (Lezak, 1995)

In the Verbal fluency task, participants are required to generate as many words as they can within 1 minute starting with F, A and S. A high number of perseverative responses indicate difficulties with set shifting. Therefore number of perseverative responses can be considered a measure of set shifting.

5.3 Measures of starvation

The only measure designed to assess degree of starvation that was used in the studies was Body Mass Index (BMI). This is calculated by dividing weight (in kilograms) by height (in metres squared) and can be considered a fairly crude index of chronic starvation.

6. Results of literature search

6.1 Study characteristics

All 13 studies used an experimental cross-sectional design and 1 study (Tchanturia el al. 2004b) attempted to follow up currently ill patients longitudinally to see whether set shifting difficulties persisted following weight gain. The WCST and TMT were the most common measures of set shifting used, with 7 studies using each of them. All studies included a HC group however Wilsdon & Wade (2006) used HCs that scored high and low on obsessionality as comparison groups.

All 13 studies included currently a unwell AN group, 6 included a recovered AN group, 3 included healthy sisters of individuals with AN and 1 included a weight recovered AN group. Only 4 studies included a currently unwell BN group, 1 included healthy sisters of individuals with BN, 1 included an EDNOS group and none included a BED group.

Of the 13 papers, 5 had been discussed in the previous review by Roberts et al. (2007). There were 8 new papers that had been published since the previous review specifically looking at set shifting in eating disorders. All 13 studies are reviewed below in two sections. The first section focuses on studies that have only investigated AN and the second section focuses on studies that have included other eating disorders. Within these sections studies are presented in chronological order.

6.2 Studies focusing on set shifting in AN

Tchanturia, Morris, Surguladze and Treasure (2002)

Tchanturia et al. (2002) looked at set shifting in current AN (n=30), recovered AN (n=16) and HC (n=23) participants using the Uznadze/Haptic illusion task and an adaptation of the paradigm of Eliava (1964) also known as the CATBAT task.

In the Uznadze illusion task (looking at perceptual set shifting), the current and recovered AN participants had significantly more illusions than the HC group indicating set shifting difficulties. These differences remained when the effects of depression, anxiety and obsessive compulsive pathology were controlled for.

In the CATBAT task (looking at cognitive set shifting), the current and recovered AN participants made significantly more perseverative errors than the HC group. Although these differences remained significant when the effects of depression and obsessive compulsive symptomatology were controlled for, they did not remain significant when anxiety was controlled for. The current AN group were also significantly slower at completing the task than the recovered AN and HC groups.

Participants with current AN had a significantly lower BMI than the recovered AN and HC groups however BMI was not further investigated to see whether it was correlated with performance on set shifting tasks.

The study reported matching the HCs to the clinical groups on age, gender and educational level. However they did not provide information about the educational level or gender of participants and so it is not clear whether they were of average intelligence and whether any males were included in the study. Unfortunately, there was a small sample size and the study did not use a power calculation to estimate the required sample size.

Tchanturia et al. (2004b)

Tchanturia et al. (2004b) compared current AN (n=34), recovered AN (n=18) and HC (n=36) participants. They combined a cross-sectional approach with a longitudinal design by retesting a proportion of the acute AN group (n=22) after inpatient treatment and weight gain three months later.

The groups were matched for age, education level and intellectual ability and set shifting was assessed using the TMT, Brixton test, Picture set test, CATBAT task, Uznadze/Haptic illusion task and Verbal fluency task.

Cross-sectional study:

In the TMT, participants with AN took significantly longer to complete the shifting component than HCs but there was no significant difference in shifting errors between the groups. There were no significant differences in shifting time or shifting errors between the recovered and HC groups.

In the Brixton test, the AN group made significantly more incorrect predictions than the HC group. There were no significant differences in errors between the recovered and HC groups. In the Picture set test, the current and recovered AN participants made significantly more errors than the HC group.

In the CATBAT task, the AN group took significantly longer to complete the BAT shifting component than the HCs. There were no significant differences in CATBAT errors and it is not clear whether there were significant differences in CATBAT time between the AN and HC groups because results only indicated a difference between the AN group (with the longest mean time), HC group and recovered AN group (with the shortest mean time) without specifically comparing the AN and HC groups. There were no significant differences in BAT time, CATBAT time or CATBAT errors between the recovered AN and HC groups.

In the Uznadze/Haptic illusion task, the current and recovered AN groups made significantly more errors than the HC group. In the Verbal fluency task, there

were no significant differences in the number of correct responses or perseverative errors between current AN, recovered AN and HC groups.

The participants with AN had a significantly lower BMI than the HC and recovered AN groups however this was not further investigated to see whether it was correlated with performance on set shifting tasks.

Longitudinal study:

When the AN group were retested after inpatient treatment, their BMI had increased significantly and their anxiety and depression scores had significantly decreased. Although there was a significant improvement in the time taken to complete the CATBAT task there were no significant changes in TMT shifting time or errors, Brixton errors, Picture set test errors, number of Haptic illusions, CATBAT perseverative responses and BAT time, indicating that they still had set shifting difficulties. Given that significant increases in BMI did not lead to significant improvements in set shifting, this study indicates that impairments are not solely a consequence of starvation.

Although there was evidence for set shifting difficulties in current and recovered AN groups there were some discrepancies which are noteworthy. While the TMT controlled for motor abilities in the shifting task, there were significant differences in the motor and alphabet tasks which indicate that something else (such as attentional difficulties or reduced motivation) might be affecting the results.

This study only included white Caucasian females and the recovered group in the cross-sectional study only included participants who had experienced the restricting subtype of AN. The authors reported that a preliminary analysis showed no difference in performance between those with restrictive and binge-purge subtypes of AN, although they did not provide details. Helpfully, the study was clear about whether the assumptions for tests were met and when significance levels were adjusted for multiple testing. However no power calculation was completed

prior to the study and a subsequent one revealed that larger samples were needed to detect differences between the recovered AN and HC groups.

This study was a valuable addition because it incorporated a longitudinal element where participants set shifting ability while acutely unwell and underweight was compared to their set shifting ability when weight recovered.

Holliday, Tchanturia, Landau, Collier and Treasure (2005)

Holliday et al. (2005) used the Haptic illusion task, Brixton test, TMT and CATBAT test to investigate set shifting in females with AN (n=47; R=19; BP=28), healthy sisters of individuals with AN (n=47) and HCs (n=47).

In the Haptic illusion task, the AN and healthy sister groups had significantly more perceptual illusions than the HC group. After adjustment for depression and obsessive compulsive symptomatology, this fell below significance in the AN group but remained significant in the healthy sister group.

In the Brixton test, the AN and healthy sister groups were not significantly different to the HC group in terms of number of errors. In the TMT, the AN and healthy sister groups were not significantly different to the HC group in terms of shifting time.

In the CATBAT task, the AN and healthy sister groups took significantly longer to complete the BAT shifting component and had a significantly higher CATBAT ratio than the HC group, indicating set shifting difficulties.

A subsidiary analysis revealed no differences in set shifting ability between fully recovered (n=23) and acutely unwell (n=24) women with AN. This in combination with the finding that healthy sisters had a similar profile to the AN group suggests that a trait may be responsible for set shifting difficulties rather than just a state of starvation.

BMI did not significantly correlate with performance on any of the set shifting tasks in the AN group. Unfortunately, the authors did not examine the relationship between BMI and set shifting tasks in unaffected sisters and HCs.

The groups did not differ significantly in age, IQ or executive functioning (based on Verbal fluency scores). This study (unlike many of the others) systematically analysed medication use and found no significant differences in performance on the neuropsychological battery between those taking and not taking medication.

This study was a valuable addition because it used a powerful design with a sister pair to investigate whether familial traits may be involved in set shifting difficulties. The study also provided information about parametric test assumptions, corrections to reduce inflation of the type 1 error rate and the use of ANOVAs with standard errors because sisters are not strictly independent. However, as a cross-sectional design with a small sample (of mainly Caucasian females) was used, this limits the conclusions that can be drawn.

Wilsdon and Wade (2006)

Wilsdon & Wade (2006) used the WCST and UCOT to assess cognitive flexibility in participants with restrictive AN (n=22) and undergraduates without eating disordered pathology that were high (n=20) and low (n=21) in obsessionality.

In the WCST, there were no significant differences in perseverative errors or categories completed between the AN group and both the high and low obsessionality groups. In the UCOT, the AN group had significantly more perseverative errors than the low obsessionality group when the influence of depression was held constant.

The AN group had a significantly lower BMI than both obsessionality groups and BMI was not significantly associated with any WCST or UCOT outcome

measure. This suggests that set shifting difficulties are not solely a consequence of a state of starvation.

Helpfully, the study provided information about assessment of normality and data cleaning techniques. Unfortunately, the study did not obtain an IQ estimate or information about educational level which means that differences in the UCOT may be due to differences in intelligence between the groups. Additionally, the study used a small sample not based on a power analysis, recruited only females and failed to include participants with the binge-purge subtype of AN. Finally, while the study stated that 68% of the AN group were on medication, it did not assess whether there were any differences between those taking and not taking medication.

Steinglass, Walsh and Stern (2006)

Steinglass et al. (2006) used the WCST to compare set shifting in participants with AN (n=15) and HCs (n=11). Although the TMT was not used specifically to look at set shifting in this study, results have been included because it is frequently used to assess set shifting.

In the TMT, there were no significant differences in the TMT B-A difference between AN and HC groups. In the WCST, the AN group had significantly more perseverative errors than the HCs but there were no significant differences in number of categories completed between the groups. The authors suggest that this difference in WCST perseverative errors is unlikely to be a consequence of comorbid anxiety or depression because this would lead to more extensive deficits and because WCST performance did not correlate with anxiety or depression.

Steinglass et al. (2006) concluded that participants with AN demonstrated difficulties specifically with cognitive flexibility in a context of otherwise normal cognitive functioning. The authors suggested that the failure to find a significant difference in the TMT was because the WCST is a purer measure of set shifting

than other measures which focus on perseveration. However they do not discuss how the constructs of perseveration and set shifting are related or different.

The AN group had a significantly lower BMI than the HCs despite the fact that only 3 of the AN participants were actually underweight during testing. Interestingly, the 12 AN participants that were within the healthy weight range still made significantly more perseverative errors on the WCST than HCs, which suggests that set shifting difficulties are not simply a consequence of starvation.

There was no significant correlation between WCST scores and BMI in the AN group and the study did not investigate whether there was a correlation in HCs.

There were no significant differences in age or estimated IQ between the groups. Unfortunately, the subtypes of AN were not specified or compared and the study used a small sample size (n=26) that consisted entirely of females. Moreover, the study did not provide information about whether a power calculation was used to estimate the required sample size, how well the parametric assumptions were met and whether a statistical correction was used for multiple comparisons to avoid inflation of the type 1 error rate. Finally, medication use was not reported or analysed in this study.

Nazakato et al. (2009)

Nakazato et al. (2009) investigated whether Serum Brain-Derived Neurotrophic Factor (BDNF) concentrations were correlated with set shifting ability in women with current AN (n=29; R=21, BP=7), recovered from restricting AN (n=18) and HCs (n=28) by using the WCST to assess set shifting ability. The biological aspects of this article will not be reviewed here as this is beyond the scope of this review.

Participants with AN had significantly more perseverative errors on the WCST than the HC group. Unfortunately, the study did not report number of categories completed. There were no significant differences in the number of

perseverative errors between the recovered AN and HC groups, although the recovered AN group had an intermediate profile and were not significantly different to the AN group either. This would support a model where trait tendencies combine with a state of starvation to affect set shifting.

The current AN group had a significantly lower BMI than all other groups. The recovered AN group had a BMI that was significantly higher than the AN group but significantly lower than the HC group. Unfortunately, BMI was not further investigated to see whether it was correlated with performance on set shifting tasks.

There were no significant differences in age or years of education between groups. Unfortunately, the study was limited by a small sample size consisting of only females and a power analysis was not used to estimate the required sample size.

Nakazato et al. (2010)

Nakazato et al. (2010) investigated whether serum concentrations of amino acids related to glutamatergic neurotransmission were associated with set shifting in women with AN (n=27), recovered from AN (n=18) and age-matched HCs (n=28) by using the WCST and the TMT to assess set shifting. The biological aspects of this article will not be reviewed here as this is beyond the scope of this review.

On the WCST, the AN group made significantly more perseverative errors than the HC group. There were no significant differences in perseverative errors between the recovered AN and HC groups, although the recovered AN group had an intermediate profile and were not significantly different to the AN group either. This suggests that set shifting deficits are not completely determined by state but are influenced by it. Unfortunately, the study did not look at number of categories completed. On the TMT, there were no significant differences in shifting time or shifting errors between current AN, recovered AN and HC groups.

The AN group had a significantly lower BMI than both other groups. The recovered AN group had an intermediate BMI that was significantly lower than the BMI of the HC group. However the study did not examine whether there were any correlations between BMI and WCST and TMT performance.

There were no significant differences between the groups in terms of age or years in education. Unfortunately, the sample consisted entirely of females and the small sample meant it was not possible to compare the AN subtypes. Finally, there was no power analysis used to estimate the required sample size and no explanation of whether the assumptions for the parametric tests had been met.

Tenconi et al. (2010)

Tenconi et al. (2010) investigated set shifting, central coherence and handedness in participants with current AN (n=153), healthy sisters of individuals with AN (n=28) and HCs (n=120). Only results for the WCST and the TMT used to measure set shifting are reported here.

In the WCST, the AN group and healthy sisters of individuals with AN made significantly more perseverative errors and completed fewer categories than the HC group. In the TMT, the AN group and healthy sisters of individuals with AN took significantly longer to complete the shifting component of the task than the HC group. The authors reported that education differed significantly between healthy sisters and HCs but did not state in which direction. This makes it difficult to identify whether this may have had an impact on these results.

The second analysis compared participants with acute AN (n=60), weight restored but currently symptomatic participants with AN (n=63) and fully recovered AN participants (n=30) and found that there were no significant differences on any measure of set shifting. This suggests that set shifting difficulties are not simply a consequence of starvation. The study found that there were no significant correlations between BMI and performance on the WCST or TMT.

However the groups were not clearly defined and the 'AN' group included three subgroups – one of which (weight restored currently symptomatic AN participants) included participants who had been previously diagnosed with AN but had current BN (n=14) and EDNOS (n=49). This means that the 'AN' group actually included participants with a variety of eating disorders and was not a clean sample of AN participants.

Usefully, the study investigated differences between AN subtypes and between medicated and non-medicated participants and reported no significant differences, although the data for these comparisons was not provided. Additionally, the study reported whether the assumptions for parametric tests were met and how violations were statistically adjusted for.

Although a large sample size was used, this was not informed by a power analysis and included only a small sample of sisters. Although participants aged 14 and over were included, the study did not specify the numbers of child and adult participants and did not explore any differences between them which may indicate developmental changes. Unfortunately, participants in the AN and healthy sisters groups were all female and the gender of HCs was unspecified. Additionally, it would have been interesting to include brothers of individuals with AN as well as sisters.

McAnarney et al. (2011)

McAnarney et al. (2011) examined set shifting in adolescents with restrictive AN (n=24) and healthy adolescents (n=37) matched on age, ethnicity, socio-economic status and estimated IQ. Adolescents with restrictive AN scored significantly higher than HCs on self report and parental questionnaires assessing set shifting difficulties (Behavior Rating Inventory of Executive Function Self-Report and Parent-Report (BRIEF-SR and BRIEF-PR), indicating elevated set shifting difficulties.

In the WCST, there were no significant differences in perseverative errors between the AN group and HCs. Unfortunately the study did not look at number of categories completed. In the IED subtest of the CANTAB, there were no significant differences in the number of errors between the AN group and HCs. Surprisingly, the study concluded that adolescents with restrictive AN had significantly more set shifting difficulties than healthy adolescents despite failing to find any significant objective differences in experimental tasks.

BMI was significantly lower in the AN group than the HC group but there was no relationship between BMI and the WCST or IED.

Unfortunately the sample size was very small and no power analysis was reported. Additionally, all participants were female and the majority were Caucasian. Also, the authors do not specify whether parametric assumptions were met and do not state whether corrections were used to prevent inflation of the type 1 error rate with multiple tests.

6.2.2 Studies looking at set shifting in other eating disorders

Tchanturia, Serpell, Troop and Treasure (2001)

Tchanturia et al. (2001) used the Fixed Set paradigm by Uznadze (otherwise known as the Haptic illusion task) to investigate set shifting in restrictive AN (n=15), BN (n=15) and HCs (n=28).

In the Haptic illusion task, the AN and BN groups had significantly more illusions than the HC group and these differences remained significant after anxiety and depression were controlled for. The BN group had significantly more absolute fluctuations (total number of changes) and relative fluctuations (controlling for the number of trials) than the AN group and control group. This suggests that the BN group showed a more flexible profile (with many illusions and many fluctuations)

than the AN group, who showed a rigid profile (with many illusions and little fluctuation) suggestive of set shifting difficulties.

The AN group had a significantly lower BMI than BN and HC groups and the BN group had a significantly lower BMI than the HC group. Unfortunately, BMI was not further analysed in the study.

ANOVAs indicated that the groups did not differ significantly in terms of age. Unlike many studies, this one used a power calculation based on a previous pilot study to estimate the required sample size. Unfortunately, the study consisted entirely of females and only included the restrictive subtype of AN.

Tchanturia et al. (2004a)

Tchanturia et al. (2004a) explored cognitive flexibility in AN (n=34), BN (n=19) and HC groups (n=35) using the TMT, Brixton test, Picture set test, Verbal fluency task, CATBAT task and Haptic illusion task.

In the TMT, the AN group had a significantly longer shifting time than the HC group but there were no significant differences in errors between the groups. There were no significant differences in shifting time or errors between BN and HC groups. In the Brixton test, the AN group had significantly more errors than the HC group but there were no significant differences in errors between BN and HC groups.

In the Picture set test, there were no significant differences in errors between the AN and BN groups and the HC group. In the Verbal fluency task, there were no significant differences in the number of correct responses or perseverative errors between the AN, BN and HC groups.

In the CATBAT task, there were no significant differences in CATBAT time, errors and BAT time between the AN and HC groups. The BN group took significantly longer to complete the BAT and CATBAT components than HCs but there were no significant differences in errors between the groups. In the Haptic

illusion task, the AN and BN groups made significantly more illusions than the HC group.

The BMI of the AN group was significantly lower than the BN and HC groups. However this was not investigated further to see whether BMI was related to set shifting measures.

The groups did not differ in terms of age, years of education or estimated IQ. Unfortunately there was a small sample size that was not based on a power analysis and consisted entirely of females. Helpfully, the study compared the subtypes of AN and those taking and not taking medication and found no significant differences in neuropsychological performance. Also, the study provided information about statistical corrections that were used.

Roberts, Tchanturia and Treasure (2010)

Roberts et al. (2010) investigated set shifting in women with current AN (n=68), BN (n=30), previous AN (n=30), healthy sisters of women with AN (n=30), healthy sisters of women with BN (n=20) and HCs (n=88). They used the TMT, WCST, Brixton and Haptic illusion tasks to assess set shifting.

On the TMT, there were no significant differences between the AN (both subtypes) and HC groups on B-A difference or errors. However the BN group had a significantly higher B-A difference and made significantly more errors than the HC group.

On the WCST, both AN subtypes and the BN group completed significantly fewer categories than the HC group. The AN binge-purge group and the BN group also had significantly more perseverative errors than the HCs. There were no significant differences between the AN restrictive group and the HCs in perseverative errors.

On the Brixton test, the AN binge-purge group made significantly more errors than the HC group. However there were no significant differences in errors between the HC group and the BN group or the AN restrictive group.

On the Haptic illusion task, the AN restrictive group and the BN group made significantly more illusions than the HC group but there were no significant differences in errors between the AN binge-purge group and HCs.

A composite set shifting score was calculated using the four tasks and participants were classified as having poor, intact or superior set shifting. This was an attempt to combine and make sense of results from tasks where there was large variability across tasks and between groups. Participants were placed in the 'poor' group if their score was more than 1 standard deviation above the HC group mean on 2 tasks (where high scores mean increased errors). Participants were placed in the 'superior' group if their score was more than 1 standard deviation below the HC group mean on 2 tasks. All others were considered to belong to the intact set shifting group. Compared to the HC group where 9.1% displayed poor set shifting, 22.9% of the AN restrictive group, 45.5% of the AN binge-purge group and 36.7% of the BN group displayed poor set shifting.

Participants who currently had AN (both subtypes) had significantly lower BMI's than all other groups. However set shifting ability was not correlated with BMI in the AN group and there were no significant differences in BMI across intact and poor set shifting groups.

There were no significant differences in education, age of onset and duration of illness between the groups. The recovered AN group were significantly older than participants with current AN (both subtypes) and sisters of individuals with AN but there were no other significant differences. There were no significant correlations between set shifting tasks and anxiety, depression and obsessive compulsive symptomatology.

This study was limited because it used a cross-sectional design with only females of white European ethnicity and did not look at estimated IQ. Helpfully, the study provided information about the order of tasks, normality of data and was informed by a power analysis.

Tchanturia et al. (2011)

Tchanturia et al. (2011) investigated cognitive flexibility in AN (n=215), BN (n=69), EDNOS (n=29), recovered AN (n=72) and HC (n=216) groups using the Brixton test. They also aimed to investigate whether performance on the Brixton test was associated with BMI and duration of illness.

The AN and EDNOS groups made significantly more errors on the Brixton test than the HCs and this remained significant when IQ was used as a covariate. There were no significant differences in errors between BN and HC groups. The AN recovered group demonstrated an intermediate profile that was not significantly different to the current AN or HC groups. It makes sense that the EDNOS group performed similarly to the AN group because the EDNOS group included participants who were one or two criteria short of obtaining a diagnosis of AN. Furthermore the EDNOS group had the highest proportion (51.7%) of participants below the 10^{th} percentile, indicating poor flexibility.

This study compared Brixton errors in inpatient (n=96) and outpatient (n=119) AN and found that while AN as a unitary group (n=215) had a medium-large effect size (0.6), AN outpatients had a small-medium effect size (0.4) and AN inpatients had a large effect size (0.9). This suggests that AN inpatients may have more impaired set shifting than outpatients.

The AN group had a significantly lower BMI than all other groups and the EDNOS group had a significantly lower BMI than the BN, recovered AN and HC groups. A regression found that there was no significant relationship between BMI

and Brixton test scores, suggesting set shifting difficulties were not just a result of starvation.

The AN and HC groups were significantly younger than the recovered AN group. The EDNOS group had a significantly lower IQ than all other groups but this was still within the normal range. The AN group had significantly longer illness duration than both the EDNOS and BN groups and AN inpatients had a significantly longer illness duration than outpatients. There was a significant negative relationship between Brixton test scores and duration of illness in the EDNOS group (when age was included as a cofounder).

This study combined a large number of published and unpublished data and this provided a wide range of severity and meant greater statistical power was achieved. However, some of the data from individual studies are described elsewhere in this review (Tchanturia et al. 2004b; Nakazato et al. 2009; Roberts et al. 2010) and caution must be taken to ensure these findings are not overrepresented. This study was included because many unpublished findings were also included that warrant consideration.

This study used a comprehensive definition of recovery and also provided information about whether assumptions were met and statistical corrections were used to control for multiple comparisons. Unfortunately, missing data meant it was not possible to control for estimated intelligence and medication effects across the whole sample, which limits conclusions that can be drawn from the study. Additionally, while this study made an effort to include EDNOS – an often neglected group – this group had a particularly small sample size and no power analysis was used to indicate the required numbers in each group. Other limitations were the inclusion of only females, failure to specify the proportion of each subtype of AN and use of only one neuropsychological test to assess set shifting.

7. Summary of the evidence

7.1 Set shifting in AN

The WCST was used to examine set shifting in AN in 7 studies (McAnarney et al. 2011; Roberts et al. 2010; Nakazato et al. 2010; Nakazato et al. 2009; Wilsdon & Wade, 2006; Steinglass et al. 2006; Tenconi et al. 2010). Of the 7 studies that looked at perseverative errors, 4 found that AN groups made significantly more perseverative errors than HCs (Nakazato et al. 2010; Nakazato et al. 2009; Steinglass et al. 2006; Tenconi et al. 2010), 2 found no significant differences between AN and HC groups (McAnarney et al. 2011; Wilsdon & Wade, 2006) and 1 found mixed results as participants with the binge-purge subtype of AN showed significantly more perseverative errors than HCs but participants with the restrictive subtype of AN showed no significant difference to HCs in perseverative errors (Roberts et al. 2010). Of the 4 studies looking at number of categories completed, 2 found that participants with AN completed significantly fewer categories than HCs (Roberts et al. 2010; Tenconi et al. 2010) and 2 found no significant differences (Wilsdon & Wade, 2006; Steinglass et al. 2006). Overall, it appears that there is evidence for a set shifting impairment in the WCST in individuals with AN. This is not consistent with some studies that have found no impairment and differences in studies may be due to degree of starvation or methodological limitations (such as small samples and inconsistency of measures).

The TMT was used to examine set shifting in AN in 7 studies (Roberts et al. 2010; Nakazato et al. 2010; Steinglass et al. 2006; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2004a; Tenconi et al. 2010). Of the 5 studies that looked at the shifting time, 3 found that the AN group took significantly longer to complete the shifting element of the task (Tchanturia et al. 2004b; Tchanturia et al. 2004a; Tenconi et al. 2010) and 2 found no significant differences between HC and

AN groups (Nakazato et al. 2010; Holliday et al. 2005). All 4 studies that looked at number of errors in the shifting task found no significant differences between AN and HC groups (Roberts et al. 2010; Nakazato et al. 2010; Tchanturia et al. 2004b; Tchanturia et al. 2004a). The 2 studies that looked at the TMT B-A difference, which controls for visual and motor difficulties, found no significant differences between AN and HC groups (Roberts et al. 2010; Steinglass et al. 2006). Overall, there appears to be little evidence that individuals with AN demonstrate a set shifting impairment in the TMT.

The CATBAT/Eliava task was used to examine set shifting in AN in 4 studies (Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2004a; Tchanturia et al. 2002). Of the 3 studies that looked at BAT time (shifting component), 2 found that AN took significantly longer to compete the BAT component than HCs (Holliday et al. 2005; Tchanturia et al. 2004b) and 1 found there were no significant differences in BAT time between HC and AN groups (Tchanturia et al. 2004a). Of the 3 three studies that looked at overall time to complete the CATBAT task, 1 found that AN took significantly longer to complete the task than HCs (Tchanturia et al. 2002), 1 found no significant differences in CATBAT time between AN and HCs (Tchanturia et al. 2004a) and 1 study only indicated a difference between AN (longest mean time), HCs, and a recovered AN group (shortest mean time) without specifying whether the AN group differed significantly to the HC group (Tchanturia et al. 2004b). The 1 study that looked at CATBAT ratio found that AN had a significantly higher CATBAT ratio, indicating set shifting difficulties (Holliday et al. 2005). The 2 studies that looked at CATBAT errors both concluded that there were no significant differences in CATBAT errors between AN and HC groups (Tchanturia et al. 2004b; Tchanturia et al. 2004a). Finally, 1 study investigated perseverations and found that although AN made significantly more perseverations than HCs, once anxiety was controlled for this difference was no longer significant (Tchanturia et al. 2002). Overall there appears to be mixed evidence about whether individuals with AN

exhibit a set shifting impairment in the CATBAT task. Again, this may be due to differences in degree of starvation or to methodological differences and limitations.

The Brixton test was used to examine set shifting in AN in 5 studies (Tchanturia et al. 2011; Roberts et al. 2010; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2004a). In 3 of the studies, participants with AN made significantly more errors than HCs (Tchanturia et al. 2011; Tchanturia et al. 2004b; Tchanturia et al. 2004a), in 1 study there were no significant differences between AN and HC groups (Holliday et al. 2005) and in 1 study there was a mixed picture with participants with the binge-purge subtype of AN making significantly more errors than HCs and participants with the restrictive subtype of AN not differing significantly from the HC group (Roberts et al. 2010). Overall, there appears to be quite strong evidence that individuals with AN exhibit a set shifting impairment on the Brixton test.

The Haptic/Uznadze illusion task was used to examine set shifting in AN in 6 studies (Roberts et al. 2010; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2004a; Tchanturia et al. 2002; Tchanturia et al. 2001). All 6 studies found that participants with AN had significantly more illusions than HCs. In 2 of these studies the differences remained significant after controlling for anxiety (Tchanturia et al. 2002; Tchanturia et al. 2001), depression (Tchanturia et al. 2002; Tchanturia et al. 2001) and obsessive compulsive symptoms (Tchanturia et al. 2002) and in 1 study differences were no longer significant after adjustment for depression and obsessive compulsive symptoms (Holliday et al. 2005). Overall, there appears to be quite strong evidence that individuals with AN exhibit a set shifting impairment on the Haptic illusion task.

The Picture set test was used to examine set shifting in AN in 2 studies (Tchanturia et al. 2004b; Tchanturia et al. 2004a). Of these, 1 found that participants with AN made significantly more errors than the HC group (Tchanturia et al. 2004b)

and 1 found that there were no significant differences between the groups (Tchanturia et al. 2004a).

The Verbal fluency task was used to examine set shifting in AN in 2 studies (Tchanturia et al. 2004b; Tchanturia et al. 2004a). Both found no significant differences between the AN and HC groups in number of correct responses and errors.

The IED subtest of the CANTAB was used to examine set shifting in AN in 1 study (McAnarney et al. 2011) and this found no significant differences in the number of errors between the groups.

The UCOT was used to examine set shifting in AN in 1 study (Wilsdon & Wade, 2006). This found that the AN group had significantly more perseverative errors than the low obsessionality group when the influence of depression was held constant.

Overall, there was very mixed evidence in AN, with strong evidence for a set shifting impairment on the WCST, Brixton and Haptic illusion tasks, moderate evidence on the Picture set task, CATBAT and UCOT task and little or no evidence suggested by the TMT, IED in CANTAB and Verbal fluency tasks.

7.2 Set shifting in BN

The WCST was used to examine set shifting in BN in 1 study (Roberts et al. 2010). This study found that the BN group made significantly more perseverative errors and completed significantly fewer categories than the HC group.

The Haptic illusion task was used to examine set shifting in BN in 3 studies (Roberts et al. 2010; Tchanturia et al. 2004a; Tchanturia et al. 2001). All 3 studies found that participants with BN had significantly more illusions than the HC group and in 1 study this difference remained significant after depression and anxiety were used as covariates.

The Brixton test was used to examine set shifting in BN in 3 studies (Tchanturia et al. 2011; Roberts et al. 2010; Tchanturia et al. 2004a) and all 3 studies found no significant differences between the BN and HC groups.

The TMT was used to investigate set shifting in BN in 2 studies (Roberts et al. 2010; Tchanturia et al. 2004a). The first study found that the BN group had significantly more errors and a significantly higher B-A difference than the HC group, indicating set shifting difficulties (Roberts et al. 2010). The second study found no significant differences in shifting time or errors between the groups (Tchanturia et al. 2004a).

The CATBAT task was used to examine set shifting in BN in 1 study (Tchanturia et al. 2004a). This study found that BN participants took significantly longer to complete the BAT component and the whole CATBAT task but found no significant differences between the groups in terms of errors.

The Picture set test was used to investigate set shifting in BN in 1 study (Tchanturia et al. 2004a). This study found no significant differences in errors between the BN and HC groups.

The Verbal fluency task was used to investigate set shifting in BN in 1 study (Tchanturia et al. 2004a). This study found no significant differences in the number of correct responses or perseverative errors between BN and HC groups.

Overall, there was much less research into set shifting in BN. However there was strong evidence for a set shifting impairment in the WCST and Haptic illusion tasks, moderate evidence on the TMT and CATBAT tasks and little or no evidence suggested by the Brixton, Picture set and Verbal fluency tasks.

7.3 Set shifting in EDNOS

Only 1 study examined set shifting in an EDNOS group (Tchanturia et al. 2011) and this study used the Brixton test. Results indicated that the EDNOS group

made significantly more errors than HCs and this remained significant when IQ was used as a covariate. However this is only 1 study and further research will need to be conducted to corroborate this finding.

7.4 Are set shifting difficulties explained by state or trait?

There are various ways to investigate the role of starvation in set shifting. If the state theory is correct (and set shifting difficulties are simply caused and maintained by a state of starvation), we would expect no significant set shifting difficulties in recovered/weight restored participants or healthy sisters and would expect a strong positive correlation between BMI (an index of starvation) and set shifting ability. If the trait theory is correct (and neuropsychological impairments are existing traits that predispose individuals to develop eating disorders), we would expect to see significant set shifting difficulties in recovered/weight restored participants and healthy sisters and would expect a weak or non-existent correlation between BMI and set shifting ability.

Therefore assessing set shifting in recovered/weight restored participants and healthy sisters and investigating whether there is a correlation between BMI and set shifting are likely to be useful sources of information in investigating the state and trait theories.

7.4.1 Body Mass Index (BMI):

Overall, 7 of the 13 studies investigated whether there was a relationship between BMI (an index of starvation) and set shifting (Tchanturia et al. 2011; McAnarney et al. 2011; Roberts et al. 2010; Wilsdon & Wade, 2006; Steinglass et al. 2006; Holliday et al. 2005; Tenconi et al. 2010).

All studies investigating a relationship between BMI and the Brixton test (Tchanturia et al. 2011; Roberts et al. 2010; Holliday et al. 2005), WCST (McAnarney et al. 2011; Roberts et al. 2010; Wilsdon & Wade, 2006; Steinglass et al. 2006; Tenconi et al. 2010), IED subtest of the CANTAB (McAnarney et al. 2011), TMT (Roberts et al. 2010; Steinglass et al. 2006; Holliday et al. 2005; Tenconi et al. 2010), Haptic illusion task (Roberts et al. 2010; Holliday et al. 2005), UCOT (Wilsdon & Wade, 2006) and the CATBAT task (Holliday et al. 2005) found no significant correlation between BMI and set shifting, indicating that starvation is not causing set shifting difficulties.

Although this suggests that starvation may not be having an impact on performance, most of the studies only looked at AN participants (Roberts et al. 2010; Steinglass et al. 2006; Holliday et al. 2005; Tenconi et al. 2010) and did not look at BMI in BN or across the groups. It is also important to recognise that BMI is only a crude indicator of long-term starvation and may not be a sensitive or accurate enough tool. A measure of acute starvation may provide more information about the participant's actual state of starvation *while* completing the study and may be a more reliable index of starvation.

7.4.2 Participants recovered from AN:

If the state theory is correct and starvation is directly causing neuropsychological impairments, we would expect participants who have gained weight and are in recovery not to have a significant impairment in set shifting. Alternatively, if the trait theory is correct and neuropsychological impairments predispose individuals to eating disorders, we would expect those who have gained weight and are in recovery to continue demonstrating a significant impairment in set shifting. Therefore, examining set shifting in those in recovery from an eating disorder is a useful source of information when investigating trait and state theories.

The WCST was used to examine set shifting in recovered/recovering AN participants in 4 studies (Roberts et al. 2010; Nakazato et al. 2010; Nakazato et al. 2009; Tenconi et al. 2010). All 3 studies that investigated perseverative errors found no significant differences between the recovered and HC groups (Roberts et al. 2010; Nakazato et al. 2010; Nakazato et al. 2009). However the recovered group was often not significantly different to the AN group either (Nakazato et al. 2010; Nakazato et al. 2009) and had an intermediate profile. The 1 study that looked at the number of categories completed found that the AN recovered group completed significantly fewer categories on the WCST than the HC group (Roberts et al. 2010). Another study looked at a recovered AN group but did not compare to a HC group (Tenconi et al. 2010).

The TMT was used to examine set shifting in recovered AN participants in 4 studies (Roberts et al. 2010; Nakazato et al. 2010; Tchanturia et al. 2004b; Tenconi et al. 2010). The 3 studies that investigated errors found there were no significant differences between recovered AN and HC participants (Roberts et al. 2010; Nakazato et al. 2010; Tchanturia et al. 2004b) and an additional repeated measures design in 1 study (Tchanturia et al. 2004b) showed no significant reduction in errors with weight gain. The 2 studies that looked at shifting time found no significant differences between the recovered AN and HC groups (Nakazato et al. 2010; Tchanturia et al. 2004b). The additional repeated measures design in 1 study (Tchanturia et al. 2004b) also showed no significant reduction in shifting time following weight gain. The 1 study that looked at B-A difference found that there were no significant differences between the recovered AN and HC groups (Roberts et al. 2010). Another study looked at a recovered AN group but did not compare to a HC group (Tenconi et al. 2010).

The Haptic illusion task was used to examine set shifting in recovered AN participants in 3 studies (Roberts et al. 2010; Tchanturia et al. 2004b; Tchanturia et al. 2002). Of these, 2 studies found that the recovered AN group made significantly

more illusions than the HC group (Tchanturia et al. 2004b; Tchanturia et al. 2002) and this difference remained significant when 1 study controlled for depression, anxiety and obsessive compulsive symptoms (Tchanturia et al. 2002). The other study found no significant differences between the groups in number of illusions (Roberts et al. 2010). An additional repeated measures design found there was no significant reduction in number of illusions following weight gain (Tchanturia et al. 2004b).

The Picture set task was used to examine set shifting in recovered AN participants in 1 study (Tchanturia et al. 2004b). This study found that the recovered AN participants made significantly more errors than the HC group. The same study used a repeated measures design and found that there was no significant reduction in errors following weight gain (Tchanturia et al. 2004b).

The Brixton test was used to examine set shifting in recovered AN participants in 3 studies (Tchanturia et al. 2011; Roberts et al. 2010; Tchanturia et al. 2004b). All 3 studies found no significant differences in errors between the recovered AN and HC groups. An additional repeated measures design found there was no significant reduction in errors following weight gain (Tchanturia et al. 2004b).

The Verbal fluency task was used to investigate set shifting in a recovered AN group in 1 study (Tchanturia et al. 2004b). In this study there were no significant differences in perseverative errors between the recovered AN and HC groups.

The CATBAT task was used to examine set shifting in recovered AN participants in 2 studies (Tchanturia et al. 2004b; Tchanturia et al. 2002). The 1 study that looked at BAT time (Tchanturia et al. 2004b) found no significant differences between the recovered AN and HC groups. The same study used a repeated measures design and found no evidence for a significant reduction in BAT time following weight gain. The 1 study that looked at CATBAT errors, found no significant differences between the recovered AN and HC groups (Tchanturia et al. 2004b). The 1 study that looked at CATBAT perseverations, found that the

recovered AN group made significantly more perseverations than the HC group but this difference did not remain significant once anxiety was controlled for (Tchanturia et al. 2002). The additional repeated measures design found no significant reduction in perseverative responses following weight gain (Tchanturia et al. 2004b). The 2 studies that looked at CATBAT time (Tchanturia et al. 2004b; Tchanturia et al. 2002) found no significant differences between the recovered AN and HC groups. The additional repeated measures study found that CATBAT time was significantly reduced following weight gain, indicating improved set shifting (Tchanturia et al. 2004b).

Overall, no tasks provided strong evidence for a set shifting impairment in the recovered AN group. Moderate evidence for a set shifting impairment was provided by Haptic illusion and Picture set tasks. Little or no evidence for a set shifting impairment was provided by the WCST, TMT, CATBAT, Verbal fluency and Brixton tasks. This provides evidence for the state theory as it appears that weight gain reduces or eliminates set shifting difficulties in the acute phase of the illness. Prospective and longitudinal studies would be particularly useful to explore this finding further.

7.4.3 Healthy sisters of individuals with AN:

If the state theory is correct and starvation causes neuropsychological impairments, we would expect healthy relatives of individuals with an eating disorder not to demonstrate significant impairments in set shifting, unless underweight themselves. If the trait theory is correct and neuropsychological impairments are endophenotypes (measurable disease associated traits linked to underlying genes), we would expect to see set shifting difficulties in close genetic relatives such as siblings. Therefore examining set shifting ability in healthy siblings of individuals with eating disorders is a useful way of exploring the trait state debate.

The WCST was used to examine set shifting in healthy sisters of individuals with AN in 2 studies (Roberts et al. 2010; Tenconi et al. 2010). Both studies looked at the number of categories completed and although 1 found that healthy sisters of individuals with AN completed significantly less categories than HCs (Tenconi et al. 2010), the other found no significant differences in categories completed between sisters of individuals with AN and HCs (Tenconi et al. 2010). Both studies also looked at perseverative errors and both found that healthy sisters of individuals with AN made significantly more perseverative errors than HCs (Roberts et al. 2010; Tenconi et al. 2010).

The TMT was used to investigate set shifting in healthy sisters of individuals with AN in 3 studies (Roberts et al. 2010; Holliday et al. 2005; Tenconi et al. 2010). The 1 study that looked at TMT errors, found no significant differences between the groups (Roberts et al. 2010). The 1 study that looked at the TMT B-A difference (Roberts et al. 2010) found no significant differences between healthy sisters of individuals with AN and HCs. Of the 2 studies that looked at TMT shifting time (Holliday et al. 2005; Tenconi et al. 2010), 1 found that healthy sisters of individuals with AN took significantly longer on the shifting component of the task than HCs (Tenconi et al. 2010) and 1 found no significant differences between the groups (Holliday et al. 2005).

The CATBAT task was used to examine set shifting in healthy sisters of individuals with AN in 1 study (Holliday et al. 2005). This study found that healthy sisters of individuals with AN took significantly longer on the BAT (shifting) component of the task and had a significantly higher CATBAT ratio than HCs indicating set shifting difficulties.

The Haptic illusion task was used to investigate set shifting in healthy sisters of individuals with AN in 2 studies. Although 1 study found that healthy sisters of individuals with AN made significantly more illusions than the HC group (Holliday et al. 2005), the other study found that there were no significant differences in the

number of illusions made by healthy sisters of individuals with AN and HCs (Roberts et al. 2010).

The Brixton test was used to examine set shifting in healthy sisters of individuals with AN in 2 studies (Roberts et al. 2010; Holliday et al. 2005). Both studies found no significant differences in the number of errors made between healthy sisters of individuals with AN and HCs.

Overall, strong evidence for a set shifting impairment was suggested by the WCST and CATBAT tasks. Moderate evidence for a set shifting impairment was suggested by the Haptic illusion task and little or no evidence for a set shifting impairment was suggested by the TMT and Brixton tasks. Hence these studies provide mixed support for the trait argument.

7.4.4 Healthy sisters of individuals with BN:

The TMT was used to investigate set shifting in healthy sisters of individuals with BN in 1 study (Roberts et al. 2010). This study found that healthy sisters of individuals with BN had a significantly higher B-A difference than HCs, indicating set shifting difficulties. However this study also found no significant differences in the number of errors between healthy sisters of individuals with BN and HCs.

The WCST was used to investigate set shifting in healthy sisters of individuals with BN in 1 study (Roberts et al. 2010). This study found no significant differences in number of categories completed or perseverative errors between healthy sisters of individuals with BN and HCs.

The Brixton test was used to investigate set shifting in healthy sisters of individuals with BN in 1 study (Roberts et al. 2010). This study found that healthy sisters of individuals with BN made significantly more errors on the Brixton test than the HC group.

The Haptic illusion task was used to examine set shifting in healthy sisters of individuals with BN in 1 study (Roberts et al. 2010). In this study, there were no significant differences in the number of illusions made by healthy sisters of individuals with BN and HCs.

Overall, there was very little research into healthy sisters of individuals with BN and no tasks provided strong evidence for a set shifting impairment. Moderate evidence for a set shifting impairment was suggested by the TMT and Brixton tasks. Little or no evidence for a set shifting impairment was suggested by the WCST and Haptic illusion tasks.

8. Discussion

8.1 Summary of the evidence

Question 1: Do participants with AN, BN and BED have significantly more difficulties set shifting than HCs?

There is very mixed evidence about whether there is a set shifting impairment in AN. There is strong evidence for a set shifting impairment on the WCST, Brixton and Haptic illusion tasks, moderate evidence on the Picture set, CATBAT and UCOT tasks and little or no evidence on the TMT, Verbal fluency, IED in CANTAB tasks.

There is much less research into set shifting in BN. However there is strong evidence for a set shifting impairment on the WCST and Haptic illusion tasks, moderate evidence on the TMT and CATBAT tasks and little or no evidence on the Brixton, Picture set and Verbal fluency tasks.

No research to date has looked at set shifting in individuals diagnosed with BED and only 1 study has investigated the EDNOS group. These are areas which may benefit from further research.

Question 2: *Does the evidence suggest that set shifting difficulties are a consequence of starvation (state argument) or does it suggest that set shifting difficulties are an enduring trait predisposing individuals to eating disorders (trait argument)?*

Overall, the evidence for a set shifting impairment in BN was not as strong as the evidence in AN. This may be because the majority of participants with BN are not in a state of extreme starvation and although some may be acutely starved, they are unlikely to be chronically starved (whereas AN participants may be acutely and chronically starved). This difference in AN and BN is consistent with the state argument which suggests that set shifting difficulties are a consequence of starvation.

All studies that investigated whether there was a relationship between BMI and set shifting found no significant relationship. Although this appears to be fairly strong evidence that set shifting impairments are not caused by a state of starvation, it is important to remember that BMI is a fairly crude index of starvation and may not be sensitive or accurate enough. Future research should consider using an index of acute starvation such as time since last calorie containing food/drink or calories consumed over the last 24 hours.

In the recovered AN group, no tasks provided strong evidence for a set shifting impairment, however some tasks provided moderate evidence for a set shifting impairment (Haptic illusion and Picture set tasks). Often the recovered group had an intermediate profile and performance on set shifting tasks was not significantly different to current AN or HC groups. This mixed evidence suggests that

neuropsychological impairments may be enduring traits that predispose individuals to eating disorders but also suggest that starvation may exacerbate and maintain set shifting difficulties.

There was quite strong evidence for a set shifting impairment in healthy sisters indicated by strong or moderate evidence for impairments on the majority of tasks. There was very little research investigating set shifting difficulties in sisters of individuals with BN and this was not as strong as the evidence for a set shifting impairment in sisters of individuals with AN. Overall, this suggests that neuropsychological impairments may be enduring traits that predispose individuals to eating disorders (and therefore supports the trait theory). Further research into healthy sisters and their self reported starvation may be useful.

Overall, we might tentatively conclude that starvation has a mediating or maintaining role in set shifting difficulties rather than causing them per se. It appears that recovered AN and BN participants and healthy sisters are more likely to have difficulties set shifting difficulties than HCs and this may be because an enduring trait is predisposing them to such difficulties. However, more research needs to be conducted before a more definitive answer can be obtained.

8.2 Clinical Implications of this review

Although evidence is mixed and few studies have focused on BN, this review has revealed evidence for set shifting difficulties in AN and BN. To date, there is no evidence assessing whether set shifting difficulties exist in BED and this warrants further investigation.

Set shifting difficulties in AN and BN may manifest as ‘stuckness’ and difficulty changing established thought and behaviour patterns. Therefore expecting participants to become more flexible around their eating and weight (the very thing they find most distressing) may be too difficult to do immediately. Therapy may need

to be adapted to increase flexibility and reduce rigidity generally before focusing on increasing flexibility around eating.

Cognitive Remediation Therapy (CRT) is a psychological therapy that includes activities to increase flexibility and has been suggested as useful in AN (Roberts et al. 2007; Tchanturia, Campbell, Morris & Treasure, 2005). A pilot study of CRT in AN (Tchanturia et al. 2008) found evidence of improved set shifting performance following CRT (although it is not clear how generalisable these gains were). This review would suggest these approaches should also be considered for individuals with BN.

It is still not completely clear whether set shifting difficulties are a trait predisposing individuals to eating disorders. However it appears that while starvation may not be solely responsible for set shifting difficulties, it is likely to contribute to and maintain them. Therefore further research into the possible benefits of weight gain alongside therapy is likely to be beneficial.

8.3 Strengths and weaknesses of the studies included

There were several methodological limitations of the studies included in this review. All were cross-sectional studies apart from one which combined a cross-sectional and longitudinal approach (Tchanturia et al. 2004b) and even this study only followed participants up for approximately three months. This limits conclusions that can be drawn about whether set shifting difficulties predispose individuals to develop eating disorders or whether they are the consequence of starvation. Helpfully, some studies (e.g. Holliday et al. 2005) used sister designs which are a powerful design when considering whether genetic traits may predispose individuals to eating disorders.

The majority of the studies had small sample sizes that were not informed by power analyses (McAnarney et al. 2011; Nakazato et al. 2010; Nakazato et al. 2009;

Wilsdon & Wade, 2006; Tchanturia et al. 2004b; Tchanturia et al. 2002; Tenconi et al. 2010; Tchanturia et al. 2004a) which means there may have been inadequate statistical power to find differences that were present. In fact, only one study used a power analysis to estimate their required sample size before recruiting participants (Tchanturia et al. 2001).

Moreover, most studies recruited only females (McAnarney et al. 2011; Nakazato et al. 2010; Nakazato et al. 2009; Wilsdon & Wade, 2006; Steinglass et al. 2006; Holliday et al. 2005; Tchanturia et al. 2004b; Roberts et al. 2010; Tchanturia et al. 2004a; Tchanturia et al. 2001; Tchanturia et al. 2011) and some did not specify the gender of participants in some groups (Tchanturia et al. 2002; Tenconi et al. 2010). Similarly, sisters were often used as comparison groups (Holliday et al. 2005) but brothers were never used and this would be a useful source of information.

Frequently, there was not enough information provided about whether assumptions for parametric tests were met and whether corrections had been used to prevent inflation of the type 1 error rate that occurs when multiple tests are used (McAnarney et al. 2011; Nakazato et al. 2010; Steinglass et al. 2006). However some studies provided this information clearly (Wilsdon & Wade, 2006; Holliday et al. 2005; Tchanturia et al. 2004b; Tenconi et al. 2010; Roberts et al. 2010; Tchanturia et al. 2004a) and this enabled a more thorough evaluation of the statistical aspects of the study.

The impact of medication was not investigated in many studies (Tchanturia et al. 2011; Wilsdon & Wade, 2006; Steinglass et al. 2006). However the studies that did compare those taking and not taking medication found no significant differences in neuropsychological performance between these groups (Holliday et al. 2005; Tchanturia et al. 2004a; Tenconi et al. 2010).

Helpfully, most studies matched or compared groups on age (McAnarney et al. 2011; Nakazato et al. 2010; Nakazato et al. 2009; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2002; Roberts et al. 2010; Tchanturia et al. 2004a;

Tchanturia et al. 2001; Tchanturia et al. 2011) and estimated intelligence/years of education (McAnarney et al. 2011; Nakazato et al. 2010; Nakazato et al. 2009; Steinglass et al. 2006; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2002; Roberts et al. 2010; Tchanturia et al. 2004a; Tchanturia et al. 2011). For some studies this was not possible (Tchanturia et al. 2011; Wilsdon & Wade, 2006) and this limits the extent to which we can propose set shifting difficulties as a specific deficit amongst a backdrop of otherwise normal functioning.

Similarly, many studies tried to assess and control for depression, anxiety and obsessive compulsive symptomatology (McAnarney et al. 2011; Nakazato et al. 2010; Nakazato et al. 2009; Wilsdon & Wade, 2006; Steinglass et al. 2006; Holliday et al. 2005; Tchanturia et al. 2004b; Tchanturia et al. 2002; Tchanturia et al. 2004a; Tchanturia et al. 2001) to ensure that these were not influencing results and this was a considerable strength of studies when interpreting results.

8.4 Limitations of this review

This review is limited by a number of factors. Firstly, although these neuropsychological tests have frequently been used to measure set shifting and mental flexibility, they are undoubtedly influenced by other cognitive abilities and this has not been given much consideration in this review. Many studies were excluded because they looked at executive functioning more widely and it was difficult to extract the relevant information from its broader context.

This review was unable to examine the differences between AN subtypes and between outpatients and inpatients, which were considered in some studies (Tchanturia et al. 2004a; McAnarney et al. 2011; Tchanturia et al. 2004b; Tchanturia et al. 2011). Often the studies had heterogeneous clinical groups and in one study the AN group had BN participants within it (Tenconi et al. 2010). This is a serious limitation that has not been discussed in detail within this review.

There appeared to be a lack of consistency in measures used within studies and this made it difficult to adequately compare them in this review. For example, some studies used perseverative errors to indicate set shifting difficulties on the WCST, while others used number of categories completed and others used both.

Finally, it was often difficult to establish what findings were because significant differences were reported clearly and non-significant differences were hidden in the detail of the papers. This review would suggest using consistent measures and reporting significant and non-significant findings with equal importance in an attempt to establish a clear answer about whether there are set shifting difficulties in eating disorders.

8.5 Implications for future research

Prospective and longitudinal studies in AN and BN and studies examining the impact of starvation on neuropsychological functioning in HCs would help resolve the debate about whether set shifting impairments are a predisposing trait or a consequence of starvation. Brain imaging techniques may also be a valuable addition to future research as they would increase understanding about which parts of the brain are involved in set shifting.

Future studies should also consider using additional indices of starvation in addition to BMI. An index of acute starvation (such as calorie intake over the last 24 hours) may be particularly relevant. Investigation of both chronic and acute starvation is particularly needed in BN and BED because there has been little investigation of starvation in these groups to date.

Future research would also benefit from trying to include more males as currently results are at best, only generalisable to half the population. This might include males with eating disorders as well as healthy brothers of individuals with eating disorders. This should help increase sample sizes and should be combined

with power analyses to ensure adequate statistical power is achieved. Future research should ensure use of clearly defined groups and consistent measures and indicators of set shifting.

9. Conclusions

This review summarised previous research investigating set shifting in eating disorders. It attempted to answer the questions of whether participants with eating disorders have set shifting impairments and whether these appear to be a consequence of prolonged starvation or a risk factor for eating disorders. This review found evidence for set shifting difficulties in AN and BN however no research has been done into BED and this warrants investigation. This review has suggested that set shifting difficulties may be a trait predisposing individuals to eating disorders but also suggested that starvation is likely to exacerbate and maintain difficulties set shifting. Future research should focus on resolving current methodological issues, using consistent measures in homogenous clinical groups and reporting significant and non-significant findings with clarity.

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Part 2: Empirical Paper

Set shifting, central coherence and starvation in eating disorders

ABSTRACT

Aims: This study aimed to examine set shifting and central coherence in Anorexia Nervosa (AN), Bulimia Nervosa (BN), Binge Eating Disorder (BED) and Healthy Control's (HC). It aimed to investigate whether various indices of chronic and acute starvation were associated with neuropsychological performance.

Method: In total 15 AN, 15 BN and 15 HC participants completed set shifting tasks (Trail Making Task; Brixton Test) and central coherence tasks (Group Embedded Figures Test; Local-Global Switching Task). Participants also completed questionnaires and completed the National Adult Reading Test to obtain an intelligence estimate. Independent sample, one way ANOVAs with post hoc tests and non-parametric alternatives were used in combination with correlational methods to analyse results.

Results: There was some evidence for set shifting difficulties in AN and BN however it was not possible to remove the confounding effects of anxiety, depression and obsessive compulsive symptomatology. There was no evidence for central coherence impairments in AN or BN. Indices of chronic and acute starvation were not significantly correlated with set shifting or central coherence performance.

Conclusions: The results suggest some evidence for set shifting difficulties in AN and BN. There was no evidence to suggest central coherence difficulties in AN or BN groups. Although results indicated that starvation was not significantly associated with neuropsychological impairments, this may be because few neuropsychological impairments were detected and because of inadequate indices of starvation. It is important to replicate these findings with more accurate indices of starvation before conclusions can be drawn about whether set shifting and central coherence impairments are a consequence of starvation or a risk factor for eating disorders.

INTRODUCTION:

Eating disorders:

Eating disorders are associated with a host of medical complications (Mitchell & Crow, 2006), low quality of life (De La Rie, Noordenbos, Donker & Van Furth, 2007), high comorbidity (Herzog, Keller, Sacks, Yeh & Lavori, 1992), and a high mortality rate in AN (Hoek, 2006; Berkman, Lohr & Bulik, 2007). These dangerous complications make it extremely important that an effective treatment is available.

AN is a serious psychiatric illness that is characterised by refusal to maintain minimally normal weight (for age and height), intense fear of gaining weight or becoming fat, amenorrhoea and disturbance in the way weight or shape are experienced.

BN is characterised by recurrent episodes of binge eating (defined by consumption of larger than average portions of food and a sense of lack of control over eating), recurrent compensatory behaviours (such as self-induced vomiting, misuse of medication, fasting and excessive exercise) and a self-evaluation that is unduly influenced by body shape and weight.

BED is characterised by regular binge eating (as specified above) without compensatory behaviours and falls within the Eating Disorders Not Otherwise Specified (EDNOS) category.

Unfortunately, there are no effective, evidence-based psychotherapeutic or pharmacological treatments for AN (Agras & Robinson, 2008) and despite good evidence for the effectiveness of Cognitive Behavioural Therapy (CBT), Interpersonal Psychotherapy (IPT) and antidepressants in BN, studies suggest that only 40-50% actually cease to binge and purge following treatment (Fairburn, Cooper & Shafran, 2003). These poor treatment outcomes for eating disorders

(particularly AN), suggest that a crucial component is missing from treatment. Therefore, continued research into eating disorders is needed in order to uncover maintaining factors and ensure they are targeted in treatment.

Recently, research has begun investigating neuropsychological functioning in eating disorders. This research has suggested that participants with eating disorders may have impaired set shifting (Roberts, Tchanturia, Stahl, Southgate & Treasure, 2007) and central coherence (Lopez, Tchanturia, Shahl, & Treasure, 2008a).

Set shifting:

Set shifting is the ability to move back and forth between multiple tasks, operations or mental sets (Miyake, Friedman, Emerson, Witzki & Howerter, 2000). It requires consideration of whether a previous pattern of responding remains relevant to the goal and changing it if necessary. Roberts et al. (2007) suggested that problems in set shifting may manifest as cognitive inflexibility (e.g. concrete and rigid approaches to problem solving and stimulus bound behaviour) or response inflexibility (e.g. perseverative or stereotyped behaviours). Bolton (2010) has described how this cognitive and behavioural inflexibility and stuckness is characterised in neuropsychological literature as perseveration.

Perseveration has been defined as “the tendency to continue a particular learned response or behaviour, even when it ceases to be effective or rewarding” (Serpell, Waller, Fearon & Meyer, 2009). It can be conceptualised as rigidity, stuckness and not wanting to deviate from a pattern of behaviour. Perseveration is generally considered a maladaptive trait because it can involve the pursuit of lower-order goals at the expense of higher-order goals or repeated behaviour to meet a goal that is no longer relevant (Serpell et al. 2009).

Perseveration has been associated with high levels of psychopathology (Serpell et al. 2009) and has been observed frequently in patients with frontal lobe damage (Lezak, Howieson, Loring, Hannay & Fischer, 2004). Interestingly, the concept of perseveration appears to fit with clinical descriptions of eating disorders, where patients with AN "are often described as having rigid, conforming or obsessional personalities" (Tchanturia, Serpell, Troop & Treasure, 2001). Therefore, one might expect perseveration to be a particularly relevant trait in eating disorder psychopathology.

Sandson and Albert (1984) described three types of perseveration - continuous, recurrent and stuck in set. Continuous perseveration was defined as continuous and inappropriate *repetition of a current behaviour* (e.g. continuing to draw circular movements after drawing the circle). Recurrent perseveration was defined as unintentional repetition of a previous response to a current task *after cessation* (e.g. saying the previous answer to the current question). Stuck in set perseveration was defined as continuous and inappropriate *maintenance of a current set* despite changing requirements (e.g. failing to switch from adding to subtracting).

To date, no research has directly investigated how the constructs of set shifting and perseveration are related and so the relationship between them is unclear. However, it would make sense that a set shifting impairment might fall under the broader area of perseveration and may relate specifically to the stuck in set type of perseveration (i.e. difficulty switching from one set to another). However the relationship between set shifting and stuck in set perseveration is difficult to test experimentally because the concepts have been operationalised the same way, with the same outcomes (e.g. long reaction times and errors) on the same tasks (e.g. WCST) used to indicate set shifting difficulties (Roberts et al. 2007) and perseveration (Wilsdon & Wade, 2006). Therefore while the term set shifting is used, the difficulties described might best be conceptualised as stuck in set perseveration.

Set shifting in eating disorders:

Research has demonstrated that individuals with AN and sisters of women with AN struggle significantly more than HCs on set shifting tasks (Holliday, Tchanturia, Landau, Collier & Treasure, 2005; Tchanturia, et al. 2004b). After systematically reviewing studies that had investigated set shifting in AN and BN, Roberts et al. (2007) concluded that a consistent set shifting deficit was present across the eating disorder population. Unfortunately, the majority of research has focused on AN and BN and has not investigated set shifting in BED.

Central coherence:

Weak central coherence has been defined as "a cognitive style in which there is a bias towards local or detailed processing of information over the natural tendency to integrate information into a context" (Lopez et al. 2008c). Central coherence was initially researched extensively in Autistic Spectrum Disorders (ASD) and since been investigated in eating disorders.

It has been suggested that the concept of weak central coherence fits with clinical descriptions of eating disorders, where patients demonstrate a preoccupation with details and rules (Lopez et al. 2008c). Therefore, one might expect weak central coherence to be a particularly relevant trait in eating disorder psychopathology.

Central coherence in eating disorders:

Research has demonstrated that individuals with AN (Southgate, Tchanturia & Treasure, 2008; Lopez et al. 2008c) and BN (Lopez, Tchanturia, Stahl & Treasure, 2008b) have weaker central coherence than HCs. Some studies have suggested

that participants with eating disorders show a similar profile to those with ASD, having stronger local processing than global processing – referred to as 'weak central coherence' (Lopez et al. 2008c). Some research has suggested that weak central coherence may play a role in the maintenance of eating disorders and suggested that clinical interventions could utilise this finding by attempting to correct information processing biases in treatment (Lopez et al. 2008c). A systematic review of studies on central coherence in eating disorders concluded that although the evidence for global processing difficulties in individuals with eating disorders was clear, the evidence for superior local processing needed further investigation (Lopez et al. 2008a). Unfortunately, no studies have investigated central coherence in BED or directly compared central coherence across diagnostic groups.

The role of starvation:

As eating disorders and starvation typically occur at the same time, it is difficult to establish whether neuropsychological impairments are risk factors for eating disorders or are a consequence of starvation. State and trait theories have been proposed to explain the role starvation might play in neuropsychological impairments (such as set shifting and central coherence).

The state argument:

The state argument hypothesises that a state of starvation *causes* neuropsychological impairments in set shifting and central coherence. Research findings that participants who have gained weight and are in recovery from AN, have an intermediate performance compared to AN and HC groups on set shifting tasks (Nakazato et al. 2009; Nakazato et al. 2010) suggest neuropsychological functioning is adversely affected by starvation and lend support to the state theory. Recent

studies demonstrating that short-term starvation has a detrimental effect on set shifting in HCs (Bolton, 2010; Pender, 2011) also lend support to the state argument.

If the state argument is correct, we would expect to see a high correlation between degree of starvation and severity of neuropsychological impairments. We would also expect chronic starvation to be more detrimental to neuropsychological performance than acute starvation. Therefore we might expect those with AN to have the greatest impairments in set shifting and central coherence (because they are likely to suffer the effects of long-term chronic fasting in addition to short-term acute fasting), followed by those with BN (because they are likely to suffer the effects of short-term acute fasting). It is thought that participants with BN will suffer the effects of acute starvation for several reasons. Firstly, because evidence suggests that restriction of food (although not necessarily total fasting) precedes bingeing in many cases of BN (Polivy & Herman, 1985; Stice, 1994). Secondly, because fasting is one type of compensatory behaviour listed in the DSM criteria for BN and research has indicated that participants with BN are frequently more calorie deprived than HCs (Davies, Freeman & Garner, 1988). Finally, it is expected that participants with BN will suffer the effects of acute starvation because research has suggested they have various nutritional deficiencies (Setnick, 2010) which are suggestive of restricted food intake.

Finally, we would expect individuals with BED not to demonstrate impairments in set shifting and central coherence because they are by definition, eating regularly outside binges and thus not in a state of starvation.

The trait argument:

The trait argument hypothesises that neuropsychological impairments are enduring traits that predispose individuals to develop eating disorders. Research

findings that set shifting and central coherence impairments persist after recovery and weight gain (Holliday et al. 2005; Tchanturia et al. 2004b; Tenconi et al. 2010; Lopez, Tchanturia, Stahl & Treasure, 2009) and are present in unaffected sisters of women with eating disorders (Holliday et al. 2005; Tenconi et al. 2010) lend support to the trait theory. If the trait argument is correct, we would expect to see a weak or nonexistent correlation between degree of starvation and severity of neuropsychological impairments.

Findings thus far have been mixed and the role that starvation plays in eating disorders is not yet clear.

Limitations of previous research:

Unfortunately, previous research in eating disorders has been unsystematic. Most studies have focused either on set shifting *or* central coherence without looking at performance on both.

Also, many studies have only investigated AN and have not compared set shifting or central coherence across AN, BN, BED and HCs (Holliday et al. 2005; Tchanturia et al. 2004b; Wilsdon & Wade, 2006). The paucity of research into BED is particularly striking and is particularly relevant at the current time when there is a proposal to make BED a standalone diagnosis (Fairburn & Cooper, 2011). The focus on AN is presumably because we would expect those with AN to be the most severely affected if starvation has a causal role in neuropsychological impairments. However this limits our capacity to talk about set shifting and central coherence across all eating disorders.

Unfortunately, previous research on the role of starvation has also focused on single diagnostic groups - most frequently AN. This means that the effect of starvation has been confounded by any impairments associated with AN itself.

Therefore obtaining a general overview across eating disorders may provide a useful indication of the role of starvation across groups.

Finally, many studies (Holliday et al. 2005; Tchanturia et al. 2004a) have only included females, meaning that results may not generalise to males. Whilst this is a difficult limitation to overcome due to the low relative prevalence of eating disorders in males, it is felt that inclusion criteria should not directly prevent males from taking part for the sake of homogeneity.

The current study:

The first aim of this study was to examine whether there were any significant differences in set shifting in individuals with AN, BN, BED and HCs. Set shifting was assessed using the Brixton Spatial Anticipation Test (Burgess & Shallice, 1997) and the Trail Making Task (TMT; Reitan, 1958).

The second aim of this study was to examine whether there were any significant differences in central coherence in individuals with AN, BN, BED and HCs. Central coherence was assessed using the Group Embedded Figures Test (GEFT; Witkin, Oltman, Raskin & Karp, 2002) and the Local-Global Switching Task (L-G Switching Task; White, O'Reilly & Frith, 2009).

The third aim of this study was to examine how acute and chronic starvation were related to set shifting and central coherence across diagnostic groups. Body Mass Index (BMI) was used as an index of chronic starvation. Four indices of acute starvation were used (time since last meal, time since last calorie containing food/drink, calorie intake in last 24 hours and calorie intake in last week) because this had not been investigated before.

If there was a strong correlation between starvation and set shifting or central coherence in this analysis, we might expect to see this reflected in the first analysis. Specifically, we would expect those with AN to be the most severely

impaired (as they are chronically and acutely starved), followed by those with BN (who are acutely starved). We might expect those with BED (who are not starved) to have a similar profile to HCs with little impairments.

Hypotheses:

Hypothesis 1 - Set shifting:

The AN group will show poorer set shifting performance (on the TMT and the Brixton) than the HC group. The BN group will show an intermediate set shifting performance that will be poorer than the HC group but better than the AN group. The BED group may have a performance similar to the HC group but this is currently unclear.

Hypothesis 2 - Central coherence:

The AN group will show superior local and impaired global performance on central coherence tasks (GEFT and L-G Switching Task) compared to the HC group. The BN group will show an intermediate central coherence performance that will be poorer than the HC group but better than the AN group. The BED group may have a performance similar to the HC group but this is currently unclear.

Hypothesis 3 – Starvation:

Indices of chronic and acute starvation will correlate with set shifting and central coherence performance, with increased starvation relating to poorer performance on the tasks.

METHOD

Participants:

Power analysis:

Tchanturia et al. (2004b) used the TMT to investigate set shifting in AN and HC groups and found a large effect size between the groups. Lopez et al (2009) used the Embedded Figures Task to investigate central coherence in participants with a history of AN or BN and HCs and found a large effect size.

Power analyses were carried out using G*Power3 (Faul, Erdfelder, Lang & Buchner, 2007) using an alpha level of five percent, a power level of eighty percent and the large effect sizes specified above to estimate the required sample. These power analyses revealed that 36-44 participants were needed in total (36 if three groups were used and 44 if four groups were used), with 11-12 participants in each diagnostic group.

Sample and inclusion criteria:

The sample consisted of 15 individuals with AN, 15 individuals with BN and 15 HCs. It was not possible to obtain a sample of participants with BED. In order to meet the inclusion criteria for the study, participants needed to be aged between 18 and 65 years old, speak English fluently, never have experienced neurological disease, brain surgery or a psychotic episode and never been diagnosed with an ASD or learning disability.

The study excluded participants who had experienced neurological disease, serious head injury or brain surgery because inflexibility and perseveration have been linked with lesions to the prefrontal regions, dorsolateral aspects of the frontal

lobes (Darby & Walsh, 1999; Lezak et al. 2004), frontosubcortical, mesolimbic damage and to dopamine system dysfunction (Hotz & Helm-Estabrooks, 1995). Participants with ASD were excluded because weak central coherence has been observed in neurodevelopmental conditions such as ASD (Frith, 2003).

Participants in the HC group also needed to have a Body Mass Index of 19 or above and have no personal history of an eating disorder. Healthy volunteers were not screened for eating pathology or mental health difficulties to allow for natural variation.

Participants with an eating disorder must have been diagnosed with AN, BN or BED by a health care professional, needed to be currently symptomatic and needed to meet the proposed DSM V criteria for AN, BN or BED (Fairburn & Cooper, 2011). Specifically, in the AN group, participants needed to have a BMI of 18.5 or below. In line with other studies in the field, participants who were menstruating were still included in the AN group as studies have suggested amenorrhea does not increase the specificity of the diagnosis (Steinglass, Walsh & Stern, 2006). In BN, participants needed to still be engaging in binge eating and compensatory behaviours regularly.

Recruitment procedure:

Participants were recruited through two eating disorder services in London, University College London (UCL) and BEAT (a national charity that provides information, help and support to people with eating disorders).

Patients currently or previously known to the eating disorder services were given a poster (Appendix 1), information sheet about the study (see Appendix 2 for information sheet given to participants with an eating disorder and Appendix 3 for information sheet given to participants without an eating disorder) and consent form (Appendix 4) for consideration. They were asked to contact the researcher directly if

they wanted to know more about the study or wanted to take part. Posters were also displayed in the services that were participating in the research.

An email was circulated to all undergraduate and postgraduate students in UCL advertising the research and asking them to contact the researcher if they were interested in taking part. Additionally, posters were displayed around UCL to advertise the study to students and staff.

Finally, an internet advertising campaign was used with BEAT which consisted of advertising the research on their website, contacting individuals on their research register and sending mini electronic advertisements about the study to people via Facebook and Twitter.

Once participants had made contact with the researcher, they were screened by telephone or email to see whether they met the inclusion criteria. If they had not been given the poster, information sheet and consent form, these were forwarded to them for consideration. Initial questions about the study were answered and if participants were happy to continue with the study, they were booked in to meet the researcher at one of the NHS sites or UCL.

Ethics:

Ethical approval was obtained from a National Research Ethics Committee in London (Appendix 5) and R&D Approval was obtained from the two trusts where the eating disorder services were based.

Design:

A quasi-experimental, independent samples design was used to compare set shifting and central coherence in participants with AN, BN, BED and HCs. The

independent variable was group and this had four levels (AN, BN, BED and HC). The dependent variables were set shifting and central coherence scores.

Measures:

Each participant had their height and weight measured at the beginning of the testing session to calculate their Body Mass Index (BMI). Each participant completed five questionnaires and five experimental tasks (to assess set shifting and central coherence and provide an IQ estimate).

Body Mass Index (BMI):

BMI was calculated by dividing each participant's weight (in kilograms) by their height (in metres squared). In two cases, participants refused to be weighed but agreed for their recent weight to be ascertained via their clinician. For five inpatients, weight was ascertained via their clinician as they were already being weighed regularly. In all other cases the participant's weight was taken by weighing them on Hanson HX5000 electronic scales and taking their height using a Seca portable stadiometer.

Questionnaires:

Lifestyle and Eating Questionnaire (LEQ)

The LEQ (Appendix 6) contained questions about demographics, physical and mental health, recent food intake and eating disorder diagnoses. As this questionnaire was specifically designed for this study, there is no information about its reliability and validity.

Obsessive Compulsive Inventory (OCI; Foa, Kozak, Salkovskis, Coles & Amir, 1998)

The OCI is a self report scale to assess levels of obsessive compulsive symptomatology. The OCI was used because there is evidence that obsessive compulsive symptomatology is associated with weaker central coherence (Lopez et al. 2008c) and elevated perseveration (Wilsdon & Wade, 2006).

Participants were required to rate 42 items on a five point likert scale in terms of how frequently in the last month they have had the experience described and how much this distressed them in the last month. Items include statements such as “I get upset if objects are not arranged properly” and “I feel I have to repeat certain numbers”. Scoring leads to a total distress score, total frequency score and a total score based on seven subscales (washing, checking, doubting, ordering, obsessing, hoarding and mental neutralizing). Foa et al. (1998) suggested that a cut-off score of 40 on the distress ratings allowed correct identification of 80% of patients with Obsessive Compulsive Disorder (OCD).

The OCI has high internal consistency and good test-retest reliability for symptom frequency and distress in individuals with OCD and HCs. It also has good discriminant validity and satisfactory convergent validity (Foa et al. 1998).

Persistence, Perseveration and Perfectionism Questionnaire (PPPQ-22; Serpell et al. 2009)

The PPPQ-22 is a self report scale to examine persistence, perseveration and perfectionism. Participants were required to rate 22 items on a scale of 1-5 depending on how much they felt each statement was true of them (1-Not at all true of me, 2-A little true of me, 3-Somewhat true of me, 4-Very true of me, 5-Totally true of me). Items include statements such as “Once I decide to do something, I keep

going until I reach my goal" (persistence), "Sometimes I find myself continuing to do something even when there is no point in carrying on" (perseveration) and "I hate making mistakes" (perfectionism). Higher mean values on the three subscales indicate higher levels of the trait.

The PPPQ-22 has been shown to have acceptable test-retest reliability and acceptable internal consistency for each scale (Serpell et al. 2009). Additionally, the intercorrelations between subscales are low to moderate indicating that they are three sufficiently distinct constructs (Serpell et al. 2009).

Eating Disorder Examination Questionnaire 6.0 (EDE-Q6; Fairburn & Beglin, 2008)

The EDE-Q6 is a self report version of the Eating Disorder Examination (EDE; Fairburn, Cooper & O'Connor, 2008) which is a well established interview to assess eating pathology. The EDE-Q6 has 28 questions such as "On how many of the past 28 days have you had a strong desire to lose weight?". Participants were required to rate their response on a scale of 0-6 (0-no days to 6-every day) and scores on 4 subscales (restraint, eating concern, shape concern, weight concern) and a global score were obtained. The EDE-Q6 also provides information about how many episodes of binge eating and how many compensatory behaviours have occurred in the last month and this was used to ensure that participants with BN met the inclusion criteria.

The EDE-Q6 has good internal consistency, good test-retest reliability (Luce & Crowther, 1999), good concurrent validity and acceptable criterion validity (Mond, Hay, Rodgers, Owen and Beumont, 2004).

Hospital Anxiety and Depression Scale (HADS; Snaith & Zigmond, 1994)

The HADS is a brief self-report screening tool used to assess anxiety and depression. The HADS was used because research has indicated that depressive and anxiety disorders can affect set shifting and central coherence (Wilsdon & Wade, 2006; Lopez et al. 2008b; Darby & Walsh, 1999). Unlike other anxiety and depression scales, the HADS does not include items about physiological symptoms of anxiety and depression (such as weight loss) that may reflect physical health difficulties or eating pathology (Snaith & Zigmond, 1994).

Participants were asked to underline the response that most closely reflected how they felt over the last week (e.g. I can sit at ease and feel relaxed – Definitely, Usually, Not often or Not at all). Seven items were presented for anxiety and seven for depression and each item was scored from 0 to 3 depending on the severity of the emotional state. A total score was derived that indicated normal (0-7), mild (8-10), moderate (11-14) or severe (15-21) levels of anxiety of depression.

The HADS is used widely in research and clinical practice (Bjelland, Dahl, Haug & Neckelmann, 2002; Herrmann, 1997). It has good internal consistency (Bjelland et al. 2002; Herrmann, 1997), good test-retest reliability (Herrmann, 1997) and good concurrent validity (Bjelland et al. 2002). Factor analyses have revealed two relatively independent dimensions (Bjelland et al. 2002) and concluded that the HADS is a reliable and valid instrument for assessing anxiety and depression in patients (Hermann, 1997) and in the general population (Bjelland et al. 2002).

Experimental tasks:

National Adult Reading Test (NART; Nelson & Willison, 1991)

The NART required participants to read aloud fifty phonetically irregular words. The number of errors was used to establish an estimated Intelligence Quotient (IQ). The NART was used in line with previous research (Holliday et al. 2005) because intellectual ability can affect performance on set shifting and central coherence tasks.

The NART has high split half, inter-rater and test-retest reliability (Nelson & Willison, 1991) and high construct validity as a measure of general intelligence (Crawford, Stewart, Cochrane, Parker & Besson, 1986).

Trail Making Task (TMT; Reitan, 1958)

In this test, participants were required to draw lines between numbers in ascending numerical order (Trail A) and numbers and letters in alternating ascending numerical and alphabetic order (Trail B). Trail B requires participants to shift between ordering numbers and letters and therefore has been widely used as a measure of set shifting difficulties (Roberts et al. 2007). In this study, Trail B completion time and Trail B completion time minus Trail A completion time (referred to as TMT B-A difference) were used as the measures of set shifting.

Brixton Spatial Anticipation Test (Burgess & Shallice, 1997)

In this test, participants were presented with 10 circles in a 5x2 grid and were required to predict the movement of a blue circle based on patterns that change without warning over 56 trials. It is expected that difficulties in set shifting will lead to

difficulties adapting to pattern change and consequently increased errors and response times. In this study, the computerised version of the Brixton was used.

Group Embedded Figures Test (GEFT; Witkin et al. 2002)

In the GEFT, participants were required to find (and trace) 1 of 8 simple shapes in 18 complex figures within a time limit. The GEFT is a measure of central coherence with more correct answers indicating strong local/detail focused processing and fewer correct answers indicating strong global processing. A copy of the simple shapes was placed beside participants to avoid memory difficulties confounding the results. The GEFT has good equivalent forms reliability and acceptable criterion validity in healthy individuals (Witkin et al. 2002).

Local-Global Switching Task (White et al. 2009)

The Local–Global Switching Task is a computerised task that was originally used to measure central coherence in ASD (White et al. 2009) and has since been used to measure central coherence and set shifting in eating disorders (Pender, 2011).

Following the computerised task instructions, letters (E, H, P, S and U) were presented on the screen either as one large letter (global condition) or several smaller letters (local condition). There were 5 practice trials for each section followed by 25 trials. Each trial consisted of two letters appearing briefly on the screen and participants were asked use the keyboard to type the letters they had seen. Participants were given feedback about performance.

This task has four sections - two global letters in each trial (GG), two local letters in each trial (LL), a global then a local letter (GL) and a local then a global

letter (LG). The proportion of correct responses for global and local letters are measures of global and local processing respectively.

Where possible, tasks controlled for visual, motor and memory impairments. The TMT B-A ratio was used which controls for visual and motor difficulties and the memory element was removed from the GEFT by placing a copy of the figures in front of the participant. This is in line with previous research by Pender (2011).

Experimental procedure:

Each participant completed one testing session that lasted approximately 90 minutes. Participants were tested at UCL or at a NHS site. Once informed consent had been obtained, weight and height were measured.

Participants were then asked to complete the set of questionnaires described above. For five inpatients, information about recent calorie intake (on the LEQ) was obtained from meal plans within eating disorder services because of concerns about the impact of asking acutely ill patients to reflect on calorie intake.

Participants then completed the NART followed by the TMT, GEFT, Brixton and L-G Switching Task. Following this, participants were thanked, debriefed and told that they would be contacted if they won the prize draw.

Statistical Analysis:

Data were analysed using SPSS version 20. Independent sample, one way Analysis of Variances (ANOVAs) followed by post hoc tests (with Bonferroni corrections) and correlational analyses were used to assess differences in demographic and clinical variables of interest between the groups.

One way ANOVAs followed by post hoc tests (with Bonferroni corrections), non-parametric Kruskal-Wallis Tests and Mann-Whitney U tests were used to

assess differences in set shifting and central coherence. Finally, correlational analyses were used to explore the relationship between indices of chronic and acute starvation and set shifting and central coherence.

Where variables showed significant deviation from the normal distribution ($p<0.05$ Kolmogorov Smirnoff test), it was decided to continue using parametric ANOVAs. This was because research has suggested ANOVAs are a robust statistical technique relatively unaffected by violations of normality (Harwell, Rubinstein, Hayes, & Olds, 1992; Schmider, Ziegler, Danay, Beyer, & Bühner, 2010) and recent research has used ANOVAs despite violations of normality (Pender, 2011; Fisher, 2011). In order to ensure that significant results were not due to a failure to meet the parametric assumptions, non-parametric tests were also conducted. Where a parametric result is reported, non-parametric tests concurred unless reported otherwise.

When significant differences were found, post hoc tests (with Bonferroni corrections) were used to identify which groups differed significantly and non-parametric pair-wise comparisons were used to ensure these differences were not due to a failure to meet the parametric assumptions. Non-parametric tests are reported when there was an additional violation in the homogeneity of variances assumption.

RESULTS

Participant Characteristics:

Overall, 8 of the 53 participants tested were excluded from the analyses. Of these, 6 were excluded (HC=1, AN=3, BN=1, BED=1) because they did not meet the inclusion criteria for the study at the time of taking part and 2 were excluded (BN=1, BED=1) because they were unable to complete the test battery. Therefore

the final sample consisted of 45 participants, with 15 participants in each of the HC, AN and BN groups. Unfortunately, it was not possible to obtain a sample of participants with BED.

The sample consisted of 41 (91.1%) females and 4 (8.9%) males. In terms of ethnicity, 36 participants (80%) were white, 4 (8.9%) were of mixed ethnicity, 2 (4.4%) were Asian/Asian British and 1 (2.2%) was black/black British. Additionally, 1 participant reported their ethnicity as other and 1 participant did not disclose their ethnicity.

In terms of education, 6 participants (13.3%) had completed GCSEs, 10 (22.2%) had completed A levels, 21 (46.7%) had completed a diploma or degree and 8 (17.8%) had completed a postgraduate qualification. The overall age range of participants was 18-65 years. Means and standard deviations for each group are presented in table 1.

Independent sample, one way ANOVAs were used to assess differences in demographic and clinical variables of interest between the groups. Many variables (age, anxiety, depression, OCI frequency and distress, PPPQ-22 perfectionism, EDE-Q6 eating concern, shape concern, weight concern and global score) showed significant deviation from the normal distribution ($p<0.05$ Kolmogorov Smirnoff test). As outlined previously, in these cases parametric and non-parametric tests were used to investigate differences. In all cases where a parametric result is reported, non-parametric tests concurred unless otherwise reported.

There were no significant differences between the groups in age ($F(2,42) = 1.131$, $p=0.332$), estimated IQ ($F(2,42) = 0.652$, $p=0.526$), self reported persistence ($F(2,42) = 0.207$, $p=0.814$), perseveration ($F(2,42) = 2.699$, $p=0.79$) or perfectionism ($F(2,42) = 0.342$, $p=0.712$).

ANOVAs revealed significant differences between the groups in anxiety ($F(2,42) = 16.333$, $p<0.001$) and depression ($F(2,42) = 14.085$, $p<0.001$). Post hoc tests (with Bonferroni corrections) revealed that participants with AN and BN had

significantly higher levels of anxiety (corrected $p<0.001$), and depression (corrected $p<0.001$) on the HADS than the HC group.

ANOVAs also revealed significant differences between the groups on all subscales of the EDE–Q6 and post hoc tests (with Bonferroni corrections) revealed that the AN and BN groups had significantly higher scores on all subscales of the EDE–Q6 than the HC group (corrected $p<0.001$) indicating greater eating disordered pathology.

Spearman's rho tests were used to investigate whether there was a relationship between the PPPQ-22 subscales and overall eating pathology as indicated by the EDE-Q6 global score. Non-parametric tests were used because some of the assumptions for parametric correlational analyses (e.g. normality) were not met. The strongest relationship was a highly significant positive correlation between EDE-Q6 global score and perseveration ($r=0.439$, $p=0.003$). The EDE-Q6 global score was also significantly positively correlated with perfectionism ($r=0.335$, $p=0.024$). The EDE-Q6 global score had a non-significant correlation with the persistence score ($r=0.126$, $p=0.409$).

ANOVAs revealed significant differences between the groups on the OCI distress subscale ($F(2,42) = 5.8380$, $p=0.006$) and marginally significant differences between the groups on the OCI frequency subscale ($F(2,42) = 3.139$, $p=0.054$). Post hoc tests (with Bonferroni corrections) revealed that participants with AN had a significantly higher frequency of obsessive compulsive symptoms (corrected $p=0.049$) and distress caused by symptoms (corrected $p=0.004$) than the HC group. However, the differences between groups on the OCI frequency subscale became non-significant ($p=0.061$) when a non-parametric Kruskal-Wallis test was used.

Table 1 – Demographic and clinical measures for AN, BN and HC groups

Characteristic	HC (n=15)	AN (n=15)	BN (n=15)	Analysis		
	Mean (SD)	Mean (SD)	Mean (SD)	F	df	P
Age	26.20 (8.08)	31.20 (11.88)	27.53 (7.76)	1.131	2, 42	0.332
Estimated IQ	109.00 (4.39)	110.60 (5.04)	110.53 (4.31)	0.652	2, 42	0.526
Anxiety	5.87 (4.26) a	14.13 (4.81) b	12.47 (3.38) b	16.333	2, 42	<0.001*
Depression	2.40 (2.64) a	9.47 (5.37) b	9.13 (3.87) b	14.085	2, 42	<0.001*
OCI Frequency	27.00 (22.66) a	51.40 (32.32) b	38.93 (24.00)	3.139	2, 42	0.054
OCI Distress	18.53 (18.02) a	50.27 (33.52) b	32.67 (22.36)	5.8380	2, 42	0.006*
Persistence	3.26 (0.62)	3.41 (0.93)	3.23 (0.89)	0.207	2, 42	0.814
Perseveration	2.24 (0.72)	2.93 (0.82)	2.64 (0.90)	2.699	2, 42	0.79
Perfectionism	3.13 (0.82)	3.37 (0.97)	3.37 (0.90)	0.342	2, 42	0.712
EDE-Q6 Restraint	0.89 (1.04) a	3.56 (1.48) b	3.85 (1.35) b	23.547	2, 42	<0.001*
EDE-Q6 EC	0.48 (0.83) a	3.49 (1.44) b	3.85 (1.34) b	33.806	2, 42	<0.001*
EDE-Q6 SC	1.41 (1.45) a	4.51 (1.15) b	4.72 (1.47) b	27.651	2, 42	<0.001*
EDE-Q6 WC	1.12 (1.86) a	3.88 (1.76) b	4.55 (1.62) b	16.174	2, 42	<0.001*
EDE-Q6 Global	0.98 (1.15) a	3.86 (1.05) b	4.24 (1.24) b	36.489	2, 42	<0.001*

*Note: HC - Healthy Control; AN - Anorexia Nervosa; BN - Bulimia Nervosa; OCI – Obsessive Compulsive Inventory; EDE-Q6 – Eating Disorder Examination Questionnaire. * Significant at p=0.05 level. Significant differences exist between groups where superscript letters differ between groups.*

Experimental tasks:

One or more of the dependent variables relating to each of the following tasks showed significant deviation from the normal distribution ($p<0.05$ Kolmogorov Smirnoff test): TMT, Brixton task, GEFT, L-G Switching Task. As outlined previously, in these cases, parametric and non-parametric tests were used to investigate differences. In all cases where a parametric result is reported, non-parametric tests concurred unless reported otherwise. Non-parametric tests are reported when there was an additional violation in the homogeneity of variances assumption.

Set shifting:

Table 2 shows performance on the two set shifting measures by group.

Table 2 – Set shifting measures for AN, BN and HC groups

Characteristic		HC (n=15)	AN (n=15)	BN (n=15)	Analysis		
		Mean (SD)	Mean (SD)	Mean (SD)	F	df	p
TMT	Trail A (time)	0.23 (0.87)	0.34 (0.25)	0.34 (0.23)	1.573	2, 42	0.219
	Trail B (time)	0.39 (0.19)	0.61 (0.36)	0.51 (0.27)	-	-	0.034* (KWT)
	TMT B-A (time)	0.16 (0.12)	0.27 (0.24)	0.17 (0.15)	1.835	2, 42	0.172
BRIXTON TEST	Brixton (errors)	14.67 (10.10)	16.07 (8.02)	11.13 (4.39)	1.567	2, 42	0.221
	Brixton (mean response time for correct answers)	1430.41 (528.66) a	2328.11 (1241.57) b	1727.92 (600.37)	-	-	0.034* (KWT)

*Note: HC - Healthy Control; AN - Anorexia Nervosa; BN - Bulimia Nervosa; TMT – Trail Making Task; KWT – Kruskal-Wallis Test; MWU – Mann-Whitney U Test. * Significant at p=0.05 level. Significant differences exist between groups where superscript letters differ between groups*

Trail Making Task (TMT):

There were no significant differences between the groups on Trail A of the TMT ($F(2,42) = 1.573$, $p=0.219$) which suggests there were no significant differences in motor or visual abilities between groups.

An independent samples Kruskal-Wallis test revealed significant differences in Trail B of the TMT between the groups ($p=0.034$). Subsequent Mann-Whitney U tests revealed that the HC group were significantly faster at completing Trail B than the AN ($p=0.023$) and BN ($p=0.026$) groups. There were no significant differences between the AN and BN groups ($p=0.775$). This suggests AN and BN groups had significantly more set shifting difficulties on Trail B than the HC group.

As anxiety, depression and OCI distress and frequency scores differed significantly between the groups, they were used as covariates in Analysis of Covariance (ANCOVA). Although the assumptions for a parametric test were not met, it was considered important to investigate whether differences in the non-parametric tests may be due to differences between the groups in anxiety, depression or obsessive compulsive symptomatology. These ANCOVA's revealed that group differences became non-significant when the effects of anxiety ($p=0.595$), depression ($p=0.633$), OCI frequency (0.248) and OCI distress ($p=0.300$) were factored out.

Trail B completion time minus Trail A completion time (known as TMT B-A difference) was used as the main measure of set shifting. A one way, independent samples ANOVA revealed that there were no significant differences in the TMT B-A difference between the groups ($F(2,42) = 1.835$, $p=0.172$). Thus, although the significant group difference in Trail B suggested differential set shifting ability between the groups, the more stringent comparison of TMT B-A scores (which controls for vasomotor speed) did not substantiate this suggestion.

Brixton Spatial Anticipation Test:

The number of errors and the mean response times for correct responses were used as the measures of set shifting. A one way, independent samples ANOVA revealed that there were no significant differences in the number of errors in the Brixton test between the groups ($F(2,42) = 1.567$, $p=0.221$), indicating no significant differences in set shifting between the groups.

An independent samples Kruskal-Wallis test revealed that there were significant differences in Brixton mean response times for correct responses between the groups ($p=0.034$). Subsequent Mann-Whitney U tests revealed that the AN group were significantly slower than the HC group ($p=0.015$) but there were no significant differences between the BN and HC groups ($p=0.148$) or the AN and BN groups ($p=0.161$).

As anxiety, depression and OCI distress and frequency scores differed significantly between the groups, they were used as covariates in an ANCOVA. Although the assumptions for a parametric test were not met, it was considered important to investigate whether differences in the non-parametric tests may be due to differences between the groups in anxiety, depression or obsessive compulsive symptomatology. These ANCOVA's revealed that the group differences became non-significant or only marginally significant when the effects of anxiety ($p=0.255$), depression ($p=0.076$), OCI frequency (0.065) and OCI distress ($p=0.078$) were factored out.

Central coherence:

Group Embedded Figures Test (GEFT):

The number of correctly traced simple shapes was used as the measure of central coherence, with more correct answers indicating strong local/detail focused processing and fewer correct answers indicating strong global processing. As the homogeneity of variance assumption was violated in addition to the normality assumption a non-parametric independent samples, Kruskal-Wallis test was used. This revealed no significant differences in the number of correct answers between the groups on the GEFT ($p=0.960$). Table 3 shows the mean and standard deviations for each group in the GEFT.

Table 3 – GEFT results for AN, BN and HC groups

Characteristic	HC (n=15)	AN (n=15)	BN (n=15)	Analysis		
	Mean (SD)	Mean (SD)	Mean (SD)	F	df	p
GEFT (no correct)	14.40 (2.92)	12.93 (5.54)	13.67 (4.34)	-	-	0.960 (KWT)

Note: HC - Healthy Control; AN - Anorexia Nervosa; BN - Bulimia Nervosa; GEFT – Group Embedded Figures Test; KWT – Kruskal-Wallis Test. Significant differences exist between groups where superscript letters differ between groups

Local-Global Switching Task (L-G Switching Task):

The proportion of correct responses for global and local letters are measures of global and local processing respectively. Additionally, fewer correct responses on trials requiring a switch from local to global letters than on trials requiring a switch from global to local letters is indicative of a weakness in global processing, or weak central coherence whilst the opposite is indicative of strong central coherence. Table 4 shows the mean and standard deviations for each condition by group.

Table 4 – Mean (standard deviation) proportion of correct responses for conditions in the L-G Switching Task

Condition	HC (n=15)	AN (n=15)	BN (n=15)	Level of processing
	Mean (SD)	Mean (SD)	Mean (SD)	
Global-Global letter 1	0.84 (0.12)	0.66 (0.30)	0.77 (0.19)	Global
Global-Global letter 2	0.91 (0.10)	0.72 (0.29)	0.87 (0.12)	Global
Local-Local letter 1	0.98 (0.45)	0.85 (0.20)	0.96 (0.44)	Local
Local-Local letter 2	0.96 (0.64)	0.84 (0.21)	0.94 (0.55)	Local
Global Local letter 1	0.86 (0.16)	0.70 (0.33)	0.85 (0.10)	Global
Global-Local letter 2	0.65 (0.16)	0.58 (0.25)	0.64 (0.20)	Local
Local-Global letter 1	0.84 (0.19)	0.87 (0.14)	0.82 (0.16)	Local
Local-Global letter 2	0.80 (0.21)	0.60 (0.23)	0.70 (0.21)	Global

Note: HC - Healthy Control; AN - Anorexia Nervosa; BN - Bulimia Nervosa.

A mixed 3 x 4 x 2 (Group [HC, AN, BN] X Condition [global-global, local-local, global-local, local-global] x Position [letter 1, letter 2]) between-within ANOVA was used to analyse the LG switching task.

Table 5 below shows the results of the ANOVA. There was a significant main effect of group ($p=0.034$) on the proportion of correct responses, with significant differences between the HC and AN groups ($p=0.026$) but no significant differences between the HC and BN groups ($p=0.300$) or AN and BN groups ($p=0.103$). Further significant differences were found, however the group factor did not significantly affect any of these. This indicates that while the AN group appeared to perform more poorly across all conditions than the HC group, there were no significant differences specifically in local or global processing between groups.

Table 5 – L-G Switching Task results

	F	df	P
Group	3.682	2, 42	0.034 *
Condition	26.373	3, 40	<0.001 *
Condition x Group	0.814	6, 80	0.562
Position	45.250	1, 42	<0.001 *
Position x Group	1.521	2, 42	0.230
Condition x Position	47.191	3, 40	<0.001 *
Condition x Position x Group	1.131	6, 80	0.352

** Significant at p=0.05 level*

As anxiety, depression and OCI distress and frequency scores differed significantly between the groups, they were used as covariates in the ANOVA to investigate whether differences in the non-parametric tests were due to differences between the groups in anxiety, depression or obsessive compulsive symptomatology. Differences in group became non-significant or only marginally significant when the effects of anxiety (p=0.176), OCI frequency (0.065) and OCI distress (p=0.085) were factored out but remained significant when the effects of depression were factored out (p=0.050).

A LG Difference score was created for each participant by subtracting their total local score from their total global score. This resulted in a single score that was a measure of central coherence, with larger scores indicating better central coherence than smaller scores. An independent samples Kruskal-Wallis test revealed no significant differences in the LG Difference score between the groups (p=0.283).

Indices of chronic and acute starvation:

In line with the expectation that participants with BN would suffer the effects of short-term acute fasting, 60% of participants with BN reported (on the EDE-Q6) having fasted for a minimum of eight hours on at least 1 of the last 28 days. Moreover, 33% of BN participants reported having fasted for a minimum of eight hours on at least 13 of the last 28 days.

As some of the assumptions for parametric tests had been violated (e.g. homoscedasticity and normality), non-parametric Spearman's rho tests were used to investigate the relationship between task performance and indices of chronic and acute starvation. See table 6 for correlations and significance values.

Cohen (1988) suggests that r values of +/- 0.10-0.29 indicate a small correlation, r values of +/-0.30-0.49 indicate a medium correlation and r values of +/-

0.50-1.00 indicate a large correlation. Correlations between chronic and acute starvation and all tasks were small and non-significant, suggesting no association between chronic or acute starvation and set shifting or central coherence.

Table 6 – Correlations between starvation measures and tasks

		Set shifting				Central coherence	
		TMT Trail B	TMT B-A	Brixton errors	Brixton mean RT for correct responses	GEFT	LG switching task Global-Local difference
Chronic starvation	BMI	r =-0.208 p = 0.169	r =-0.219 p = 0.148	r =-0.187 p =0.220	r =-0.239 p =0.114	r =-0.004 p =0.980	r =0.048 p =0.753
Acute starvation	Hours since last meal	r = 0.082 p = 0.590	r =0.073 p = 0.636	r =-0.241 p =0.111	r =-0.058 p =0.704	r =0.048 p =0.753	r = 0.161 p =0.289
	Hours since any calories	r = 0.103 p = 0.503	r =-0.042 p = 0.783	r =-0.270 p =0.073	r =-0.117 p =0.443	r =0.192 p =0.206	r =-0.057 p =0.712
	Calories in last 24 hrs	r = 0.265 p = 0.078	r =0.246 p = 0.103	r =0.155 p =0.309	r =0.133 p =0.385	r =-0.214 p =0.159	r = -0.081 p =0.598
	Calories in last week	r = 0.139 p = 0.363	r =0.176 p = 0.247	r =0.098 p =0.521	r =0.141 p =0.357	r =-0.176 p =0.248	r = 0.119 p =0.437

*Note: BMI – Body Mass Index; TMT – Trail Making Task; GEFT – Group Embedded Figures Test; LG – Local Global. * Correlation is significant at p=0.05 level (2-tailed)*

Indices of chronic and acute starvation were also compared to investigate whether there were significant differences between the groups. BMI, time since last meal, time since calorie containing food/drink, calorie intake in the last 24 hours and calorie intake in the last week showed significant deviation from the normal distribution ($p<0.05$ Kolmogorov Smirnoff test). As outlined previously, in these cases, parametric and non-parametric tests were used to investigate differences. In all cases where a parametric result is reported, non-parametric tests concurred unless otherwise reported. Non-parametric tests are reported when there was an additional violation in the homogeneity of variances assumption.

Chronic starvation:

ANOVAs revealed significant differences between the groups in BMI ($F(2,42) = 20.305$, $p<0.001$), and post hoc tests (with Bonferroni corrections) revealed that the AN group had a significantly lower BMI than the BN (corrected $p<0.001$) and HC (corrected $p<0.001$) groups. There were no significant differences in BMI between the HC and BN group (corrected $p=1.00$). Overall, this indicates that the AN group were more chronically starved than the BN and HC groups.

Acute starvation:

Non-parametric independent samples Kruskal-Wallis tests were used to assess differences between the groups on time since participants last meal and time since any calorie containing food/drink because the homogeneity of variance assumption was violated (in addition to the normality assumption) in both cases. These tests revealed no significant differences in time since any calorie containing food/drink ($p=0.286$) between the groups but revealed a marginally significant difference in time since last meal between groups ($p=0.064$). Post hoc analyses

revealed that the AN group had significantly longer since their last meal than the HC group ($p=0.023$) suggesting a trend for the AN group to go longer without eating meals. There were no significant differences in time since last meal between the HC and BN group ($p=0.089$) or the AN and BN group ($p=0.838$).

A one way, independent samples ANOVAs revealed that there were no significant differences in calorie intake over the last week between the groups ($F(2,42) = 1.435$, $p=0.250$) and a non-parametric independent samples Kruskal-Wallis test revealed that there were no significant differences in calorie intake in the last 24 hours between the groups ($p=0.404$).

Table 7 – Chronic and acute starvation measures for AN, BN and HC groups

Characteristic	HC (n=15)	AN (n=15)	BN (n=15)	Analysis		
	Mean (SD)	Mean (SD)	Mean (SD)	F	df	p
BMI	22.41 (3.33) a	15.35 (1.99) b	23.76 (5.49) a	20.305	2, 42	<0.001*
Hours since last meal	2.80 (3.07) a	8.27 (10.12) b	8.17 (10.19)	-	-	0.64 (KWT)
Hours since any calories	1.63 (0.99)	3.20 (3.74)	5.57 (9.51)	-	-	0.286 (KWT)
Calories in last 24 hrs	1771.53 (440.67)	1477.80 (611.58)	1614.27 (1122.72)	-	-	0.404 (KWT)
Calories in last week	21142.80 (29469.12)	9749.07 (5240.53)	17172.27 (12377.50)	1.435	2, 42	0.250

*Note: HC - Healthy Control; AN - Anorexia Nervosa; BN - Bulimia Nervosa; BMI – Body Mass Index; KWT – Kruskal-Wallis Test. * Significant at p=0.05 level. Significant differences exist between groups where superscript letters differ between groups*

These results suggest that the AN group were significantly more chronically starved than the BN and HC group and may go longer without eating meals than the HC group.

DISCUSSION

Summary of main findings:

This study aimed to investigate whether participants with AN, BN and BED demonstrate neuropsychological impairments in set shifting and central coherence. It also aimed to investigate whether performance on set shifting and central coherence tasks was related to chronic and acute starvation. The study found limited evidence for set shifting impairments in AN and BN. There was no evidence for impaired central coherence in AN or BN groups. None of the indices of acute or chronic starvation correlated with performance on set shifting or central coherence tasks.

Review of specific hypotheses:

Hypothesis 1 - Set shifting:

The AN group will show poorer set shifting performance (on the TMT and the Brixton) than the HC group. The BN group will show an intermediate performance with poorer set shifting than the HC group but better set shifting than the AN group. The BED group may have a performance similar to the HC group.

This hypothesis was partly supported. In the TMT, longer time to complete Trail B and a larger TMT B-A difference value are indicative of impaired set shifting.

Participants with AN and BN took significantly longer to complete Trail B than the HC group. However this became non-significant when anxiety, depression and obsessive compulsive symptomatology were controlled for and therefore the possibility that differences in Trail B are due to differences in anxiety, depression and obsessive compulsive symptomatology cannot be ruled out.

Although inspection of the TMT B-A difference group means suggest that the AN group took longer than the BN group who took longer than the HC group, there were no statistically significant differences in the TMT B-A difference between the groups. Overall, the TMT provided limited evidence for impaired set shifting in AN and BN.

In the Brixton, increased errors and higher mean response times are indicative of impaired set shifting. There were no significant differences in Brixton errors between the groups indicating no differences in set shifting accuracy between the groups.

The AN group had a significantly higher mean response time for correct answers than the HC group, meaning they performed more slowly. This significant difference may reflect the speed with which participants could understand and switch between the pattern changes but it might also reflect motor factors (such as the time taken to move the mouse from one circle to the next). As there were no significant differences between the groups on Trail A of the TMT (which would highlight any differences in motor ability), it is likely that significant differences in the Brixton mean response times were a result of the AN group experiencing difficulties switching quickly between the patterns.

However as differences became non-significant or only marginally significant once anxiety, depression and obsessive compulsive symptomatology were controlled for, the possibility that differences in the Brixton were due to these factors rather than the different diagnostic groups cannot be excluded, especially given evidence that depression, anxiety and obsessive compulsive symptomatology is

associated with impaired set shifting and elevated perseveration (Wilsdon & Wade, 2006; Darby & Walsh, 1999).

Overall there was some evidence to suggest the AN and BN groups had poorer set shifting than the HC group but this was weak. It was not possible to investigate set shifting in a BED sample.

Hypothesis 2 - Central coherence:

The AN group will show superior local and impaired global performance (collectively referred to as 'weak central coherence') on central coherence tasks (GEFT and L-G Switching Task) compared to the HC group. The BN group will show an intermediate performance with weaker central coherence than the HC group but stronger central coherence than the AN group. The BED group may have a performance similar to the HC group.

This hypothesis was not supported in any of the tasks. In the GEFT, more correct answers indicate strong local processing and fewer correct answers indicate strong global processing. This means that more correct answers indicate weak central coherence. Although the group means suggested an opposite trend to the one expected (with the AN group having the fewest correct answers, followed by the BN and HC groups respectively), there were no significant differences in the number of correct responses on the GEFT between any of the groups. This suggests there were no significant differences in central coherence between the groups.

In the L-G Switching Task, the proportion of correct responses for global and local letters are measures of global and local processing respectively. Although the AN group appeared to perform more poorly across all conditions than the HC group, there were no significant differences specifically in local or global processing between groups. There were no significant differences in LG Difference scores

between groups either, suggesting no significant differences in central coherence between the groups.

Overall there was no evidence to suggest any differences in central coherence between the groups.

Hypothesis 3 – Starvation:

Indices of chronic and acute starvation will correlate with set shifting and central coherence performance, with increased starvation relating to poorer performance on the tasks.

This hypothesis was not supported. There were no significant correlations between chronic or acute starvation and set shifting or central coherence performance. This suggests that they are not related and lends support to the trait argument which suggests set shifting and central coherence impairments are enduring traits (independent of starvation) that may predispose individuals to develop eating disorders.

General discussion of findings:

Set shifting and perseveration:

Previous research has suggested increased self reported perseveration in psychological disorders (Serpell et al. 2009) and impaired set shifting in individuals with AN (Holliday et al. 2005; Tchanturia et al. 2004b). The current study found some evidence for reduced speed in set shifting in participants with AN and BN but did not find any evidence for reduced accuracy in set shifting performance compared to HCs.

In terms of the TMT, the AN and BN groups took significantly longer to complete Trail B of the TMT than the HC group, which suggests set shifting difficulties. As Trail A was not significantly different between groups, it is unlikely that differences in Trail B were due to differences in motor or visual ability between the groups. These findings are consistent with previous studies which have shown TMT impairments in AN (Tchanturia et al. 2004b; Tenconi et al. 2010). Although there were no significant differences between groups in the TMT B-A difference, the mean response times showed the expected trend (AN group taking the longest time and HC group taking the shortest time) and it is possible that non-significant differences represent a problem with statistical power as the effect size may be smaller than expected.

In terms of the Brixton test, there were no significant differences in number of errors between the groups, indicating no significant differences between groups in accuracy. This is consistent with research demonstrating no significant differences in Brixton errors between AN and HC groups (Holliday et al. 2005) but inconsistent with other research suggesting participants with AN make significantly more errors than HCs (Tchanturia et al. 2011). As the group means revealed a non-significant trend for the AN group to have more errors than the HC group, this non-significant result may represent a problem with statistical power as a small sample was used and the effect size may be smaller than anticipated. The AN group performed significantly more slowly on the Brixton test than the HC group, suggesting the possibility of set shifting difficulties which manifest as reduced speed.

Overall, the evidence for set shifting difficulties was stronger in AN than BN. However, given that group differences in Trail B on the TMT and Brixton response times became non-significant or only marginally significant once anxiety, depression and obsessive compulsive symptomatology were factored out, the possibility that group differences were due to these factors cannot be ruled out.

Although there were no significant differences in self reported perseveration (or persistence or perfectionism) between the groups, there was a highly significant positive correlation between EDE-Q6 global score and perseveration (on the PPPQ-22). This correlation is consistent with previous research (Waller et al. 2012) and indicates that those with the greatest eating pathology reported the greatest perseveration. There was no significant correlation between the EDE-Q6 global score and persistence (on the PPPQ-22) but there was a significant positive correlation between the EDE-Q6 global score and perfectionism (on the PPPQ-22). This is consistent with the suggestion that the construct of perfectionism contains elements of persistence and perseveration and with the idea that perseveration is associated with higher levels of psychopathology (Serpell et al. 2009).

Central coherence:

Previous research has demonstrated that participants with AN (Southgate et al. 2008; Lopez et al. 2008c) and BN (Lopez et al. 2008b) have weaker central coherence than HCs. The current study found no evidence for weak central coherence in AN or BN compared to a HC group. Again, these non-significant results may represent a problem with statistical power and larger sample sizes should be used in future research.

Although there were no significant differences between groups on the GEFT, inspection of the group means indicate that the AN and BN groups had fewer correct answers than the HC group. This is the opposite trend to expected, because we would expect weak central coherence to lead to superior performance on this task. It is possible that participants performed more poorly on this task because of fatigue, given that the central coherence tasks were towards the end of the testing session. This may have affected AN and BN participants more than HC participants because questions about eating may have been particularly difficult and triggered emotional

responses for AN and BN participants, which may have led to withdrawal and greater fatigue. Fatigue may also have been greater in AN and BN participants if they were more hungry and therefore had less energy than the HC group. Future research could consider using a larger sample, randomised order of tasks and completion of tasks before questionnaires to explore these possibilities

The role of starvation:

State and trait theories have been proposed to explain the role starvation might play in neuropsychological impairments (such as set shifting and central coherence). The state theory suggests a state of starvation *causes* neuropsychological impairments whereas the trait theory suggests neuropsychological impairments are enduring traits that predispose individuals to develop eating disorders. Findings about the role of starvation in eating disorders have been mixed and this study sought to investigate whether indices of chronic and acute starvation are related to set shifting and central coherence.

Findings in this study were also mixed. There was stronger evidence for a set shifting impairment in AN (as indicated by difficulties on the TMT and Brixton tasks) than BN (where only the TMT indicated difficulties). More impaired set shifting in AN than BN may be due to a difference in starvation (as AN are generally chronically and acutely starved while BN are generally only acutely starved). Therefore this finding might suggest that set shifting impairments are a consequence of starvation (state theory).

Findings provided no evidence for an association between acute and chronic starvation, set shifting and central coherence. This is surprising given that previous research has demonstrated that even short-term fasting in HCs is associated with impaired set shifting and weak central coherence (Bolton 2010; Pender 2011). Several explanations that may account for these findings are discussed below.

Although the absence of an association between starvation and neuropsychological performance may appear to lend support to the trait theory (which would predict a weak or nonexistent correlation between starvation and neuropsychological impairments), it is important to remember that few objective impairments in set shifting and particularly central coherence were found. Perhaps if there had been larger differences in set shifting and central coherence performance between groups, there would have been a more significant association between starvation and set shifting and central coherence.

It is also surprising that no significant differences were found in calorie intake (in the last 24 hours and last week) between the groups because a core feature of AN is refusal to maintain minimally normal weight and so restricting calorie intake is common. This failure to find expected differences in calorie intake between groups suggests inadequacies in the indices of acute starvation. It was observed that participants struggled considerably to recall calorie intake and time since last consumed calorie containing food or drink. Therefore indices of acute starvation may not be particularly accurate and future research should think about ways to ensure optimal accuracy – perhaps using food diaries to record food intake. Additionally, indices of acute starvation only estimated calorie intake and did not consider how many of these calories were lost due to vomiting, and to a lesser extent due to laxative use. Research suggests that around 50% of calories consumed in a binge are lost due to vomiting (Kaye, Weltzin, Hsu & McConaha, 1993). Given that eating disordered participants are more likely to be engaging in compensatory behaviours than HCs, it is likely indices of acute starvation overestimated their calorie intake and may explain why no significant differences were detected between groups. Future research should use clearer, more detailed questions to aid participants in providing accurate estimates of calorie intake.

It is also possible that no significant associations were found between starvation and neuropsychological performance because looking at acute and

chronic starvation separately does not capture the combined effect of both which may adversely affect performance. Therefore, future research should consider how to capture the combined effect of acute and chronic starvation when investigating a relationship with set shifting and central coherence.

Finally, it is possible that using a combination of inpatients, outpatients and HCs that were not screened for eating disorder symptoms (to allow for natural variation) may have confounded the study results. Inpatients may not be in an acute state of starvation as they are often on refeeding plans and refeeding may have ameliorating effect on neuropsychological impairments and weakened any group differences in starvation. HCs may have taken part in the study because of undisclosed eating disorder symptoms and consequently may have had a more detailed focused, inflexible style as shown in Holliday et al (2005).

Limitations of the current study:

Sample limitations:

Unfortunately, it was not possible to obtain a BED sample and the majority of participants were females of white ethnicity. Consistent with the high rate of migration or 'diagnostic drift' between diagnostic groups reported by Rose, Frampton & Lask, (2012), a major limitation was the fact that several participants had previously been diagnosed with a different eating disorder and so groups were not clearly distinct. Additionally, the study only included participants aged 18 and over and so the results may not be generalisable to children and adolescents.

Limitations of the measures:

A further limitation is the fact that the neuropsychological tests used to measure set shifting and central coherence are undoubtedly influenced by other executive functions and cognitive abilities such as attention and memory. An effort was made to reduce this limitation by selecting tasks which have demonstrated impairments in similar research previously (Roberts, Tchanturia & Treasure, 2010; Pender, 2011), reducing memory demands (e.g. placing a copy of the shapes beside participants in the GEFT and using only two letters at a time in the L-G Switching Task) and by using measures that tried to control for visual and motor difficulties (e.g. TMT). However no tasks assess one aspect of executive functioning in isolation and future studies should seek to compare results on different measures.

As mentioned previously, participants struggled to accurately remember calorie intake and time since they last ate and may have been making inaccurate guesses. Although, asking participants to monitor their calorie intake prior to completing the study was initially considered clinically unhelpful (as it may encourage participants to calorie count in their natural environment), this may be one way of obtaining more accurate indices of acute starvation.

It is also possible that significant differences were not detected between the groups because participants became fatigued by the length of the testing session which was 90 minutes on average.

Limitations of statistical methods:

Although the sample size exceeded that recommended by the power analyses, it is possible that significant differences were missed due to smaller than expected effect sizes.

Additionally, multiple comparisons were conducted within this study and these increase the possibility of a Type 1 error (finding a statistically significant result by chance). Although an attempt was made to control for this in ANOVAs (by using Bonferroni corrections), the exploratory correlational analyses and non-parametric T tests did not control for the multiple comparisons and this is a limitation of those particular analyses.

The analyses on starvation were limited because correlational methods can only tell us whether there is an association between set shifting, central coherence and starvation and does not provide information about causality. While these comparisons were primarily exploratory (as studies have not investigated acute starvation before), future research investigating acute starvation should consider using a different design that can be analysed with statistical analyses other than correlation.

Clinical and theoretical implications of findings:

The current study found some evidence for reduced speed in set shifting in participants with AN and BN but did not find any evidence for reduced accuracy in set shifting performance compared to HCs. This may reflect a speed-accuracy trade off, where accuracy is prioritised over speed.

In terms of the TMT, evidence for a significantly slower response on Trail B in AN and BN groups compared to the HC group is consistent with previous studies which have shown TMT impairments in AN (Tchanturia et al. 2004b; Tenconi et al. 2010). It is possible that non-significant differences between groups in the TMT B-A difference (despite the expected trend) may represent a problem with statistical power and future studies should use larger samples to investigate this.

In terms of the Brixton test, no significant differences in errors between the groups suggest no differences between groups in accuracy. This is consistent with

previous research that found no significant differences in Brixton errors between AN and HC groups (Holliday et al. 2005). Despite no differences in accuracy, the AN group performed significantly more slowly than the HC group, indicating that the AN group have reduced speed in this set shifting task.

As group differences in Trail B on the TMT and Brixton response times became non-significant or only marginally significant once anxiety, depression and obsessive compulsive symptomatology were factored out, the possibility that group differences were due to these factors cannot be ruled out.

Overall, the evidence for set shifting difficulties was stronger in AN and this suggests that interventions designed to increase flexibility such as Cognitive Remediation Therapy (Davies & Tchanturia, 2005) may be more important for individuals with AN than those with BN.

There were no significant differences in central coherence between the groups, implying that individuals with eating disorders may not have a bias towards local or detailed processing. This suggests that caution should be employed in using interventions focusing on increasing central coherence, unless there is a particular clinical indicator that this would be helpful for an individual.

Most results indicated that starvation was not significantly associated with neuropsychological impairments in set shifting and central coherence. However some findings (such as the limited evidence that the AN group may have had more difficulties set shifting than the BN group) might be evidence that set shifting impairments are caused by starvation. Given that few neuropsychological impairments were detected and indices of starvation may have been inaccurate, we cannot conclude that starvation does not cause neuropsychological impairments.

Although there was not much evidence to suggest that starvation causes neuropsychological impairments, the starvation indices in this study were limited and therefore it is important to replicate these findings with more accurate information about acute starvation before conclusions can be drawn about whether set shifting

and central coherence impairments are a consequence of starvation or a risk factor for eating disorders.

Future research:

Future research looking at acute and chronic starvation in set shifting and central coherence should consider using a large sample because null findings could represent a problem with statistical power if the effect size is smaller than originally anticipated. This could include a BED group, more males and a more ethnically diverse sample. Research could also be extended to include children and adolescents.

Consistent and varied measures of set shifting and central coherence should be used in future research, combined with an attempt to control for other aspects of executive functioning. Further exploration of accuracy and speed in set shifting may help determine whether speed is compromised in order to ensure accuracy.

More accurate indices of acute starvation should be used, with clearer questions that consider calories expelled through compensatory behaviours. This may include completion of food diaries prior to completing the study but the ethical implications of asking participants to calorie count in their natural environment warrants further consideration. It would also be helpful to look at the combined effect of acute and chronic starvation. Future research should also consider the impact of fatigue, using a randomised order of tasks and a shorter testing session.

Prospective and longitudinal studies examining flexibility, eating patterns, the impact of starvation and neuropsychological functioning in HCs and adolescents would help resolve the debate about whether neuropsychological impairments are a predisposing trait or a consequence of starvation. It would also be helpful to examine the impact of chronic starvation on neuropsychological functioning in the

absence of eating disorders (e.g. in populations where poverty restricts calorie intake).

Future studies should consider comparing outpatients and inpatients because inpatient refeeding programmes may lead to a significant reduction in acute starvation. This may have an ameliorating effect on neuropsychological impairments and may explain why there were not many significant differences in the current study. Although this would require large samples, it may shed light on why different studies have had different results. Comparisons between the different subtypes of AN would also be useful.

Conclusion:

Although previous research has documented set shifting and central coherence impairments in AN and BN, the current study found only weak evidence of set shifting impairments in AN and BN and it was not possible to remove the confounding effects of anxiety, depression and obsessive compulsive symptoms. There was no evidence for central coherence impairments in AN or BN. The null findings may represent a problem with statistical power as the effect size may be smaller than originally anticipated.

In terms of starvation, there was stronger evidence for set shifting difficulties in the AN group than the BN group; this may be because the AN group experience greater (acute and chronic) starvation. There were no correlations between chronic or acute starvation and set shifting or central coherence (although the AN group were significantly more chronically starved than the BN and HC groups). Although most results indicated that starvation was not significantly associated with neuropsychological impairments, this may be because few neuropsychological impairments were detected and because indices of starvation may have been inaccurate. Therefore it is important to replicate these findings with more accurate

indices of starvation before conclusions can be drawn about whether set shifting and central coherence impairments are a consequence of starvation or a risk factor for eating disorders.

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Part 3: Critical Appraisal

1. Introduction:

This critical appraisal contains a description of and reflection on the various stages of the research process. It considers the decisions, difficulties and personal challenges on the journey from choosing the study to meeting with participants and considering the role of a psychologist in research. Study limitations and consistency with previous research are also explored, followed by personal reflections and conclusions about the research process.

2. Choosing the study:

Initially, I was interested in conducting research in both body dysmorphic disorder and eating disorders and I considered the research project a good opportunity to investigate one of the areas more widely than would have been possible in clinical practice. After some consideration, I decided to pursue research into executive functioning in eating disorders and specifically decided to investigate set shifting and perseveration in Anorexia Nervosa (AN), Bulimia Nervosa (BN), Binge Eating Disorder (BED) and Healthy Control's (HC). Although a considerable amount of research had investigated set shifting and perseveration in AN (Roberts, Tchanturia, Stahl, Southgate & Treasure, 2007; Tchanturia, Serpell, Troop & Treasure, 2001), no research had investigated set shifting and perseveration in BED and compared performance across the diagnostic groups.

3. Modification of study design:

Although the initial research proposal outlined an investigation of set shifting and perseveration, it became clear that previous research had operationalised set shifting and perseveration in the same way, with the same outcomes (e.g. long

reaction times and increased errors) on the same tasks (e.g. WCST) being used to indicate both set shifting difficulties and perseveration. While, I hypothesised that a set shifting impairment might relate specifically to the stuck in set type of perseveration described by Sandson and Albert (1984), I felt that the task of investigating the relationship between the two constructs was too ambitious for a D.Clin.Psy thesis. Consequently, the study design was modified to investigate set shifting and central coherence in AN, BN, BED and HC groups.

Additionally, I decided to investigate the role of starvation in set shifting and central coherence in this clinical sample to try and establish whether a state of starvation causes neuropsychological impairments (as suggested by the state argument) or whether neuropsychological impairments might be enduring traits that predispose individuals to develop eating disorders (as suggested by the trait argument).

Previous studies had used Body Mass Index (BMI) as an index of starvation and found no significant relationship between starvation and set shifting in participants with an eating disorder (Tchanturia, et al. 2011; Roberts, Tchanturia & Treasure, 2010; Holliday, Tchanturia, Landau, Collier & Treasure, 2005). However studies in healthy populations had shown that short-term fasting has a detrimental effect on set shifting and central coherence (Bolton, 2010; Pender, 2011). It seemed possible therefore that there might be an association between short-term acute starvation and set shifting and central coherence. This had not been investigated in a clinical sample before and I decided to conduct an exploratory investigation into the relationship between short-term starvation and neuropsychological functioning using four indices of acute starvation in addition to BMI (an index of chronic starvation).

4. Selection of measures:

Measures of set shifting and central coherence that had been used in previous research were chosen in order to allow comparison of results. Although, initially it was decided to use all online tasks (to make participation easier), after consultation with a member of academic staff in UCL, it was decided that a combination of computerised tasks and pen and paper tasks might be more useful as this would order to allow investigation of set shifting and central coherence in tasks that had varied characteristics.

The National Adult Reading Test (NART; Nelson & Willison, 1991) was used to investigate differences in estimated intelligence between the groups, in line with previous research (Holliday et al. 2005). This was an attempt to ensure that any significant differences in set shifting and central coherence were not due to more general intellectual differences between the groups, which would confound the results.

Measures of depression, anxiety and obsessive compulsive pathology were also used because some research had found that they affected set shifting and central coherence (Wilsdon & Wade, 2006; Darby & Walsh, 1999; Lopez et al. 2008c). The Hospital Anxiety and Depression Scale (HADS) was selected to measure anxiety and depression because unlike other anxiety and depression scales, it does not include items that may reflect physical health difficulties or eating pathology (Snaith & Zigmond, 1983).

The Eating Disorder Examination Questionnaire (EDE-Q6) was used to assess eating pathology and to ensure that participants with BN were still regularly binging and engaging in compensatory behaviours.

Although five questionnaires (in addition to the five experimental tasks) felt like quite a lot to ask participants to complete, all questionnaires were all highly relevant. I considered asking participants to complete some of the questionnaires

before the testing session but decided that this might discourage participants from taking part. I also felt this might lead to less accurate responses because participants often did not come to testing appointments and were repeatedly rebooked over several months – after which time, responses on questionnaires might no longer reflect their current state. The Lifestyle and Eating Questionnaire (LEQ) asked about time since last ate a meal and calorie containing food/drink and about calorie intake in the last 24 hours and week and therefore needed to be completed at the testing session.

5. Recruitment of participants:

Recruiting participants was probably the most difficult aspect of the research. Obtaining ethical approval for the study was a lengthy process with delays due to organisational difficulties. This meant that there was a delay in beginning recruitment and meant that there was less time available to test participants than originally expected.

Although I anticipated that it would be difficult to obtain an acceptable sample size, I did not anticipate the length of time that it would take to screen participants by telephone and email. Also participants often had mixed AN/BN symptoms or no longer met the (already limited) criteria and did not disclose this until the testing session. This meant considerable time was spent trying to establish whether individuals were suitable to take part and often meant participants were tested even though I knew it would not be possible to include them in the analysis.

There was a very high non-attendance rate for participants and this felt increasingly disheartening as the testing period progressed. It was very difficult to obtain a BN sample and was not possible to recruit even one participant with BED whose results could be used. On reflection, this may be because individuals with BED seek help from obesity services rather than eating disorder services and it may

have been helpful to recruit from an obesity service in addition to eating disorder services. Recruitment of participants with BED may also have been difficult because BEAT (a national charity created to help people with eating disorders, that I used to recruit participants) is used mainly by individuals with AN and BN. Finally, I felt that there may be a greater stigma towards BED than AN and BN, with worries about blame preventing individuals from disclosing their diagnosis. Although, I managed to test two participants with BED, one was unable to complete the testing session (because they felt frustrated with the tasks) and one no longer met the criteria for BED at testing, meaning that neither could be included.

During recruitment, a special effort was made to recruit males because of the increasing proportion and under diagnosis of eating disorders and body image conditions in males (Morgan, 2008) and because most research into set shifting and central coherence in eating disorders had included only females (Holliday et al. 2005; Lopez et al. 2008c). Overall, four males were included, three with a diagnosis of AN and one HC.

6. Working with a clinical and non-clinical population:

It was interesting working with a clinical and non-clinical population as there were different challenges with each group. Often the non-clinical sample struggled a great deal on questions about their calorie intake as they simply did not know (even approximately) how many calories they were consuming and could not remember what they had eaten. This was also the case for some of the clinical participants who restricted food intake or used compensatory behaviours instead of monitoring calories. These difficulties meant that participants often estimated their calorie intake and may have forgotten to include items (particularly drinks containing calories) and ultimately meant that indices of acute starvation were not very accurate. Moreover, all inpatients within the study had their calorie intake obtained from a meal plan

because it was felt that asking participants in such an acutely unwell state to discuss food intake would be unethical and these estimations may not have been accurate.

Initially I had considered using a food diary that would be completed prior to the testing session. However I decided against using this because I felt encouraging participants to monitor food and calorie intake in their natural environment may be clinically unhelpful and ethically questionable. I also felt that this would discourage many participants from taking part. In hindsight, I wonder whether there would have been much difference between asking participants to recall food and calorie intake in the testing session and recording it at home. Using a food diary may have led to more accurate information about acute starvation being obtained and may have led to more significant differences between the groups. Additionally, this may have allowed reporting of and consideration of whether compensatory behaviours led to a reduction in calories retained by individual participants. These are issues that should be considered carefully in future research.

With the clinical sample, weighing participants was also difficult because I did not want to cause participants distress and some participants became visibly uncomfortable at this point in the testing session. I tried to overcome this obstacle by allowing participants to use the creative solutions they employed in other situations, some participants chose not to look at the weight and one participant got on the weighing scales backwards. For the few that felt very distressed or for acutely unwell inpatients being weighed frequently, I obtained their weight from their eating disorder clinic.

7. The role of a psychologist in research:

Before undertaking this research, I was aware that clinical psychologists undertook a mixture of clinical work and research but had not given much consideration to the role of a clinical psychologist in research. During my time

meeting and testing participants, it was an issue I spent considerable time thinking about. This was because during several testing sessions clinical and non-clinical participants began to tell me about their difficulties and on occasions became upset. I found that I had to try very hard not to do all the things you are trained as a clinical psychologist to do - to find out more, to listen and to offer support and suggestions of what might be helpful. I found it particularly difficult to close down these conversations and had to keep reminding myself that I was there as a researcher and it would not be helpful for participants to begin therapeutic conversations about difficult topics that I would not be able to continue supporting them with. Although, I was able to direct participants to appropriate support services immediately after the testing session, in the future I would probably give all participants a list of support contacts as a routine part of the testing session.

8. Relation to other studies:

Overall, the study found some evidence for set shifting difficulties in AN and BN but did not find evidence for a central coherence impairment in AN or BN or for an association between starvation and neuropsychological impairments.

Although the results on set shifting are reasonably in line with previous research which has demonstrated set shifting impairments in AN and BN (Roberts et al. 2007), the results on central coherence were not consistent with previous research demonstrating a central coherence impairment in AN (Lopez et al. 2008c) and BN (Lopez, Tchanturia, Stahl & Treasure, 2008b). Given that the same or similar measures have been used previously to demonstrate central coherence impairments in participants with an eating disorder (Lopez et al. 2008c) and fasting HCs (Pender, 2011), it is unlikely that the failure to find any significant difference is due to the measures used.

Rosenthal (1979) suggested that a publication bias may result in studies with significant results being published more easily and frequently than studies with non-significant results. He referred to this as the 'file drawer problem' because of the possibility that the majority of studies on a topic showing non-significant findings were left hidden in researchers file drawers, while the minority of significant results were published and utilised by clinicians and researchers. It is possible that a publication bias may exist in this area and studies that published on central coherence may overestimate significant differences between participants with eating disorders and HCs. This would help explain why results of the current study are not consistent with existing published literature. Alternatively, it may be that non-significant results represent a problem with statistical power due to smaller than expected effect sizes.

In terms of starvation, there were no significant correlations between indices of acute or chronic starvation and set shifting or central coherence. This is consistent with previous research reporting no significant association between chronic starvation (measured by BMI) and set shifting (Tchanturia, et al. 2011; Roberts et al. 2010; Holliday et al. 2005). As this was an exploratory investigation into acute starvation (which had not been previously investigated) and neuropsychological impairments, it was not possible to compare results to other research and it is hoped that future research will continue investigating this issue.

9. Limitations of the study:

When trying to interpret results of the study (particularly many non-significant findings), it became apparent that there were considerable limitations in the research. One of the major limitations was potentially inaccurate indices of acute starvation that were based on participant's retrospective recollections of food and calorie intake and did not consider calories lost due to vomiting and other

compensatory behaviours. Although inadequacies in the indices of acute starvation were disappointing, the comparisons were still useful as a first step in exploring acute starvation.

Another limitation was the fact that the neuropsychological tests used to measure set shifting and central coherence do not assess these abilities in isolation and are affected by other factors such as attention and memory. Although no tasks assess one ability in isolation, the use of multiple tests with adjustments to remove additional demands (e.g. on working memory) and repeated replication would help negate this limitation.

It is hoped that future research will overcome these limitations and replicate this study to see whether findings are consistent with this research.

10. Personal reflections and conclusions:

The process of designing, conducting and interpreting this research has been a challenging but immensely rewarding experience. I feel that not only have I learnt a great deal about research in general but I have also had the opportunity to meet participants with firsthand experience of what it is like to have an eating disorder and this has been an invaluable experience.

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Appendix 1:

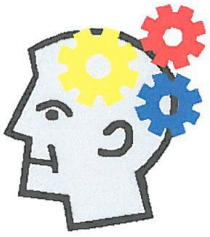
Poster used for recruiting participants

South West London and St.George's NHS
Mental Health NHS Trust

North East London NHS
NHS Foundation Trust

UCL

VOLUNTEERS NEEDED



We are researching thinking styles & eating disorders.

You will be eligible to win **£100 VOUCHER** from a store of your choice

We are recruiting:

- People with a diagnosis of Anorexia, Bulimia or Binge Eating Disorder
- People who have no personal history of eating disorders

To participate, you must:

- Fit into one of the above categories, speak English fluently, be between 18 and 60 years old

You must *not* have:

- Had a head injury, neurological disease or brain surgery.
- Been diagnosed with a learning disability or autistic spectrum condition
- Had a psychotic episode.

If you are not sure if you meet the criteria, we are happy to discuss this further.

Please contact: Denise McConnellogue
By email: denisemccon@yahoo.co.uk OR phone/text: **0754-077-9274**

This study has been funded by the Research Department of Clinical, Educational & Health Psychology at UCL and has been approved by a Research Ethics Committee.

Thinking & eating study
denisemccon@yahoo.co.uk
0754-077-9274

Appendix 2:

Information sheet for participants with an eating disorder

South West London and St.George's NHS
Mental Health NHS Trust

North East London NHS
NHS Foundation Trust

UCL

Participant Information Sheet

Study title: Thinking styles and eating disorders

Investigators:
Denise McConnellogue (Trainee Clinical Psychologist)
Dr Lucy Serpell (Clinical Psychologist)
Dr Bryony Bamford (Clinical Psychologist)
C/o Research Department of Clinical, Educational & Health Psychology, UCL, Gower Street, London. WC1E 6BT

We would like you to take part in our research study. Before you decide we would like you to understand why the research is being done and what it could involve for you. One of our team will go through the information sheet with you and answer any questions you have. We suggest that this will take about 10 minutes.

Talk to others about the study if you wish.

Part 1 tells you the purpose of the study and what will happen if you take part
Part 2 gives you more detailed information about the conduct of the study

Please ask us if anything is not clear.

PART 1

What is the purpose of the study?
This study explores the relationship between thinking styles and eating disorders. The first aim of the study is to understand whether people with anorexia, bulimia or binge eating disorder share similar thinking styles that are different to those used by people who have never had an eating disorder. The second aim of the study is to understand whether specific thinking styles are related to long term and short term food restriction.

This may help eating disorder researchers discover whether certain thinking styles might put people at risk for developing eating disorders or whether thinking styles change following food restriction and may be important to think about in therapy.

Why have I been invited?
This study is inviting people who have a current eating disorder diagnosis to take part. It is also inviting people with no personal history of eating disorders to take

part as a comparison group. You have been invited to take part in this study because you have been in contact with one of our recruitment sites.

Who can take part?
We are recruiting:

- People who have a current diagnosis of anorexia, bulimia or binge eating disorder
- People with no personal history of eating disorders and have a Body Mass Index of 19-26

To be eligible to participate all participants must meet the following requirements:

- Fit into one of the above categories
- Be between 18 and 60 years old
- Speak English fluently
- Never had a head injury, neurological disease or brain surgery
- Not been diagnosed with a learning disability or autistic spectrum disorder
- Never had a psychotic episode

If you are not sure whether you meet these requirements, we are happy to discuss them further with you.

Do I have to take part?
It is up to you to decide to join the study. We will describe the study and go through this information sheet. If you agree to take part, we will then ask you to sign a consent form. If you decide to take part you are still free to withdraw from the study at any time without giving a reason. This will not affect the standard of care you receive.

What happens if I agree to take part?
If you agree to take part in the study, we will ask you to complete a consent form. Following this, we will arrange to meet you at an NHS or university site on one occasion or send you details about how to complete the study online. We will ask you to complete some questionnaires, computer tasks and pen and paper tasks. This will take 60-90 minutes in total.

Prize draw:
If you participate in the study, you will be entered into a prize draw to win a £100 voucher (the winner can chose which store this is for). Additionally, if you are a first year undergraduate psychology student you can get two course credits for your participation in this study. We will give you the course credits and voucher at the end of the testing session.

What are the possible disadvantages and risks of taking part?
It is unlikely that you will experience any distress by taking part in this study, although you may wish to consider the potential effects on you before agreeing to participate.

What are the possible benefits of taking part?
As this study is investigating thinking styles and is not a therapeutic trial, it is unlikely that you will experience any direct benefits from taking part. However, the information that we get from this study may help improve the treatment of people with eating disorders.

What if there is a problem?
Any complaint about the way you have been dealt with during the study or any possible harm you might suffer will be addressed. The detailed information on this is given in Part 2 of this information sheet.

Will my taking part in the study be kept confidential?
Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in part 2 of this information sheet.

This completes part 1.

If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decisions.

PART 2

What will happen if I don't want to carry on with the study?
You can withdraw from the study at any time without giving a reason. However, as participation is anonymous it will not be possible for us to withdraw your data once you have completed the study.

What if there is a problem?
Every care will be taken in the course of this study. However in the unlikely event that you are injured by taking part, compensation may be available.

If you suspect that the injury is the result of the Sponsor's (University College London) or the hospital's negligence then you may be able to claim compensation. After discussing with your research doctor, please make the claim in writing to Dr Lucy Serpell who is the Chief Investigator for the research and based at the Research Department of Clinical, Educational & Health Psychology, UCL, Gower Street, London, WC1E 6BT. The Chief Investigator will then pass the claim to the Sponsor's Insurers, via the Sponsor's office. You may have to bear the costs of the legal action initially, and you should consult a lawyer about this.

Regardless of this, if you wish to complain, or have any concerns about any aspect of the way you have been approached or treated by members of staff or about any side effects (adverse effects) you may have experienced due to your participation in the research, the normal National Health Service complaints mechanisms are available to you. Please ask your research doctor if you would like more information on this. Details can also be obtained from the Department of Health website: http://www.dh.gov.uk

Will my taking part in this study be kept confidential?
Yes. All responses are treated as confidential. Once your testing session is complete, you will be given a unique participant number and will only be identifiable by this. If you have provided us with your contact details, this information will be kept separate from your data. All data will be collected and stored in accordance with the Data Protection Act 1998. Only researchers involved in the study will have access to the data and it will be stored securely at all times.

If you disclose any information that suggests serious risk to self or others, the researcher is obliged to contact your GP or other health professional and inform them. Where possible, this will always be discussed with you beforehand.

What will happen to the results of the research study?
It is intended that the broad results of the study will be written up as a research paper and published by a journal. Individual participants will not be identified in any written report or publication without their consent.

If you would like a summary of the results of this study, please ask the researcher to include you on the email correspondence list.

Who is funding the study?
The Research Department of Clinical, Educational and Health Psychology at University College London (UCL) have provided £250 towards the finding of this study.

Who has reviewed this study?
All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by a Research Ethics Committee.

Further Information and Contact Details:
If you would like advice about whether to participate in this study, you may want to speak to one of your health care professionals.

If you would like further information about this study or would like to participate please contact Denise McConnellogue, by emailing denisemccon@yahoo.co.uk or phoning 0754-077-9274.

Thank you for taking the time to read this.

Appendix 3:

Information sheet for participants without an eating disorder

South West London and St.George's NHS
Mental Health NHS Trust

North East London NHS
NHS Foundation Trust

UCL

Participant Information Sheet

Study title: Thinking styles and eating disorders

Investigators:

Denise McConnellogue (Trainee Clinical Psychologist)
Dr Lucy Serpell (Clinical Psychologist)
Dr Bryony Banford (Clinical Psychologist)
C/o Research Department of Clinical, Educational & Health Psychology, UCL, Gower Street, London. WC1E 6BT

We would like you to take part in our research study. Before you decide we would like you to understand why the research is being done and what it could involve for you. One of our team will go through the information sheet with you and answer any questions you have. We suggest that this will take about 10 minutes.

Talk to others about the study if you wish.

Part 1 tells you the purpose of the study and what will happen if you take part
Part 2 gives you more detailed information about the conduct of the study

Please ask us if anything is not clear.

PART 1

What is the purpose of the study?

This study explores the relationship between thinking styles and eating disorders. The first aim of the study is to understand whether people with anorexia, bulimia or binge eating disorder share similar thinking styles that are different to those used by people who have never had an eating disorder. The second aim of the study is to understand whether specific thinking styles are related to long term and short term food restriction.

This may help eating disorder researchers discover whether certain thinking styles might put people at risk for developing eating disorders or whether thinking styles change following food restriction and may be important to think about in therapy.

Why have I been invited?

This study is inviting people who have a current eating disorder diagnosis to take part. It is also inviting people with no personal history of eating disorders to take

part as a comparison group. You have been invited to take part in this study because you have been in contact with one of our recruitment sites.

Who can take part?
We are recruiting:

- People who have a current diagnosis of anorexia, bulimia or binge eating disorder
- People with no personal history of eating disorders and have a Body Mass Index of 19-26

To be eligible to participate all participants must meet the following requirements:

- Fit into one of the above categories
- Be between 18 and 60 years old
- Speak English fluently
- Never had a head injury, neurological disease or brain surgery
- Not been diagnosed with a learning disability or autistic spectrum disorder
- Never had a psychotic episode

If you are not sure whether you meet these requirements, we are happy to discuss them further with you.

Do I have to take part?
It is up to you to decide to join the study. We will describe the study and go through this information sheet. If you agree to take part, we will then ask you to sign a consent form. If you decide to take part you are still free to withdraw from the study at any time without giving a reason.

What happens if I agree to take part?
If you agree to take part in the study, we will ask you to complete a consent form. Following this, we will arrange to meet you at an NHS or university site on one occasion or send you details about how to complete the study online. We will ask you to complete some questionnaires, computer tasks and pen and paper tasks. This will take 60-90 minutes in total.

Prize draw:
If you participate in the study, you will be entered into a prize draw to win a £100 voucher (the winner can chose which store this is for). Additionally, if you are a first year undergraduate psychology student you can get two course credits for your participation in this study. We will give you the course credits and voucher at the end of the testing session.

What are the possible disadvantages and risks of taking part?
It is unlikely that you will experience any distress by taking part in this study, although you may wish to consider the potential effects on you before agreeing to participate.

What are the possible benefits of taking part?
As this study is investigating thinking styles and is not a therapeutic trial, it is unlikely that you will experience any direct benefits from taking part. However, the information that we get from this study may help improve the treatment of people with eating disorders.

What if there is a problem?
Any complaint about the way you have been dealt with during the study or any possible harm you might suffer will be addressed. The detailed information on this is given in Part 2 of this information sheet.

Will my taking part in the study be kept confidential?
Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in part 2 of this information sheet.

This completes part 1.

If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decisions.

PART 2

What will happen if I don't want to carry on with the study?
You can withdraw from the study at any time without giving a reason. However, as participation is anonymous it will not be possible for us to withdraw your data once you have completed the study.

What if there is a problem?
Every care will be taken in the course of this study. However in the unlikely event that you are injured by taking part, compensation may be available.

If you suspect that the injury is the result of the Sponsor's (University College London) or the hospital's negligence then you may be able to claim compensation. After discussing with your research doctor, please make the claim in writing to Dr Lucy Serpell who is the Chief Investigator for the research and based at the Research Department of Clinical, Educational & Health Psychology, UCL, Gower Street, London, WC1E 6BT. The Chief Investigator will then pass the claim to the Sponsor's Insurers, via the Sponsor's office. You may have to bear the costs of the legal action initially, and you should consult a lawyer about this.

Regardless of this, if you wish to complain, or have any concerns about any aspect of the way you have been approached or treated by members of staff or about any side effects (adverse effects) you may have experienced due to your participation in the research, the normal National Health Service complaints mechanisms are available to you. Please ask your research doctor if you would like more information on this. Details can also be obtained from the Department of Health website: http://www.dh.gov.uk

Will my taking part in this study be kept confidential?
Yes. All responses are treated as confidential. Once your testing session is complete, you will be given a unique participant number and will only be identifiable by this. If you have provided us with your contact details, this information will be kept separate from your data. All data will be collected and stored in accordance with the Data Protection Act 1998. Only researchers involved in the study will have access to the data and it will be stored securely at all times.

If you disclose any information that suggests serious risk to self or others, the researcher is obliged to contact your GP or other health professional and inform them. Where possible, this will always be discussed with you beforehand.

What will happen to the results of the research study?
It is intended that the broad results of the study will be written up as a research paper and published by a journal. Individual participants will not be identified in any written report or publication without their consent.

If you would like a summary of the results of this study, please ask the researcher to include you on the email correspondence list.

Who is funding the study?
The Research Department of Clinical, Educational and Health Psychology at University College London (UCL) have provided £250 towards the finding of this study.

Who has reviewed this study?
All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by a Research Ethics Committee.

Further Information and Contact Details:
If you would like advice about whether to participate in this study, you may want to speak to one of your health care professionals.

If you would like further information about this study or would like to participate please contact Denise McConnellogue, by emailing denisemccon@yahoo.co.uk or phoning 0754-077-9274.

Thank you for taking the time to read this.

Appendix 4:

Consent form

South West London and St.George's NHS
Mental Health NHS Trust

North East London NHS
NHS Foundation Trust

UCL

Patient Identification Number:

Consent Form

Study Title: Thinking styles and eating disorders

Investigators: Denise McConnellogue (Trainee Clinical Psychologist)
Dr Lucy Serpell (Clinical Psychologist)
Dr Bryony Bamford (Clinical Psychologist)

Please initial box

1. I confirm that I have read and understood the information sheet dated 19/07/2011 (Version 1.1) for 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, without my medical care or legal rights being affected. ☐
3. I agree to take part in the above study ☐

Name of Participant	Date	Signature
Name of person taking consent	Date	Signature

Appendix 5:

Letter of ethical approval

NHS
National Research Ethics Service
NRES Committee London - Central
Level 7N019, Maternity Block
Northwick Park Hospital
Watford Road
Harrow
Middx
HA1 3UJ

Telephone: 020 8869 3775
Facsimile: 020 8869 5222

06 September 2011

Dr Lucy Serpell
Clinical Psychologist & Lecturer
University College London
Department of Clinical, Educational
and Health Psychology, UCL
Gower Street, London
WC1E 6BT

Dear Dr Serpell

Study title:	**Set Shifting and Central Coherence in Eating Disorders**
REC reference:	**11/LO/1299**
Protocol number:	**1**

The Research Ethics Committee reviewed the above application at the meeting held on 31 August 2011. Thank you for attending to discuss the study.

Ethical opinion

Some discussion on whether or not there should be a separate patient information sheet for healthy controls and those with an eating disorder.

The members of the Committee present gave a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

Ethical review of research sites

- The committee felt that there ought to be two separate patient information sheets one for healthy controls and one for those with an eating disorder.
- Members found some of the language used in the patient information sheet difficult to comprehend.
- Members will ask the researcher to explain in more detail her recruitment methods.

The Chair invited Dr Serpell and Denise McConnellogue to join the meeting and thanked them for attending. A summary of the items discussed and the researcher's response to the issues are given below.

a. The committee asked for an explanation to the researchers' recruitment methods. Miss McConnellogue said that there were various different NHS sites where Miss McConnellogue will meet participants at explain the study, in addition to the sites they will use particular student sites on the internet and put up the study advertisement at UCL.
b. The committee asked if approaching people in clinic appeared forceful. You assured the committee that after a discussion with participants and they show a definite interest only then will you recruit.
c. The committee asked you to consider using two separate patient information sheets one for those with an eating disorder and one for the healthy group.

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.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study 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 a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

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

It is 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 documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Evidence of insurance or indemnity		06 September 2010
Investigator CV		01 July 2011
Letter from Sponsor		20 June 2011
Other: CV for Academic Supervisor		05 July 2011
Other: CV for Student		27 July 2011
Other: Letter from Funder		09 March 2011
Other: Study Invitation	1.0	18 July 2011
Other: Study Invitation 2	1.0	18 July 2011
Participant Consent Form	1.1	19 July 2011
Participant Information Sheet: Information sheet for patients (Information Sheet 1)	1.1	19 July 2011
Participant Information Sheet: Information sheet for healthy controls (Information Sheet 2)	1.1	19 July 2011
Protocol	1.1	19 July 2011
Questionnaire: Obsessive Compulsive Inventory		
Questionnaire: Persistence, Perseveration & Perfectionism Questionnaire		
Questionnaire: Eating Disorder Examination Questionnaire EDE-Q6.0 (Eating Questionnaire)		
Questionnaire: Lifestyle & Eating Questionnaire	1.0	18 July 2011
REC application		24 July 2011
Referees or other scientific critique report		21 October 2010
Referees or other scientific critique report		02 June 2011
Summary/Synopsis		18 July 2011

NRES Committee London - Central

Attendance at Committee meeting on 31 August 2011

Committee Members:

Name	*Profession*	*Present*	*Notes*
Sir Adrian Baillie	Financial Investment Advisor	Yes	
Dr Sue Birtwistle	General Practitioner	No	
Dr Daniel Bradford	Pharmacologist	Yes	
Dr Peter Brodrick	Consultant Anaesthetist	Yes	
Mr Clive Carsley	Retired Lawyer	Yes	
Mrs Emma Crawford-Collins	Communications Director	No	
Dr Parastou Donyai	Senior Lecturer in Pharmacy Practice	No	
Dr Olivia Festy	Clinical Trials Administrator	No	
Mrs Sophie Forsyth	Lawyer	Yes	
Mrs Rosie Glazebrook	Consumer Marketing	Yes	
Dr Frances Goodhart	Consultant Clinical Psychologist	No	
Dr Leslie Huson	Consultant Medical Statistician	No	
Dr John Keen	General Practitioner	Yes	
Dr Amin Rahemtulla	Consultant Haematologist	Yes	
Ms Dani Singer	Psychotherapist	Yes	
Professor Lewis Spitz	Emeritus Nuffield Professor of Paediatric Surgery	Yes	
Dr Gareth Tudor-Williams	Consultant in Paediatric Infectious Diseases	Yes	

Also in attendance:

Name	*Position (or reason for attending)*
Ms Julie Kidd	Coordinator

Written comments received from:

Name	*Position*
Dr Parastou Donyai	Senior Lecturer in Pharmacy Practice
Dr Leslie Huson	Consultant Medical Statistician

Appendix 6:

Lifestyle and Eating Questionnaire (LEQ)

South West London and St.George's NHS
Mental Health NHS Trust

North East London NHS
NHS Foundation Trust

UCL

Participant code: _____

Lifestyle & Eating Questionnaire

Section 1: General Health:

Please answer the following questions. All responses will be kept anonymous.

1) How old are you at present? _____ years old

2) Are you male or female? Please tick the relevant box. **Female ☐ Male ☐**

3) What is the highest educational qualification level that you have achieved? (e.g. GCSE, OLEVEL, DEGREE)?

_____

4) How would you describe your ethnicity? Please tick the box that describes you best.

Asian or Asian British	**Black or Black British**	**White**	**Mixed**	**Other Ethnic Group**	
☐ Bangladeshi ☐ Indian ☐ Pakistani ☐ Any other Asian background	☐ African ☐ Caribbean ☐ Any other Black background	☐ British ☐ Irish ☐ Any other White background	☐ White & Asian ☐ White & Black African ☐ White & Black Caribbean ☐ Any other mixed background	☐ Chinese ☐ Any other ethnic group	☐ I do not wish to disclose this

5) Have you ever been diagnosed with any physical health conditions? **Yes ☐ No ☐.** If yes, please give details below.

Diagnosis:	**Date:**	**Please tick the conditions that you <u>still</u> suffer with**

6) Do you have any visual/hearing or motor impairments? **Yes ☐ No ☐**. If yes, please give details below.

Difficulty:	**Date diagnosed:**	**Please list any aids you use to reduce these (e.g. glasses, hearing aid)**

7) Have you ever been diagnosed with any mental health conditions (e.g. anxiety, depression)? **Yes ☐ No ☐.** If yes, please give details below.

Diagnosis:	**Date:**	**Please tick the conditions that you <u>still</u> suffer with**

8) Are you currently taking any medication? **Yes ☐ No ☐**. If yes, please give details below.

Medication name:	**Dose (please state whether per day or week):**	**Taken for which condition?**

9) Is there any history of mental health conditions in your family? **Yes ☐ No ☐**. If yes, please give details below.

Relative:	**Which mental health condition? (e.g. anxiety, depression, OCD, psychosis)**

10) Have you ever been involved in any health research before? **Yes ☐ No ☐**. If yes, please give details below.

Research I was involved in **(please provide a brief description of the research)**	**Approximate date**

Section 2: Eating

11) Have you ever been diagnosed with an eating disorder? **Yes ☐ No ☐.**
If yes, please list all eating disorder diagnoses you have been given with dates below.

Diagnosis:	**Date of diagnosis:**

12) Has anyone else in your family ever had an eating disorder? If yes, please give details below.

Relative:	**Which eating disorder?**

13) How long ago did the first symptoms of an eating disorder emerge?

_____

14) How long has it been since you last ate any calorie containing food/drink? Please do not include water, diet carbonated drinks or black tea/coffee.

_____hours

What did you eat/drink?

_____

15) How long has it been since you last ate a meal? _____hours

What did you eat? _____

16) How many calories did you consume in the following time periods.

Time period:	Average Calorie intake:
Last 24 hours	
Last 7 day week	