The World Journal of Biological Psychiatry, 2014; Early Online: 1–13

REVIEW ARTICLE

Central coherence in eating disorders: An updated systematic review and meta-analysis

KATIE LANG[1]*, CAROLINA LOPEZ[2]*, DANIEL STAHL[3], KATE TCHANTURIA[1] & JANET TREASURE[1]

[1]*King's College London (KCL), Psychological Medicine, Section of Eating Disorders Institute of Psychiatry, UK,* [2]*University of Chile, Faculty of Medicine, Chile, and* [3]*King's College London (KCL), Department of Biostatistics, Institute of Psychiatry, UK*

Abstract

Objectives. A bias towards local information over the global "gist" (weak central coherence, WCC), has been identified as a possible contributing and maintaining factor in eating disorders (ED). The present study aimed to provide an updated review of the WCC literature and examine the hypothesis that individuals with ED have WCC. *Methods.* The new search found 12 eligible studies. Meta-analyses were performed on nine of these 12 studies, the remaining three were commented on individually. Data were combined with data from the previous 2008 review, and meta-analyses were performed on 16 studies (nine studies from the new search and seven studies from 2008 review). *Results.* Meta-analysis of the Group Embedded Figures Task provided evidence of superior local processing across all ED subtypes (pooled effect size of $d = -0.62$ (95% CI $= -0.94$, -0.31), $P < 0.001$). Evidence of poorer global processing in ED groups was found from meta-analyses of the Rey-Osterrieth Complex Figures task ($d = -0.63$ (95% CI $= -0.77$, -0.49, $P < 0.001$), and the Object Assembly Task ($d = -0.65$ (95% CI $= -0.94$, -0.37), $P < 0.0001$). *Conclusions.* As well as supporting the results of previous studies by providing evidence of inefficient global processing, this review has provided evidence of superior local processing, which supports the WCC hypothesis in ED.

Key words: *eating disorders, anorexia nervosa, bulimia nervosa, central coherence, global processing*

Introduction

Anorexia nervosa (AN) is characterised by problems with eating, weight and shape that often develop in the context of obsessive compulsive and perfectionistic personality traits (Wade and Tiggeman 2013). These personality traits are associated with a poorer prognosis (Crane et al. 2007; Sauro et al. 2013) and can moderate the effect of treatment (Le Grange et al. 2012). The traits are an important component of a cognitive interpersonal model, which has been developed to explain the onset and maintenance of AN (Treasure and Schmidt, 2013). In this model cognitive features (obsessive compulsive and perfectionistic traits) are considered to increase the vulnerability to develop AN, and also contribute to the maintenance of the disorder through fostering pro anorexia nervosa beliefs and behaviours. One of the predictions from this model is that obsessive compulsive and perfectionistic traits are intermediate phenotypes, which arise from cognitive processing styles such as inflexibility and weak central coherence (WCC).

WCC refers to a cognitive style whereby there is a processing bias towards detail or local information at the expense of global integration or "gist" (both superior detail processing and poor holistic processing, Happé and Booth, 2008). A systematic review of the literature (Lopez et al. 2008) found consistent evidence of difficulties with global integration, however a bias towards superior local processing was not evident and therefore WCC in ED could not be confirmed. Since the previous review there have been

*Joint first authorship.
Correspondence: Katie Lang, PO59, King's College London, Psychological Medicine, London SE5 8AF, UK. E-mail: Katie.lang@kcl.ac.uk

(Received 12 December 2013; accepted 19 March 2014)
ISSN 1562-2975 print/ISSN 1814-1412 online
DOI: 10.3109/15622975.2014.909606

further attempts to test the hypothesis of WCC in individuals with eating disorders. Several studies have shown a moderate to large superiority in detail processing tasks in the state of illness (Lopez et al. 2008; Tenconi et al. 2010) and after recovery (Lopez et al. 2009; Tenconi et al. 2010; Harrison et al. 2011; Roberts et al. 2012). Superior detail processing is also found in first-degree unaffected relatives (sisters) (Tenconi et al. 2010; Roberts et al. 2012; Kanakam et al. 2013). This suggests that a processing bias towards detail might be an inherited vulnerability of AN. Global integration is poor in acute AN, and it may be a consequence of low weight (Harrison et al. 2011).

The present study aims to provide an updated review and meta-analysis where possible of the current literature in order to test the hypothesis that individuals with ED display WCC. We hypothesise that those with AN will show strengths in detail/local processing and weaknesses in global integration.

Methods

The systematic review and meta-analysis was conducted according to the "PRISMA" statement (preferred reporting items for systematic review and meta-analysis, Moher 2009).

Eligibility criteria

Three authors conducted the search (KL, CL and KT) and studies were selected based on the following criteria:

1. Studies were published in English in peer-reviewed journals.
2. Studies employed the use of a neuropsychological measure of central coherence.
3. Studies contained participants with an ED and a healthy control (HC) comparison group.
4. Means, standard deviations and effect sizes were reported.
5. Minimum of 10 participants per group.

Information sources and search

Electronic databases were used to identify relevant articles. The databases used were Medline, Embase, PsychINFO, ISI Web of Science and Scopus. Searches were conducted between September 2008 and January 2014.

The same search strategy that was used by earlier systematic review by Lopez et al. (2008). The terms included in the first search were central coherence, cognition, information processing, neuropsychology, cognitive function, cognitive styles, local/global processing, field dependency/independence, holistic/analytic style, and abstract thinking. Following this the search was then narrowed down by searching for articles including ED populations (using the search terms anorexia nervosa, bulimia nervosa, eating disorders, binge eating disorder or bulimic disorder), in addition a search for tests and tasks used to measure central coherence (Rey-Osterrieth Figure Test, Group Embedded Figures Test, Object Assembly, the Fragmented Pictures Task, Matching Familiar Figures, overlapping figures test, Sentence Completion Task, Homographic Reading Test, Block Design) was also made. Reference lists of retrieved manuscripts were also manually searched for relevant studies.

Selection

Articles sourced from the initial search were then screened by the content of their abstracts, and then relevant manuscripts were retrieved. Full text articles were then assessed further for suitability (see Figure 1 for consort diagram of study selection).

Summary of measures

Five neuropsychological measures were used in studies that met the criteria for inclusion since September 2008. The tasks are listed in order of their popularity for studying central coherence in ED and their impact in the field.

Group/Embedded Figures Test (EFT/GEFT; Witkin et al. 1971/2002)

Participants are required to locate a simple shape within a much more detailed and complex shape. The time taken to find the embedded shape is recorded. Shorter times are indicative of detail-focused processing. As highlighted by Lopez et al. (2008) there are differences in the mode of administration of this task between studies, which contributed to a large variation in outcomes. When Happé et al. (2001) originally used this task to test the WCC hypothesis – both the object and the figure were presented simultaneously which minimized the working memory requirements. In the present study only studies using the non-memory version of the task (G/EFT) were included.

Rey-Osterrieth Complex Figure Test (ROFT; Osterrieth 1944)

A pen and paper task, in which participants copy a complex figure as accurately as they can. The

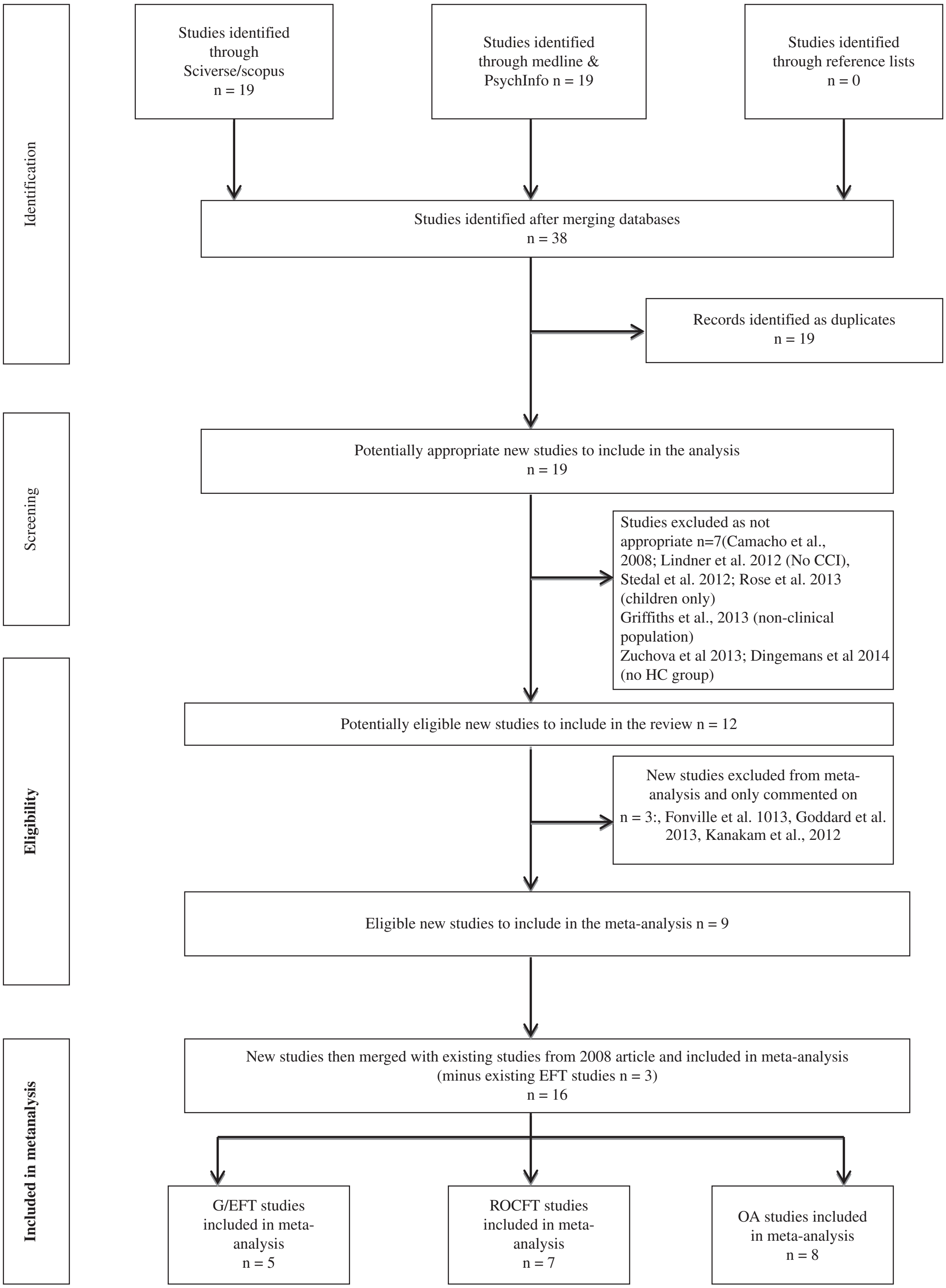

Figure 1. Flow diagram of study according to “PRISMA”.

drawing style adopted by the individual is used to measure central coherence abilities. The central coherence index (CCI) is obtained from calculating the style index and the order index as defined by Happé's group (see Booth 2006 and Lopez et al. 2008b for references). A higher CCI score indicates a more global processing strategy. Only studies reporting the CCI as an outcome measure were included in the meta-analysis.

Object Assembly (OA, Wechsler 1974, 1981)

Participants are required to complete five jigsaw puzzles depicting familiar objects. The main outcome measure is the time taken to complete each puzzle. Time is scaled whereby higher scores (shorter times) indicate better global integration.

Overlapping Figures Test (OFT, Della Salla et al. 1995)

Participants are presented with a line drawing of a number of entangled objects. They must discriminate as many objects as they can in 4 min. Detecting a smaller number of objects indicates that the participant is more susceptible to distraction by the background details, and therefore is a marker of excessive local processing or weak global processing. Therefore performance on this task is benefited by global processing whereby better global integration will result in a higher score being obtained.

The Fragmented Pictures Task (FPT; Snodgrass and Vanderwart, 1980)

Participants are presented with a picture that forms slowly frame-by-frame over eight frames on a computer screen. Participants are instructed to respond verbally with what they think the picture is as soon as they know. If they guess incorrectly they may have another go. The outcome measure is the mean frame number. Slower responses (higher mean frame) are indicative of difficulties in global processing.

Synthesis of data

Means and standard deviations for ED participants and HC comparison groups were collated.

The mean difference in outcome measures between the AN and HC groups was standardised by calculating Cohen's *d*, the difference between the two raw means divided by the pooled standard deviation (Everitt 2003). A positive effect size means that the HC group performed better than the AN group. The standard error of each study's standardised effect size was calculated from the estimated effect and the group sizes of the two groups (Cooper and Hedges, 2009).

It was possible to conduct a meta-analysis for three tasks (GEFT, ROCFT and OA) by pooling the standardised effect sizes using a random-effects model. This model assumes that as well as within-group variability of scores (due to sampling error), variability of mean effect sizes is also caused by differences of the effect between studies (between-study heterogeneity). Random-effects models incorporate the between group heterogeneity. They result in estimates with wider confidence intervals than fixed-effects models, but are thought to be more realistic in psychiatric studies due to the variety of case mix and settings between studies (Everitt 2003).

Some studies reported several experimental groups (for example an anorexia nervosa group and a bulimia nervosa group) and compared them to only one control group. To avoid counting the control patients twice we followed the recommendation of the Cochrane Collaboration and divided the control group equally into two (or more groups) with smaller sample sizes, so that the total numbers of participants add up to the original size of the group.

Homogeneity between the studies was assessed using Cochran's Q-test and by calculating the measure of heterogeneity or inconsistency I^2 (Higgins et al. 2003). I^2 describes the percentage of total variation across studies that is due to heterogeneity rather than sampling error and ranges between 0% (no inconsistency) and 100% (high heterogeneity) with values of 25, 50 and 75% suggested as low, moderate, and high heterogeneity (Higgins et al. 2003).

Analyses were carried out in STATA 11 (StataCorp, College Station, TX, USA) using the user-contributed *metan* command for meta-analyses (Bradburn et al. 1998) and *metabias* (Steichen et al. 1998). Forest plots are used to graphically show the meta-analysis results.

Publication bias

Statistically significant results are more likely to be published than studies with non-significant results. The presence of publication bias on the results was assessed informally by visual inspections of funnel plots [a plot of a study's standard error or precision (1/standard error) against effect size]) using the user-written function metafunnel (Sterne 2003). If no publication bias is present the effect sizes should scatter randomly above and below true population effect size and the scatter gets wider as the standard error (and sample size) decreases. Most studies should lie within the pseudo 95% confidence limits.

We also used Duval and Tweedie's (2000) non-parametric "trim and fill" method of accounting for publication bias in meta-analysis as implemented in STATA's user-written command *metatrim* (Thomas and Steichen, 2001). The trim and fill method imputes values estimated to be missing from the analysis due to for example publication bias, and re-estimates the effect size. If the conclusion of the meta-analysis remains unchanged following adjustment for the publication bias using the trim and fill method, the results can be considered as robust, excluding publication bias. Publication bias was only assessed if at least six studies were available. However, because the number of studies was small, any assessment of publication bias needs to be treated with caution.

Results

Study selection

A total of 12 new studies were identified from the search terms that were appropriate for inclusion in the review. It was possible to conduct meta-analyses on nine of the 12 studies, the remaining four studies were commented on individually. The meta-analysis also combined data from Lopez et al.'s (2008) review on studies utilizing OA, REY, and G/EFT (a total of seven studies). Therefore meta-analyses were performed on 16 studies in total.

One new study employed Block Design (BD; Van Autreve et al. 2013), however, the decision was taken to exclude BD from the present review due to concerns about the validity of this test as a measure of central coherence raised in the previous review (see Lopez et al. 2008).

A number of other neuropsychological tasks were also used since 2007 (The Overlapping Figures Test, OLFT; Fragmented Pictures Task, FPT); however, there were not enough studies to perform meta-analysis (OLFT $N = 1$, FPT $N = 1$), so these are commented on individually.

Study characteristics

A summary of all study characteristics can be found in Table I.

Fifteen studies included an anorexia nervosa group and a healthy control group. Five studies also included a bulimia nervosa group, six included a recovered ED or anorexia group, one included a mixed ED group and one mixed ED males.

Synthesis of results

The updated review includes data from G/EFT, FPT, OFT, OA, ROCFT. Meta-analysis are summarized below for those tests that were utilized in five or more studies (e.g., G/EFT, OA and ROCFT).

There were no new studies utilizing the Matching Familiar Figures Task, Sentence Completion Task and Homographic Reading Task since the 2008 review.

The results are presented in order of the tasks popularity for studying central coherence in ED and the impact they are currently having in the ED field.

Group/Embedded Figures Task (G/EFT)

The G/EFT was used in four new studies since 2008. However, three studies were excluded from the meta-analysis (Fonville et al. 2013; Goddard et al. 2013; Kanakam et al., 2013). Fonville et al. (2013) was excluded from the analysis as they used a modified version of the EFT for fMRI study, in which participants were asked to indicate in which of two shapes the embedded figure appeared. Goddard et al. (2013) was excluded due to the sample only including males. Kanakam et al.'s (2013) sample consisted largely of individuals recovered from an ED, and so was excluded.

Meta-analyses were performed only on data where the working memory component had been excluded.

A random effects meta-analysis of $N = 5$ studies (Figure 2) including only AN groups showed a pooled effect size of $d = -0.63$ (95% CI $= -0.87$, -0.39, $P = <0.001$). Four studies also included a BN group. There was a pooled effect size of $d = -0.28$ (95% CI $= -0.58$, 0.03, $P = 0.08$). Three studies report EDREC data. A random effect meta-analysis showed a pooled effect size of $d = -0.62$ (95% CI $= -0.94$, -0.31), $P < 0.001$. When data from all ED subtypes was pooled there was an effect size of $d = -0.51$ (95% CI $= -0.67$, -0.35), $P = 0.0025$).

There was little heterogeneity across the studies ($x^2(11) = 11.35$, $P = 0.41$, $I^2 = 3.1\%$) or within the sub-studies (AN: $I^2 = 0\%$. $P = 0.79$, BN: $I^2 = 20.4\%$. $P = 0.29$ and REC: $I^2 = 0\%$, $P = 0.44$).

Publication bias

A funnel plot using studies of all ED sub-types suggested some minor asymmetry. There were more studies with larger negative effect sizes (Figure 3). However, the trim and fill method did not estimate any missing studies.

Table I. Study demographics.

Author/Date	Group	*N*	Age	BMI	IQ	Medication	Comorbidities
Thompson et al. (1993)	AN	10	25.8	>15% normal weight	115.8	N.R	40%dep; ++ OCD
	HC	10	23.2		119.7	N.R	None
Gillberg et al. (1996)	AN	51	21	21.2 (3.5)	102.9	N.R	10 ASD
	HC	51	20.8	21.2 (2.3)	106.5	N.R	None
Mathias and Kent et al. (1996)	AN	34	22.7 (7.4)	15.3 (1.7)	96.1 (8.8)*	33%	++ anxiety; ++ dep
	HC	31	20.8 (2.4)	22.8 (2.4)	101.1 (6.9)*	None	None
Galderisi et al. (2003)	AN	14	23.7 (4.54)**	15.3 (2.23)	100 (10.8)**	None	None
	BN	31	23.7 (4.54)	21.5 (2.30)	100 (10.8)	None	4 dep; 4PD
	HC	45	24.2 (4.8)	N.R	101.1 (13.6)	None	None
Tokley and Kemps et al. (2007)	AN	24	21.9 (5.3)	16.8 (1.5)	Matched	N.R	++ OCD; ++ anxiety; ++dep
	HC	24	22.0 (5.0)	22.7 (4.3)		N.R	None
Gillberg et al. (2007)	AN	47	24.5	22.2 (4.1)	105.2*	N.R	N.R
	HC	51	24.2	22.2 (3.4)	109.4	N.R	N.R
Lopez et al. (2008b)	AN	42	28.4 (9.6)	15.8 (1.7)	112.8 (6.8)	40.5%	++OCD; ++Anxiety; ++Dep
	BN	42	27.0 (7.2)	21.7 (2.4)	111.8 (6.9)	16.7%	++OCD; ++anxiety; ++dep
	HC	42	26.3 (6.4)	21.9 (2.7)	112.2 (5.4)	None	None
Lopez et al. (2009)	EDREC	42	25 (21-31)	20.9 (2.2)	113.6 (5.3)	None	+OCD, +Anxiety, +Dep
	HC	42	26.3 (6.4)	21.9 (2.7)	112.2 (5.4)	None	None
Tenconi et al. (2010)	AN	60	26.2 (6.9)	16.2 (1.5)	N.R	N.R	N.R
	EDREC	63	N.R	20.5 (3.1)	N.R	N.R	N.R
	HC	120	27.4 (4.5)	21.8 (3.0)	N.R	N.R	N.R
Harrison et al. (2011)	AN	50	N.R	N.R	111.40 (8.64)	N.R	N.R
	BN	48	N.R	N.R	109.65 (6.95)	N.R	N.R
	ANrec	35	N.R	N.R	109.12 (8.12)	N.R	N.R
	HC	89	N.R	N.R	112.27 (7.39)	N.R	N.R
Kim et al. (2011)	AN	22	22 (6.96)	15.63 (1.47)*	105.17 (9.14)	N.R	N.R
	BN	28	23.04 (4.57)	20.40 (2.72)*	110.88 (12.23)	N.R	N.R
	HC	26	23.46 (4.14)	21.36 (2.78)	113.04 (10.52)	N.R	N.R
Roberts et al. (2012)	ANR	35	23.71 (6.39)	17.98 (2.18)	N.R	N.R	N.R
	ANBP	33	25.58 (7.64)	17.88 (3.00)	N.R	N.R	N.R
	BN	30	26.43 (6.84)	21.66 (2.94)	N.R	N.R	N.R
	ANrec	30	32.13 (11.64)	20.76 (1.75)	N.R	N.R	N.R
	HC	88	28.43 (8.47)	22.07 (1.79)	N.R	N.R	N.R
Danner et al. (2012)	AN	16	25.63 (5.41)	14.65 (1.70)	N.R	N.R	N.R
	ANrec	15	24.33 (4.72)	21.20 (1.82)	N.R	N.R	N.R
	HC	15	25.80 (4.69)	21.46 (2.29)	N.R	N.R	N.R
Kanakam et al. (2013)	MZ ED	26	31 (25)	20.6 (3.30)	108 (14)	N.R	N.R
	DZ ED	10	35 (24.75)	21.15 (2.25)	111.5 (14)	N.R	N.R
	MZ HC	17	54 (32)	21.9 (7)	110.5 (15.5)	N.R	N.R
	DZ HC	4	52 (34.50)	23.65 (4.3)	113 (14.8)	N.R	N.R

(Continued)

Table I. Continued.

Author/Date	Group	*N*	Age	BMI	IQ	Medication	Comorbidities
Fonville et al. (2013)	AN	35	23 (9)	16.0 (1.6)	110 (9)	46% SSRI	N.R
	HC	37	25 (4)	21.9 (1.9)	117 (10)	0%	N.R
Van Autreve et al. (2013)	AN	51	26 (12)	14.4 (2)	N.R	N.R	++OCD; ++Dep;
	HC	26	19 (2)	20.9 (1.8)	N.R		
de Sampaio et al. (2013)	AN	24	24.5 (7.6)	18.1 (1.8)	102.5 (19.8)	54.2% psychoactive	+Anx; +Dep
	BN	24	24.4 (6)	25 (6.5)	96.5 (16.0)	62.5% psychoactive	+Anx; +Dep
	HC	24	25.2 (6.9)	21.5 (18.1)	100.2 (15.2)	0%	
Goddard et al. (2013)	Mixed ED (males)	29	26.2 (8.2)	17.2 (2.2)	106.9 (9.4)	N.R	N.R
	HC (males)	42	26.4 (7.2)	23.2 (2.5)	108.4 (8.2)	N.R	N.R

BMI, Body mass index; AN, anorexia nervosa; BN, bulimia nervosa; ED, eating disorder; ANrec, recovered anorexia nervosa; HC, healthy control; MZ, mono zygotic, DZ, dizygotic; dep, depression; OCD, obsessive compulsive disorder; ASD, autistic spectrum disorder; SA, substance abuse; GAD, generalized anxiety disorder; PD, personality disorder. *Significant differences between groups. **The authors reported age and IQ grouping AN and BN.

Fonville et al. (2013) reported no differences between AN and HC groups in terms of reaction times. Goddard et al. (2013) reported that ED males were slower at detecting the complex shapes than HC males ($d = -0.6$, $P = 0.022$). Kanakam et al. (2013) reported no differences between ED twins and HC twins ($d = 0$, $P = 0.98$).

Rey-Osterrieth Complex Figures Test (ROCFT)

The ROCFT was employed by seven studies, which fulfilled the inclusion criteria with ED populations. Three studies were excluded. Goddard et al. (2013), as it included only a male ED population, Kanakam et al. (2013) as its sample mainly consisted of recovered ED participants. Goddard et al. (2013), found that ED males had weaker central coherence than HC males ($d = -0.5$, $P = 0.009$). Kanakam et al. (2013) reported no differences between ED twins and HC ($d = 0.1$, $P = 0.054$).

Seven studies employed ROCFT with an AN population. A random effects meta-analysis showed a pooled effect size for CCI of $d = -0.63$ (95% CI $= -0.85$, 0.42), $P < 0.001$. Four studies report data from a BN population. A random effects meta-analysis showed a pooled effect size for CCI of $d = -0.84$ (95% CI $= -1.16$, -0.52), $P < 0.001$. Lastly, five studies reported data comparing participants recovered from an ED (mixed). A random effects meta-analysis demonstrated a pooled effect size for CCI of $d = -0.49$ (95% CI $= -0.71$, -0.26) $P < 0.001$ (Figure 4). When data from all ED studies was pooled there was an effect size of $d = -0.63$ (95% CI $= -0.77$, -0.49, $P < 0.001$).

There was evidence of heterogeneity across the studies combined ($x^2(13) = 7{,}55$, $P = 0.297$, $I^2 = 13.6\%$), including those with AN ($P = 0.321$, $I^2 = 14.3\%$) and BN ($P = 0.304$, $I^2 = 17.3\%$).

Publication bias

An assessment of funnel plots did not indicate any publication bias and the trim and fill method did not estimate any missing studies using all or AN studies only (Figure 5).

Object assembly (OA)

Figure 6 presents all eight studies employing OA with ED populations in a meta-analysis. Since 2008, only one study employed OA with an ED population (Tenconi et al. 2010). Eight studies used OA with an AN population. Lower scores, indicating poorer global integration were observed in AN participants in all but one study (Galderisi et al. 2003). A random effects meta-analysis showed a pooled

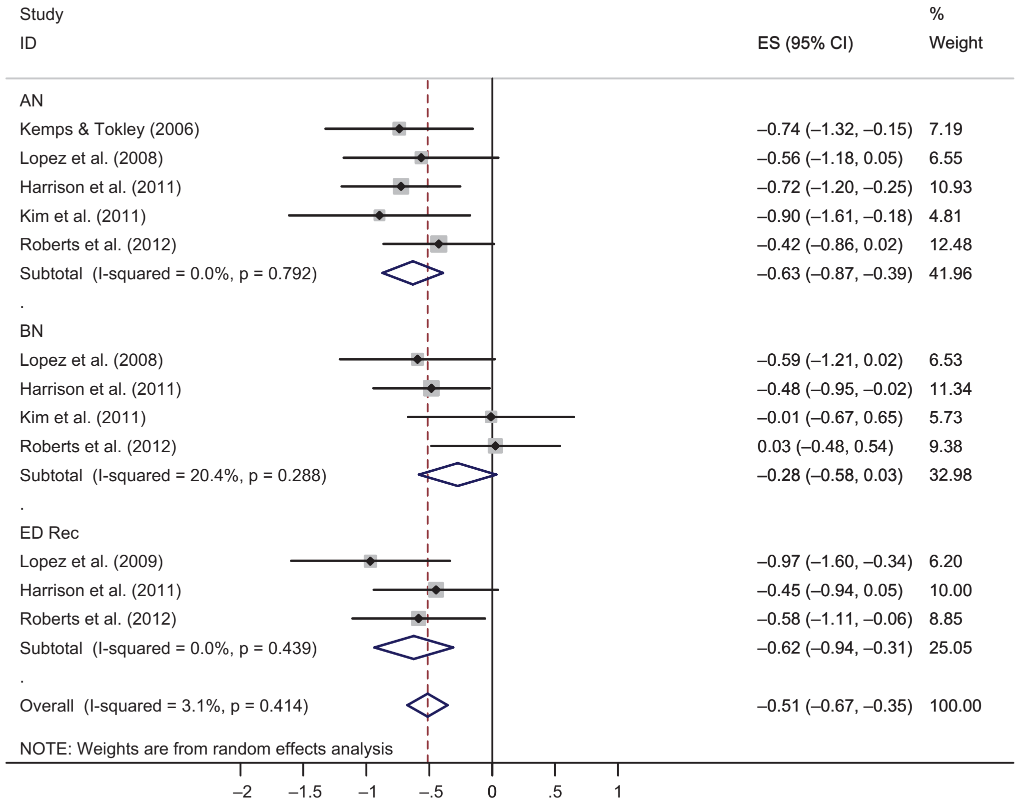

Figure 2. Forest plot for G/EFT studies.

effect size of $d = -0.58$ (95% CI $= -0.86$ to -0.29), $P < 0.0001$.

One study also recruited a BN group (Galderisi et al. 2003), which (in contrast to their AN group) showed a lower score compared to HCs [$d = -0.44$ (95% CI $= -0.91$, 0.02, $P = 0.063$)]. One study observed OA performance in recovered AN (Tenconi et al. 2010), also showing lower scores and therefore poorer global processing compared to HCs [$d = -1.48$ (95% CI $= -2.01$, -0.95), $P < 0.001$]. For all subtypes there was a pooled effect size of $d = -0.65$ (95% CI $= -0.94$, -0.37, $P < 0.0001$.

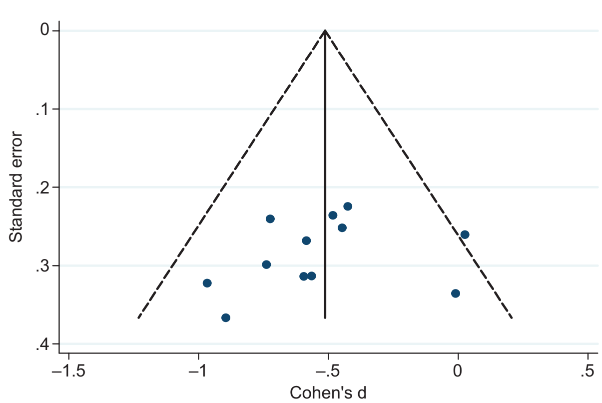

Figure 3. Funnel plot of Group/Embedded Figures Test (G/EFT) studies.

There was evidence of moderate heterogeneity across all studies ($x^2(9) = 27.35$, $P = 0.001$, $I^2 = 67.1\%$) including those with AN only ($x^2(7) = 16.41$, $P = 0.022$, $I^2 = 57.3\%$).

Publication bias

An assessment of the funnel plot did not indicate any publication bias using AN groups or all ED subtypes (Figure 7) The trim and fill method estimated that there were no missing studies.

Overlapping Figures Test (OFT)

Tenconi et al. (2010) used the OFT and found that fewer shapes were detected by the AN group compared to HCs ($d = -0.61$) meaning that those with current AN showed excessive local processing and weak global processing. The same paper also reported data from a recovered group, who also detected fewer shapes than HCs ($d = -0.61$).

Fragmented Pictures Task (FPT)

Harrison et al. (2011) used the FPT. They found that the ED group (including AN, BN and REC) took significantly longer to discern what the picture was compared to the HC group ($d = -0.82$). This effect

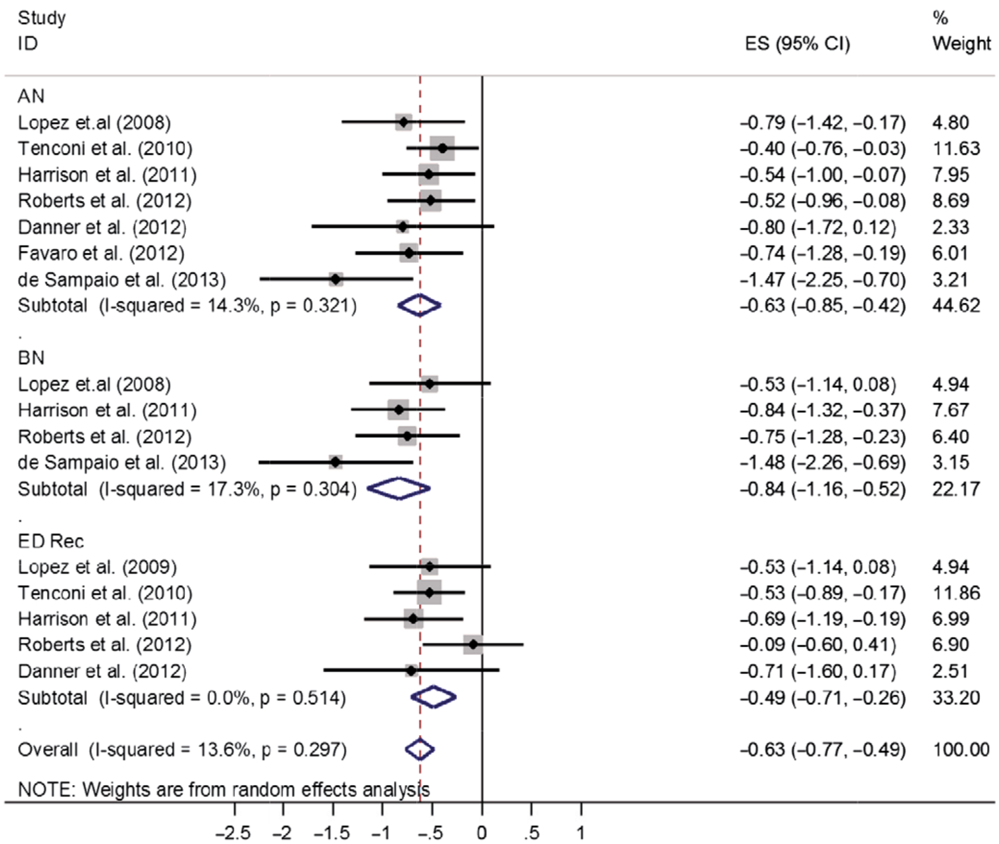

Figure 4. Forest plot of Rey Osterrieth Complex Figures Test (ROCFT).

was due to the AN group versus the HCs ($d = -0.81$). There were no differences in performance between the BN, recovered group and HCs. Goddard et al. (2013) used the FPT with a male ED population and also reported that compared to HC comparison group, they too had difficulty with global integration ($d = -0.5$, $P = 0.022$).

Discussion

The aim of the present study was to provide an updated systematic review and meta-analysis in

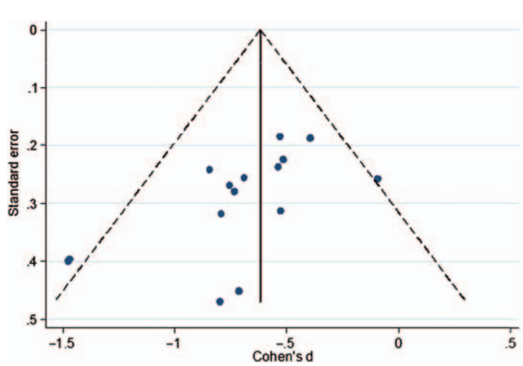

Figure 5. Funnel plot of Rey Osterrieth Complex Figures Test (ROCFT) studies.

order to test the hypothesis that individuals with ED display Weak Central Coherence (WCC). The results confirmed the hypothesis, with individuals with ED displaying a bias towards detail at the expense of global integration.

The present review found new studies using the G/EFT to examine local processing, and new studies using the ROCFT, OA, OFT and FPT to examine global processing.

The strongest evidence of extreme local processing came from the G/EFT. A bias towards details over the global "gist" was consistently demonstrated in all studies using this measure, and this finding was robust across ED subtypes with medium effect sizes (−0.51), particularly in AN. Evidence of inefficient global processing was also demonstrated, with the ROCFT being the most popular measure of global processing. Poorer performance on the ROCFT was evident across all ED subtypes with medium effect sizes (−0.62). Further evidence of inefficient global processing across ED subtypes was also found in studies using the OA, OFT and FPT (medium-large effect sizes).

This review therefore provides the first strong evidence of a bias towards detail-focused processing in ED, along with further consistent evidence of suboptimal global processing on numerous tasks.

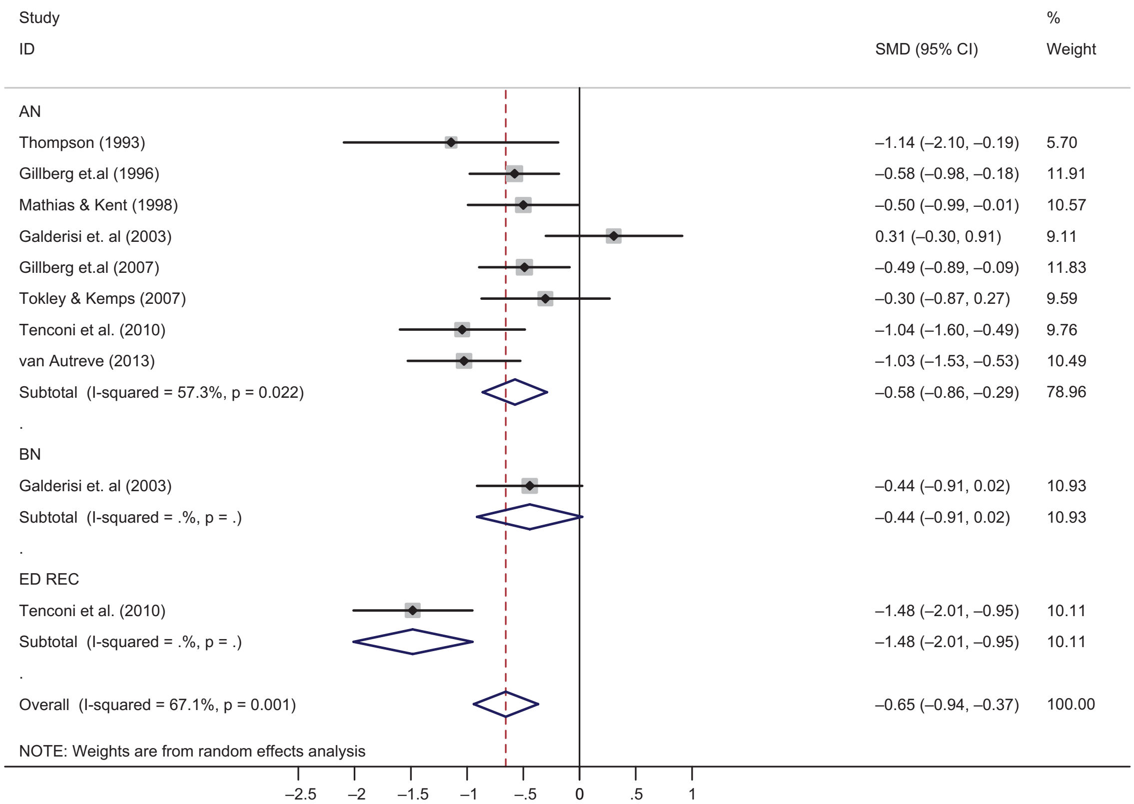

Figure 6. Forest plot of Object Assembly (OA) Studies.

Taken together, these results give evidence of WCC in this population.

As with the previous review (Lopez et al. 2008), there was little variation in the size of the effect between the diagnostic sub-groups of eating disorders. A bias towards detail over global integration was observed on a number of tasks across the spectrum of ED, with this profile being most accentuated amongst those with AN. Currently there are fewer studies examining WCC in those recovered from AN, however the existing literature demonstrated that recovered individuals exhibited an intermediate profile, whereby their performance was in between those with AN and healthy control counterparts. The observation that this information processing bias continued to be present in both the acute or recovered stage of illness (albeit it on a continuum) provides some support for the notion that Weak Central Coherence (WCC) may be an endophenotype for ED. However, further studies utilising recovered individuals, siblings and family members are needed to provide stronger support to this hypothesis.

These findings have important clinical implications. Conventional psychological treatments are not associated with good outcomes for many individuals with ED. Elucidating potential predisposing and maintaining factors for the disorder may lead to more effective tailor-made treatments and consequently improve treatment outcome. Underlying cognitive traits such as WCC may interact with, and exaggerate perfectionistic and obsessive-compulsive personality traits, which may make engaging in psychological treatments that emphasise behavioural change difficult. Future treatments may focus first on targeting core cognitive characteristics such as WCC, prior to attempting to create behavioural change. For example, Cognitive Remediation Therapy (CRT) has been developed to target maintaining factors, by encouraging “bigger picture” and flexible thinking (Tchanturia et al. 2013a). A case series using CRT showed improvements with medium

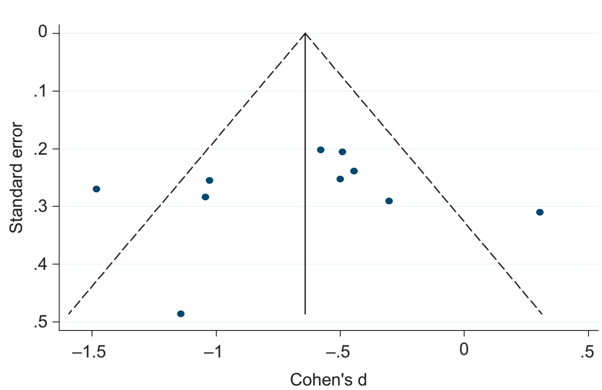

Figure 7. Funnel plot of Object Assembly (OA) studies.

effect sizes in CC index after 10 sessions of CRT (Tchanturia et al. 2008). As CRT is associated with cognitive improvements, it could therefore prepare individuals for engagement in treatment that then directly target ED pathology.

The finding that WCC is a transdiagnostic trait in ED also carries important clinical implications. There is a wealth of research supporting inefficient cognitive processing in AN, however, its presence in individuals with BN is a fairly novel finding. Although it is the first line recommended treatment for BN, Cognitive Behaviour Therapy (CBT) is not effective for approximately 35% of patients (Agras et al. 2000; Fairburn et al. 2003; Shapiro et al. 2007). The treatment refractoriness of such patients could be due to the cognitive style they are exhibiting, and information regarding their cognitive profile could be used to help make slight treatment modifications to traditional CBT to increase engagement and ultimately improve outcomes.

A preference for detailed processing over global integration is not specific to ED and has been observed across a number of disorders, for example in both Obsessive Compulsive Disorder (OCD; Kuelz et al. 2004) and Autistic Spectrum Condition (ASC; Booth 2006).

Such disorders exhibit similarities in cognitive styles across a number of domains including WCC and set-shifting/cognitive rigidity. More recently there have also been parallels drawn between the socio-emotional profile of AN and ASD (Tchanturia et al. 2013b). Along with this, there are also inflated comorbidity rates of both OCD and autistic traits within AN samples (Swinbourne et al. 2007; Tchanturia et al. 2013b). These elevated comorbidity rates, along with shared neuropsychological traits and clinical symptomatology, strongly hint that these disorders share a common underlying mechanism. Such thinking further highlights the importance of tailoring treatments for ED populations, for example incorporating work focusing on neurocognition and emotion skills training (Davies et al. 2012), to target both obsessive-compulsive and socio-emotional symptoms.

This study has some limitations in that tasks such as the ROCFT do not only measure global or local processing, but instead examine the tradeoff between the two.

Following on from this, many neuropsychological tasks not only measure one element of cognition, but instead measure an array of cognitive functions. For example the ROCFT can be used to examine numerous abilities such as memory, planning, organization, as well as central coherence. It is therefore impossible to isolate the particular property one intends to study. The authors have assumed this potential bias in the interpretation of the results and conclusions are supported with a careful examination of several tasks aimed to explore the same concept.

Secondly, many studies do not describe their exact method of administration or comment on comorbidities or medication, therefore leaving the effect of possible biases unknown. With this in mind, it is also important to highlight some inconsistencies within the Object Assembly results. One study (Galderisi et al. 2003) found the opposite result to the other seven studies (finding that the AN group performed more globally than the HC). Such inconsistencies could be attributed to differences in methodologies, and further inspection highlighted that this study had recruited drug-naïve AN patients (where as a majority of other participants had been medicated), and this may have therefore had an effect on neuropsychological performance.

In conclusion, this study has provided evidence supporting the WCC hypothesis in ED transdiagnostically. As well as adding to the existing evidence for inefficient global processing in this group, it has also provided further evidence of superior local processing. The persistence of WCC following recovery also provides partial support to the endophenotype hypothesis for ED.

Statement of Interest

Katie Lang is funded by the National Institute for Health Research (NIHR) [Mental Health Biomedical Research Centre and/or Dementia Biomedical Research Unit] at South London and Maudsley NHS Foundation Trust and King's College.

Daniel Stahl, Janet Treasure and Kate Tchanturia were in part supported by the NIHR Biomedical Research Centre for Mental Health at South London and Maudsley NHS Foundation Trust and King's College London. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health. Kate Tchanturia would like to thank the Swiss Anorexia Foundation for funding.

References

Agras WS, Walsh BT, Fairburn CG, Wilson GT, Kraemer HC. 2000. A multicenter comparison of cognitive-behavioral therapy and interpersonal psychotherapy for bulimia nervosa. Arch Gen Psychiatr 57:459.

Booth R. 2006. Local-global processing and cognitive style in autism spectrum disorders and typical development. London: Institute of Psychiatry, King's College London.

Bradburn MJ, Deeks JJ, Altman, DJ. 1998 Metan – an alternative meta-analysis command. Stata Technical Bulletin 8:44.

Cooper H, Hedges L. 2009. The handbook of research synthesis. The Russell Sage Foundation: New York.

Crane AM, Roberts ME, Treasure J. 2007. Are obsessive compulsive personality traits associated with a poor outcome in anorexia nervosa? A systematic review of randomized controlled trials and naturalistic outcome studies. Int J Eat Disord 40:581–588.

Danner UN, Sanders N, Smeets PA, van Meer F, Adan RA, Hoek HW, et al. 2012. Neuropsychological weaknesses in anorexia nervosa: set-shifting, central coherence, and decision making in currently ill and recovered women. Int J Eat Disord 45:685–694.

Davies H, Fox J, Naumann U, Treasure J, Schmidt U, Tchanturia K. 2012. Cognitive remediation and emotion skills training (CREST) for anorexia nervosa: an observational study using neuropsychological outcomes. Eur Eat Disord Rev 20(3):211–217.

de Sampaio, TP, Soneira S, Aulicino A, Martese G, Iturry M, Allegri RF. 2013. Theory of mind and central coherence in eating disorders: two sides of the same coin? Psychiatry Res 210:1116–1122.

Della Sala S, Laiacona M, Trivelli C, Spinnler H. 1995. Poppel-reuter–Ghent's Overlapping Figures Test: its sensitivity to age, and its clinical use. Arch Clin Neuropsychol 6: 511–534.

Duvall S, Tweedie R. 2000. A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. J Am Med Assoc 95:89–98.

Everitt BS. 2003. Modern medical statistics. London: Arnold.

Fairburn CG, Cooper Z, Shafran R. 2003. Cognitive behaviour therapy for eating disorders: A "transdiagnostic" theory and treatment. Behav Res Ther 41:509–528.

Favaro A, Santonastaso P, Manara R, Bosello R, Bommarito G, Tenconi E, et al. 2012. Disruption of visuospatial and somatosensory functional connectivity in anorexia nervosa. Biol Psychiatr 72:864–870.

Fonville L, Lao-Kaim NP, Giampietro V, Van den Eynde F, Davies H, Lounes N, et al. 2013. Evaluation of enhanced attention to local detail in anorexia nervosa using the Embedded Figures Test: an fMRI Study. PloS ONE 8:e63964.

Galderisi S, Mucci A, Monteleone P, Sorrentino D, Piegari G, Maj M. 2003. Neurocognitive functioning in subjects with eating disorders: the influence of neuroactive steroids. Biol Psychiatr 53:921–927.

Gillberg IC, Gillberg C, Råstam M, Johansson M. 1996. The cognitive profile of anorexia nervosa: a comparative study including a community-based sample. Comp Psychiatr 37:23–30.

Gillberg I, Råstam M, Wentz E, Gillberg C. 2007. Cognitive and executive functions in anorexia nervosa ten years after onset of eating disorder. J Clin Exp Neuropsychol 29:170–178.

Goddard E, Carral-Fernández L, Denneny E, Campbell IC, Treasure, J. 2013. Cognitive flexibility, central coherence and social emotional processing in males with an eating disorder. World J Biol Psychiatr 1–10. DOI: 10.3109/15622975.2012.750014

Happé FG. 1997. Central coherence and theory of mind in autism: reading homographs in context. Br J Dev Psychol 15:1–12.

Happé FG, Booth RD. 2008. The power of the positive: revisiting weak coherence in autism spectrum disorders. Q J Exp Psychol 61:50–63.

Happé F, Briskman J, Frith U. 2001. Exploring the cognitive phenotype of autism: weak "central coherence" in parents and siblings of children with autism: I. Experimental tests. J Child Psychol Psychiatr 42:299–307.

Harrison A, Tchanturia K, Treasure J. 2011. Measuring state trait properties of detail processing and global integration ability in eating disorders. World J Biol Psychiatr 12:462–472.

Higgins JP, Thompson SG, Deeks JJ, Altman DG. 2003. Measuring inconsistency in meta-analyses. BMJ 327:557.

Kanakam N, Raoult C, Collier D, Treasure J. 2013. Set shifting and central coherence as neurocognitive endophenotypes in eating disorders: a preliminary investigation in twins. World J Biol Psychiatr 14:464–75.

Kim YR, Lim SJ, Treasure J. 2011. Different patterns of emotional eating and visuospatial deficits whereas shared risk factors related with social support between anorexia nervosa and bulimia nervosa. Psychiatr Invest 8:9–14.

Kuelz AK, Hohagen F, Voderholzer U. 2004. Neuropsychological performance in obsessive-compulsive disorder: a critical review. Biol Psychol 65:185–236.

Lindner SE, Fichter MM, Quadflieg N. 2012. Central coherence in full recovery of anorexia nervosa. Eur Eat Disord Rev 21:115–120.

Le Grange D, Lock J, Agras WS, Moye A, Bryson SW, Jo B, et al. 2012. Moderators and mediators of remission in family-based treatment and adolescent focused therapy for anorexia nervosa. Behav Res Ther 50:85–92.

Lopez C, Tchanturia K, Stahl D, Treasure J. 2008. Central coherence in eating disorders: a systematic review. Psychol Med 38:1393–1404.

Lopez C, Tchanturia K, Stahl D, Booth R, Holliday J, Treasure J. 2008b. An examination of the concept of central coherence in women with anorexia nervosa. Int J Eat Disord 41:143–152.

Lopez C, Tchanturia K, Stahl D, Treasure J. 2009. Weak central coherence in eating disorders: a step towards looking for an endophenotype of eating disorders. J Clin Exp Neuropsychol 31:117–125.

Mathias JL, Kent PS. 1998. Neuropsychological consequences of extreme weight loss and dietary restriction in patients with anorexia nervosa. J Clin Exp Neuropsychol 20: 548–564.

Moher D, Liberati A, Tetzlaff, Altman DG. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Br Med J 339:b2535.

Osterrieth P. 1944. The test of copying a complex figure: a contribution to the study of perception and memory. Arch Psychol 30:206–356.

Roberts ME, Tchanturia K, Treasure JL. 2012. Is attention to detail a similarly strong candidate endophenotype for anorexia nervosa and bulimia nervosa? World J Biol Psychiatr 14:452–63.

Sauro CL, Castellini G, Lelli L, Faravelli C, Ricca V. 2013. Psychopathological and clinical features of remitted anorexia nervosa patients: a sixyear follow up study. Eur Eat Disord Rev 21:78–83.

Shapiro JR, Berkman ND, Brownley KA, Sedway JA, Lohr KN, Bulik CM. 2007. Bulimia nervosa treatment: a systematic review of randomized controlled trials. Int J Eat Disord 40: 321–336.

Snodgrass JG, Vanderwart M. 1980. A Standardized set of 260 pictures: norms for name agreement, familiarity and visual complexity. J Exp Psychol Learn Mem Cogn 6:174–215.

Steichen T. 1998. sbe19: tests for publication bias inmeta-analysis. Stata Technical Bulletin 41:9–15.

Sterne J. 2003. METAFUNNEL: Stata module to produce funnel plots for meta-analysis. Boston, MA: Statistical Software Components S434101, Boston College Department of Economics.

Swinbourne JM, Touyz SW. 2007. The co-morbidity of eating disorders and anxiety disorders: a review. Eur Eat Disord Rev 15:253–274.

Tchanturia K, Davies H, Lopez C, Schmidt U, Treasure J, Wykes T. 2008. Letter to the Editor: neuropsychological task performance before and after cognitive remediation in anorexia nervosa: a pilot case-series. Psychol Med 38: 1371–1373.

Tchanturia K, Lloyd S, Lang K. 2013a. Cognitive remediation therapy for anorexia nervosa: Current evidence and future research directions. Int J Eat Disord 46:492–495.

Tchanturia K, Smith E, Weineck F, Fidanboylu E, Kern N, Treasure, J, et al. 2013b. Exploring autistic traits in anorexia: a clinical study. Mol Autism 4:44.

Tenconi E, Santonastaso P, Degortes D, Bosello R, Titton F, Mapelli D, et al. 2010. Set-shifting abilities, central coherence, and handedness in anorexia nervosa patients, their unaffected siblings and healthy controls: exploring putative endophenotypes. World J Biol Psychiatr 11:813–823.

Thomas J, Steichen. 2001. Nonparametric trim and fill analysis of publication bias in meta-analysis, Stata Technical Bulletin, StataCorp LP.

Thompson SB. 1993. Implications of neuropsychological test results of women in a new phase of anorexia nervosa. Eur Eat Disord Rev 1:152–165.

Tokley M, Kemps E. 2007. Preoccupation with detail contributes to poor abstraction in women with anorexia nervosa. J Clin Exp Neuropsychol 29:734–741.

Treasure J, Schmidt U. 2013. The cognitive-interpersonal maintenance model of anorexia nervosa revisited: a summary of the evidence for cognitive, socio-emotional and interpersonal predisposing and perpetuating factors. J Eat Disord 1:13.

Van Autreve S, De Baene W, Baeken C, Heeringen C, Vervaet M. 2013. Do Restrictive and bingeing/purging subtypes of anorexia nervosa differ on central coherence and set shifting? Eur Eat Disord Rev 21:308–314.

Wade TD, Tiggemann M. 2013. The role of perfectionism in body dissatisfaction. J Eat Disord 1:2. DOI 10.1186/2050-2974

Wechsler D. 1974. Manual for the Wechsler intelligence scale for children. New York: Psychological Corporation.

Wechsler D. 1981. WAIS-R manual: Wechsler adult intelligence scale-revised. New York: Psychological Corporation.

Witkin HA 1971. A manual for the embedded figures tests. California: Consulting Psychologists Press.

Witkin HA. 2002. Group embedded figures test. California: Mind garden.