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**A Systematic Review and Meta-analysis of Cognitive Processing Deficits Associated with Body  
Dysmorphic Disorder**

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**Abstract**

This systematic review and meta-analysis examined the evidence supporting the association between body dysmorphic disorder (BDD) symptomology and four types of cognitive processing abnormalities: local processing, selective attention, interpretive biases, and memory deficits. Twenty-three studies met inclusion requirements that examined differences in performance on cognitive tasks between BDD and control groups across the four categories. Multilevel modelling was used to calculate an overall effect size for each cognitive category. BDD and control groups differed significantly on measures of selective attention ( $g=.60$ , 95% CI=.26: .93), interpretive biases ( $g=.30$ , 95% CI=.07: .54), and memory deficits ( $g=.56$ , 95% CI=.26: .87). Differences between the BDD and control groups on measures of local processing did not reach significance. These findings support the hypothesis that people with BDD may selectively attend to perceived threats or to disorder-related stimuli, misinterpret ambiguous stimuli as threatening, overvalue the importance of attractiveness, and have inaccurate coding and recall for facial or bodily stimuli. Recommendations for future research of these specific cognitive deficits in BDD include introducing the use of Modified Dot Probe Paradigms and new treatment targets that can be used as adjuncts to current treatment modalities.

*Keywords:* body dysmorphic disorder; meta-analysis; local processing, selective attention; interpretive biases; memory deficits

Body dysmorphic disorder (BDD) is characterised by repetitive behaviours or mental acts concerning preoccupations with perceived flaws in appearance (Phillips, 2005). Common behaviours include mirror checking, camouflaging to conceal the perceived defect, mirror avoidance, seeking reassurance about appearance, and excessive grooming. The most common areas of focus include the nose, skin, and hair; however, some patients may also focus on areas of the body. For example, muscle dysmorphia is a specifier of BDD that presents as a preoccupation with muscle mass (American Psychiatric Association [APA], 2013).

BDD affects approximately 1-2% of the population (Bjornsson, Didie, & Phillips, 2010), and is thought to affect males and females equally. However, sufferers rarely seek out mental health services and therefore BDD remains a poorly understood and under-researched disorder, and incidence rates may be far greater than currently estimated (Bjornsson et al., 2010). Until the recent release of the 5<sup>th</sup> edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013), BDD was classified as a somatoform disorder. New evidence surrounding clinical and neuropsychological similarities between BDD and obsessive-compulsive disorder (OCD) has led to the reclassification of BDD under the obsessive-compulsive and related disorders category. For example, BDD and OCD have similar brain abnormalities that impair frontal lobe functioning (Labuschagne, Rossell, Dunai, Castle, & Kyrios, 2013). Research also shows commonalities in treatment response to cognitive behavioural therapy (CBT), exposure and response prevention, and selective serotonin reuptake inhibitors, suggesting neuroanatomical similarities between the two disorders (Labuschagne et al., 2013). Furthermore, there are similarities in the presenting symptoms, with the obsessions in both OCD and BDD resulting in compulsive checking and reassurance-seeking behaviours (Phillips, 2005).

### **Theoretical perspectives on the aetiology and maintenance of BDD**

Progress in the treatment of BDD remains limited, restrained by the paucity of theoretical models of BDD, most of which are cognitive behavioural in nature. The most recent model encompasses a comprehensive paradigm related to the evidence-base that currently informs the aetiology of BDD (Fang & Wilhelm, 2015). In addition to earlier experiences of teasing, sociocultural values, and genetic

factors, Fang and Wilhelm (2015) suggest that perfectionism, rejection sensitivity, and fear of negative evaluation from others may act as precursors to the development of four types of cognitive processing deficits (described below and in **Table 1**), one of which includes selective attention that has been highlighted in previous models (e.g., Veale, 2004). These deficits are hypothesised to contribute to the development and maintenance of negative emotions, such as anxiety and disgust, which then trigger behaviours characteristic of BDD, namely avoidance and compulsions. In line with Neziroglu, Roberts, and Yaryura-Tobias (2004), Fang and Wilhelm (2015) further contend that these maladaptive behaviours maintain dysfunctional beliefs by way of negative reinforcement. Although avoidance and compulsions serve to reduce anxiety in the short term, maladaptive beliefs are reinforced in the long term; BDD sufferers fail to learn that they would have managed despite engaging in these maladaptive behaviours.

### **Cognitive deficits associated with BDD**

**Central coherence.** Weak central coherence, a limited ability to understand context or to "see the big picture", is thought to influence selective attention toward perceived flaws in appearance rather than holistically processing body or facial stimuli (Feusner, Moller, et al., 2010). Studies using cognitive tasks like the Inverted Face Task (Thompson, 1980), Mooney Faces Task, Rey Complex Figures Task (RCFT; Osterrieth, 1944), a variation of an Inverted Face Task called the Famous Faces Task, as well as attractiveness ratings using high and low spatial frequency images and functional magnetic resonance imaging (fMRI) technology have shown support for this hypothesis (Arienzo et al., 2013; Deckersbach et al., 2000; Feusner, Hembacher, Moller, & Moody 2011; Feusner, Moller, et al., 2010; Feusner, Moody, et al., 2010; Moody et al., 2017; Feusner, Townsend, Bystritsky, & Bookheimer, 2007; Jefferies, Laws, Hranov, & Fineberg, 2010; Jefferies, Laws, & Fineberg, 2012; Li, Lai, Bohon, et al., 2015; Toh, Castle, & Rossell, 2017a). However, other studies using the Benton Facial Recognition Task (Benton & Van Allen, 1968), a variation of the Inverted Face Task using houses and facial stimuli, the Navon task (Navon, 1977), electroencephalogram (EEG), magnetic resonance imaging (MRI), fMRI and the Composite task (Young, Hellawell, & Hay, 1987) have failed to detect significant differences

between BDD and control groups (Buhlmann, McNally, Etcoff, Tuschen-Caffier, & Wilhelm, 2004; Li, Lai, Loo, et al., 2015; Moody et al., 2015; Monzani, Krebs, Anson, Veale, & Mataix-Cols, 2013).

Research using a Navon task and an Embedded Figures task (Witkin, 1971) found that compared to controls, the BDD group performed worse on *both* the global and local processing trials (Kerwin, Hovav, Hellemann, & Feusner, 2014). Furthermore, given that brain-imaging and the same or similar variations of cognitive tasks have been found to produce null findings as well as results both in support of and counter to the hypothesis, results across these studies suggest that the relationship of central coherence difficulties and associated global processing abnormalities (or conversely strengths in local processing) and BDD remain inconclusive.

**Selective attention biases.** Selective attention biases are thought to account for biased attention toward disorder-related or threat stimuli (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). In the case of BDD, this involves specific physical features. Neuropsychological research on eating disorders has described selective attention as enhanced distractibility (Tchanturia, Campbell, Morris, & Treasure, 2005). Thus, it has been proposed that sufferers of BDD may attend to external stimuli that have become associated with their obsessions, or to perceived flaws in appearance, which are considered to be relevant (e.g., attractive) or threatening (e.g., hideous) to the disorder. Although so Hübner me studies which have used Emotional Stroop tasks (Watts, McKenna, Sharrock, & Trezise, 1986), eye trackers, symmetry tasks, discrimination tasks, and perceptual modification tasks (Buhlmann, McNally, Wilhelm, & Florin, 2002; Greenberg, Reuman, Hartmann, Kasarskis, & Wilhelm, 2014; Grochowski, Kliem, & Heinrichs, 2012; Kollei, Horndasch, Erim, & Martin, 2017; Lambrou, Veale, & Wilson, 2011; Stangier, Adam-Schwebe, Muller, & Wolter, 2008; Toh, Castle, & Rossell, 2017b; Toh, Castle, & Rossell, 2017c; Thomas & Goldberg, 1995; Yaryura-Tobias et al., 2002), have supported this hypothesis; other studies using facial discrimination tasks, symmetry tasks, Emotional Stroop tasks, and video face distortion tasks (Buhlmann, Rupf, Gleiss, Zschenderlein, & Kathmann, 2014; Hübner, et al., 2016; Reese, McNally, & Wilhelm, 2010; Rossell, Labuschagne, Dunai, Kyrios, & Castle, 2014) have failed to detect significant differences between BDD and control groups. There remains some

uncertainty around whether BDD participants, compared to controls, have enhanced discriminatory abilities solely for their own facial stimuli or for objects or other people's faces. In their 2011 study, Lambrou and colleagues detected a response bias toward detecting symmetry changes to their own faces, which did not extend to the object and other-face control conditions, concluding that BDD sufferers selectively attended to self-referent information.

**Interpretive biases.** Interpretive biases describe negative appraisals of body image and are thought to contribute to biases for ambiguous information and overvalued ideas about the importance of attractiveness. Interpretive biases, which are said to be influenced by specific triggers such as stress, negative mood, comments by others, and physiological changes that occur during adolescence, may in part account for why BDD sufferers are highly critical of their appearance (Fang & Wilhelm, 2015). While some studies have found that BDD sufferers have a tendency to misinterpret neutral facial expressions as expressing negative emotion (Buhlmann, Etcoff, & Wilhelm, 2006; Buhlmann, Gleiß, Rupf, Zschenderlein, & Kathmann, 2011; Buhlmann, McNally, Etcoff, Tuschen-Caffier, & Wilhelm, 2004; Labuschagne, Castle, & Rossell, 2011), results concerning the specific emotions underlying these maladaptive cognitions remain inconclusive. Although Buhlmann et al. (2006) found that compared to controls, BDD participants had a tendency to misinterpret neutral expressions for anger and contempt, consistent with Buhlmann, Gleiß et al. (2011), the misinterpretation of neutral facial stimuli for disgust failed to reach significance. This is somewhat surprising given that all of the BDD models identify disgust as one of the central emotions that drives avoidance and ritualistic behaviours (Neziroglu et al., 2004; Veale, 2004; Wilhelm & Neziroglu, 2002). Furthermore, a 2002 study by Buhlmann, Wilhelm et al. found that compared to controls, BDD participants misinterpreted ambiguous situations (general, social, and body-related scenarios) as threatening.

Results concerning the tendency of BDD sufferers to over-value the importance of attractiveness are also mixed. While some studies which have used the Go/No-go Association Task (Nosek & Banaji, 2001), the Implicit Association Task (Greenwald, McGhee, & Schwartz, 1998), and a Values Scale to look at implicit attractiveness beliefs (Buhlmann, Teachman, & Kathmann, 2011; Buhlmann, Teachman,

Naumann, & Fehlinger, 2009; Lambrou et al., 2011) have found significant differences between BDD and control groups, other studies using the same measures have failed to detect any differences across these groups (Buhlmann, Teachman, Gerbershagen, Kikul, & Rief, 2008; Hartmann et al., 2015).

**Memory deficits.** Results relating to memory deficits, thought to account for inaccurate coding of facial or bodily stimuli, are also mixed. Some studies which have looked at verbal, visual, nonverbal, semantic, and spatial working memory (Deckersbach et al., 2000; Dunai, Labuschagne, Castle, Rossell, & Kyrios, 2010; Labuschagne et al., 2011; Rossell et al., 2014) have found significant group differences among BDD and controls, while others which have looked at verbal, visual, and semantic memory (Hanes, 1998) have failed to detect significant group differences. Furthermore, a study by Toh, Castle, and Rossell (2015) found that compared to controls, the BDD group showed poor immediate recall of words and stories but did not detect deficits to delayed memory, as measured by word, story, and figure recall on the Repeatable Battery for the Assessment of Neuropsychological Status (Rey, 1964).

### **Aim of the meta-analysis**

The main aim of the current meta-analysis was to investigate the empirical evidence supporting an association between the four cognitive processing deficits and symptoms of BDD. Specifically, we seek to answer the following question: compared to controls, do clinically-diagnosed BDD participants display heightened local processing of stimuli, selective attention biases for disorder-relevant and symmetrical stimuli, interpretive biases for misinterpreting neutral facial expressions as representing negative affect and overvaluing the importance of appearance, and memory deficits? This meta-analysis is the first to investigate the strength of the proposed relationships between cognitive processing deficits and BDD, an important undertaking given the presence of so many conflicting findings across individual studies. Understanding the underlying mechanisms, which produce and maintain symptoms of BDD is crucial for the development of new and existing interventions.

## **Method**

### **Search strategy**

No published protocol exists for this review and meta-analysis. The review process was conducted according to the PRISMA statement (Moher, Liberati, Tetzlaff, & Altman, 2009), described in **Figure 1**. A PsycINFO (OvidSP) database search was conducted, covering professional and academic literature across psychology and other related disciplines, including medicine, mental health, nursing, nutrition and dietetics, physiology, and linguistics. The following terms were combined using the “AND” Boolean operator and searched in the database: *body dysmorphic disorder*, *dysmorphophobia*, *BDD*, *body image*, *body image disturbance*, AND *cognition*, *cognitive*, *cognitive task*. Additional articles from reference lists and extended searches, including those pertinent to the proposed theoretical model, were included in the present literature search. To reduce the likelihood of having included more frequently in our analyses studies that were selectively chosen for publication due to significant effect sizes (publication bias), we attempted to locate unpublished studies and dissertations that met our inclusion criteria. Additional searches were conducted in PsycINFO, PubMed (OvidSP), CINAHL and MEDLINE to obtain data from dissertations. Furthermore, all corresponding authors whose studies met inclusion criteria were contacted to inquire about whether they were aware of any existing unpublished BDD studies that used cognitive tasks to assess the four cognitive processing abnormalities. However, no additional eligible studies could be located. With the exception of case studies, all designs and cognitive tasks used to assess the four cognitive deficit categories were included.

The search resulted in 615 published studies listed on May 10, 2017. Of these, 569 studies were removed after reviewing the publication and abstract. Although included in the systematic literature review, twenty-three of the remaining forty-six were excluded from the meta-analysis, leaving twenty-three studies. Omitted studies used case studies that did not include quantitative data (N=1), self-report measures of cognitive impairment rather than performance-based tests (N=1), EEG technology (N=1), MRI technology (N=1), fMRI technology (N=6), eye trackers (N=6), the use of statistical approaches which were not readily interpretable in terms of effect sizes (N=1), studies where data could not be readily converted into effect sizes and/or further data could not be obtained (N=5), and pilot studies (N=1). A final search was conducted on November 20, 2017, and no additional studies that met our

specified inclusion criteria were identified. The first author, using the inclusion-exclusion criteria described below, conducted all screening.

**Inclusion Criteria.** In order to examine a homogeneous group to give the greatest clarity in the face of the varied and inconsistent results to date, only studies of clinical populations were included in the meta-analysis. We only selected BDD studies that compared differences in cognitive task performance. Although one was identified (Yaryura-Tobias et al., 2002), given that under normal conditions, most BDD studies tend to be underpowered, pilot studies were not considered. Furthermore, given that some cognitive tasks measure central coherence on a continuum, where one score is representative of both global and local processing, we were only able to calculate scores for one of these processes. Local processing was prioritised because it has been theorised that BDD sufferers hyper-focus on specific, focal aspects of appearance. Traditionally, it has been assumed that heightened local processing subsequently hinders global processing abilities. However, as evidenced by Kerwin et al. (2014) who found BDD sufferers to perform worse on both global and local trials, high performance on one may not be indicative of low performance on the other and *visa versa*. To avoid cherry picking, each condition of every task used to capture the four constructs of interest was included in the analyses. Studies dated from 1998 when the first such study appeared. Therefore the inclusion criteria were as follows: (1) publication in English, (2) in a peer-reviewed journal, (3) studies using a clinical population of individuals with BDD where diagnoses were confirmed using the DSM criteria, Body Dysmorphic Disorder Diagnostic Module, and/or a clinical interview, and (4) studies that assessed at least one of the four cognitive processing deficits using cognitive tasks. We contacted Buhlmann et al. (2004), Feusner et al. (2010), Hartmann et al. (2015), Kerwin et al. (2014), Monzani et al. (2013), and Toh et al. (2017b) to obtain means and standard deviations not provided in the published online studies. To maintain homogeneity, neuroimaging studies and eye trackers were excluded from the analyses. Furthermore, we excluded the Feusner et al. (2010) study from our analyses involving central coherence, which used an Inverted Face Task, as it was not possible to convert their results to a similar metric to the other studies without making a number of assumptions that would have been difficult to justify. We were also unable

to obtain the means and standard deviations of the BDD and control groups from Jefferies et al. (2010) who also used an Inverted face Task to look at global-local processing, Thomas and Goldberg (1995) who utilised a video face distortion task to look at selective attention, Buhmann, Wilhelm, et al. (2002) who used ambiguous scenarios to look at negative interpretation bias, and Moody et al. (2017) who used attractiveness ratings following presentations of high spatial frequency images to analyse local processing. The first author performed a quality assessment and data collection.

### Statistical methods

Cohen's  $d$  values used for the meta-analysis were obtained with the means, standard deviations, and the  $N$  from the control and treatment groups using an online Practical Meta-Analysis Effect Size Calculator (<https://www.campbellcollaboration.org/effect-size-calculator.html>). Because we wanted a representation of the population that included individuals with and without a diagnosis of BDD, the pooled estimate of the standard deviation was used. Using Comprehensive Meta-Analysis Version 2 (Borenstein, Hedges, Higgins, & Rothstein, 2005), we employed a multilevel model with effect sizes (level 1) nested within studies (level 2) and random intercepts. This allowed us to use multiple outcomes from any one study while correcting for correlated observations in the data. This also allowed us to account for multiple comparisons, in which the same control group was used in the Toh et al. (2015), (2017a), and (2017b) studies. Forest plots were generated with Hedge's  $g$  values and 95% confidence intervals (CI), which were calculated for each individual study, providing an assessment of heterogeneity for local processing, selective attention, interpretive biases, and memory deficits. Given that for some measures a higher score indicates greater cognitive deficit, such as selective attention tasks, whereas the opposite is true for other measures, such as many of the memory deficit tasks, the sign of the correlation coefficients were all transformed so that a positive value for  $g$  indicated a greater cognitive deficit in the BDD group. Heterogeneity was also assessed with the  $Q$  statistic, a measure of weighted squared deviations around the mean (Laird, Tanner-Smith, Russell, Hollon, & Walker, 2017), and the  $I^2$  statistic, where a value of 0% indicates no observed heterogeneity, 25% low heterogeneity, 50% moderate heterogeneity, and 75% high heterogeneity (Higgins & Thompson, 2002). As

recommended by Moreno et al. (2009), we used regression-based adjustments for publication bias available with Egger's regression intercept.

## Results

### Studies included in the meta-analysis

A total of 518 BDD participants and 534 control participants (all except 20 participants from the Stangier et al., 2008 study were healthy controls) were included in the analyses. Due to the paucity of available research in this field using a single task as a measure of each construct, a variety of different tasks were selected to measure similar constructs across the four cognitive categories. See the **Supplementary Table** for a summary description of the studies discussed below.

**Local processing.** The studies included in these analyses are listed in **Table 2** and **Figure 2**. Our analyses included difference scores on the Short Form Benton Facial Recognition Task between a BDD and control group from the Buhlmann et al. (2004) study. When analysing results from the Deckersbach et al. (2000) study, we only analysed scores from the RCFT organisation copy condition, and not the accuracy copy condition, since only the organisation condition could be used to assess local processing. Given that it is the inverted condition from the Famous Faces Task, a variation of the Inverted Face Task, that is said to tap into local processing, only differences between the BDD and control group on inverted trials were included from the Jefferies et al. (2012) study. We included RT and accuracy scores on local trials of the Navon task and Embedded Figures Task to assess local processing differences between BDD and control groups from the Kerwin et al. (2014) study. Monzani et al. (2013) hypothesised a face inversion effect in the BDD group, thus we looked at differences in space and part RT's to the inverted face condition of the Inversion Task, as well as differences in accuracy and RT's on local trials of the Navon and Composite (aligned face condition) tasks. Toh et al. (2017a) used the Mooney Faces Task to compare global-local processing difference scores between a BDD, OCD and healthy control group. To capture differences in local processing between the BDD and healthy control group, we analysed the accuracy difference scores between the upright and inverted conditions for the

facial and object stimuli. In the current meta-analysis the mean weighted effect size for local processing was found to be small ( $g = .35$ , 95% CI=  $-.25: .95$ ).

**Selective attention.** The studies used to investigate selective attention are listed in **Table 2** and **Figure 3**. For Emotional Stroop tasks, only RT and Stroop inhibition/interference conditions were included, since attention control theories predict that accuracy conditions produce no differences between treatment and control groups on these measures (Eysenck, Derakshan, Santos, & Calvo, 2007). To determine differences between the BDD and control groups in selective attention to disorder-relevant or threat stimuli, we selected the mean Stroop interference scores to the BDD positive (e.g. *ugly*) and BDD negative (e.g., *attractive*) word conditions used in the Buhlmann et al. (2002) study, RT to the body condition (e.g., *nose*) and inhibition effect of the body-animal condition from the Rossell et al. (2014) study, and RT to the BDD-positive (e.g. *deformed*) and BDD-negative (e.g. *beautiful*) masked word conditions from the Toh et al. (2017b) study. We did not include the Hanes (1998) Stroop task, because the original task (Stroop, 1935) was used to compare difference scores between a BDD and control group for reading words and naming colours. Thus, this was a measure of interference using neutral words and was not used to detect differences across groups in selectively attending to threat or disorder-related stimuli.

We analysed difference scores between the BDD and healthy control group on the Object Discrimination Task and Facial Discrimination Task (Erwin et al., 1992) in the Buhlmann et al. (2014) study. Similarly, difference scores on the Facial Discrimination Task between the BDD and the non-disfigured dermatological group from the Stangier et al. (2008) study were analysed. For the Lambrou et al. (2012) study, the *object* and *other face* conditions were considered control groups, and the authors compared differences between BDD, art and design controls, and non-art and design controls. Thus, we analysed difference scores between the BDD and non-art control groups on all measures used to assess symmetry preference only for the stimuli depicting the participant's own face. Symmetry preference was considered indicative of enhanced discriminatory abilities and was based on the frequency of selection, heightened accuracy, and less discrepancy in discriminating among symmetrical stimuli. The conditions

included were as follows: *Aesthetic Perceptual Sensitivity* (*perceptual understanding; perceptual accuracy*); *Aesthetic Emotional Sensitivity* (*perceptual selection pleasure; perceptual selection disgust*); *Aesthetic Evaluative Sensitivity* (*aesthetic standard: attractiveness standard/perceptual selection; aesthetic standard: self-ideal/personal standards; aesthetic standard: self-perfect vs ideal/personal standards*). When analysing results from the Reese et al. (2010) study, we selected the overall symmetry preference condition, which took into account total symmetry preference, as measured by RT's and accuracy scores for dot arrays and facial stimuli of other people. In the current meta-analysis the mean weighted effect size for selective attention was found to be medium ( $g = .60$ , 95% CI= .26: .93).

**Interpretive Biases.** The studies used to examine interpretive biases are listed in **Table 2** and **Figure 4**. Buhlmann et al. (2004) administered an Emotion Recognition Task (Ekman & Friesen, 1975) and compared differences in the ability to accurately identify facial expressions. In order to assess interpretive biases toward ambiguous stimuli, we compared differences between BDD and control groups in the tendency to misidentify neutral facial expressions for fear-based emotions, which included disgust. Due to insufficient reporting of data and the inability to obtain further information, the stimuli "anger" and "scared" were not included in the analyses. Buhlmann et al. (2006) created both a self and other-referent scenario, with facial stimuli depicting neutral, angry, disgusted, and surprised expressions. Participants were then asked to rate whether the facial expressions represented neutral, angry, disgusted, surprised, contemptuous, fearful, or happy emotions. We analysed group differences in accuracy ratings of the self-referent scenario for misinterpretations of neutral facial expressions as disgusted, angry, and contemptuous. Due to insufficient reporting of data and the inability to obtain further information, the stimulus "fear" was not included in the analyses. Buhlmann, Gleiß et al. (2011) presented participants with angry, disgusted, happy, neutral, sad, scared, and surprised facial expressions. We compared difference scores between the BDD and control group in the misidentification of neutral facial expressions for disgusted and angry expressions. Due to insufficient reporting of data and the inability to obtain further information, the stimulus "scared" was not included in the analyses.

In the Buhlmann et al. (2008) study, the Implicit Association Task was used to measure differences between a BDD, subclinical, and control group in RT toward pairing the words “Attractive-Important”, “Attractive-Meaningless”, “Self-Good”, and “Self-Bad”. Our analyses included difference scores between the BDD and control group on the “Attractiveness Implicit Association Task” outcome, which compared differences in overall implicit attractiveness beliefs. We chose to analyse implicit measures of attractiveness because it has been suggested that one of the driving forces behind appearance-related obsessions and compulsions is an over-valued belief about the importance of beauty (Fang & Wilhlem, 2015; Phillips, 2005; Veale, 2004). In a similar Buhlmann et al. (2009) study, the Implicit Association Task was used to measure implicit self-esteem and attractiveness beliefs in a BDD, subclinical, and control group. Implicit beliefs concerning attractiveness were measured by pairing the words “Attractive-Important” and “Attractive-Competent”. We analysed difference scores on the “Attractive-Important” and “Attractive-Competent” trials between the BDD and control group. Buhlmann, Teachman et al. (2011) used the Go/No-go Association Task to measure implicit attractiveness beliefs in a BDD, dermatology, and control group. The words “Attractive”, “Beautiful”, “Good looking”, and “Pretty” were paired with the words “Important”, “Meaningful”, “Crucial”, and “Significant”. We analysed difference scores between the BDD and control group using the “Attractive Important Go/No-go Association Task” scores, which assessed overall implicit attractiveness beliefs. In a similar study, Hartmann et al. (2015) compared implicit attractiveness beliefs among a BDD, anorexia nervosa, and control group on the Go/No-go Association Task, which paired the words “Attractive-Important” and “Attractive-Competent”. We analysed differences in RT scores on the trials that paired “Attractive-Important” and “Attractive-Competent” between the BDD and control group. In the current meta-analysis the mean weighted effect size for interpretive biases was small ( $g = .30$ , 95% CI = .07: .54).

**Memory Deficits.** The studies used to analyse memory deficits in BDD are listed in **Table 2** and **Figure 5**. Deckersbach et al. (2000) compared difference scores between a BDD and control group on the RCFT and the California Verbal Learning Test (Delis, Kramer, Kaplan, & Ober, 1987). We

compared differences between BDD and control groups in the average immediate and delayed recall scores (percent recall) of the RCFT and percent recall on the California Verbal Learning Test. Dunai et al. (2010) compared differences between a BDD, OCD, and control group on measures of spatial working memory, including the Spatial Span Test (De Luca et al., 2003), the Spatial Working Memory Test (De Luca et al., 2003), which included conditions that assessed within search errors, between search errors, and search strategy, and the Stocking of Cambridge task (Shallice, 1982), which included conditions that assessed number of problems solved, number of perfect solutions, and total moves in excess of the minimum. In addition, a Pattern Recognition Test (De Luca et al., 2003) was used to look at differences in visual pattern recognition memory. We analysed difference scores between the BDD and control group in performance on all measures and task conditions.

Hanes (1998) compared difference scores between the groups on several tasks used to assess memory impairment, including the Rey Auditory Verbal Learning Test (Rey, 1964), the New Tower of London Task (Shallice, 1982), the Category Fluency Task, and the RCFT. We analysed difference scores between the BDD and control group on the delayed recall (memory) condition of the RCFT, and to all conditions of the Rey Auditory Verbal Learning Test, New Tower of London Task, and Category Fluency Task. Rossell et al. (2014) measured differences in semantic memory between the BDD and control group using a Sentence Verification Task (Clark & Chase, 1972) and the Controlled Oral Word Association Test (Ruff, Light, Parker, & Levin, 1996), which was used to assess phonological and semantic fluency. We analysed difference scores on all conditions of the Sentence Verification Task and Controlled Oral Word Association Test. In the study by Toh et al. (2015), we analysed difference scores between the BDD and control group on the overall “immediate memory” and “delayed memory” subtests of the Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, Tierney, Mohr, & Chase, 1998). In the current meta-analysis the mean weighted effect size for memory deficits was medium ( $g = .56$ , 95% CI= .26: .87).

### **Heterogeneity**

For the pooled effect size analysis,  $Q$  was found to be significant ( $Q= 57.23, p<. 001$ ), indicating that the observed variability in effect sizes across all studies included in the meta-analysis was unlikely due to sampling error alone. Furthermore, the overall  $I^2$  was found to be 61.56%, indicating a moderate to high degree of heterogeneity. These findings may be explained by differences among the varying outcomes, and as a result, we conducted subgroup analyses by calculating  $Q$  and  $I^2$  for each cognitive category separately, finding moderate to high degrees of heterogeneity for the categories of local processing and selective attention (See **Table 3** for  $Q$  and  $I^2$  values of all cognitive categories). Potential sources of heterogeneity are outlined in detail below. See **Table 3** for  $Q$  and  $I^2$  values.

### **Publication Bias**

Funnel plots were also created for local processing, selective attention, interpretive biases, and memory deficits (see **Supplementary Figures 1 to 4**). A  $p$  value of  $<. 05$  was indicative of publication bias, as it suggests there is a significant relationship between the effect size and precision (Laird et al, 2017). When all studies were combined into a single analysis, there was no indication of publication bias, as evidenced by Egger's regression intercept ( $ERI=. 50, p=. 40$ ). Furthermore, when studies were grouped on cognitive category and analysed separately, publication bias was not detected for any of the cognitive categories (See **Table 3** for  $ERI$  values across all cognitive categories).

### **Risk of bias for individual studies**

Based on the recommendations by the Cochrane review group, and biases relevant to non-intervention studies, biases related to individual studies (reporting, detection, and attrition biases) were considered (Lundh & Gøtzsche, 2008). Reporting bias, the biased selection of variables and results included in the analyses, could not be assessed, as protocols for studies were not available. Detection bias refers to systematic differences in how group outcomes are determined (Lundh & Gøtzsche, 2008). In all of the included studies, the diagnosis was assessed with a diagnostic manual and/or clinical interview but only one of the studies included in the analyses (Hanes, 1998) reported blinding of the experimenter to participant diagnosis. Finally, attrition bias refers to systematic differences between

groups due to participant dropout. Generally, drop out of participants was not explicitly stated apart from two studies (Hartmann et al., 2015; Kerwin et al., 2014).

### **Discussion**

BDD is a complex disorder that can be hard to treat (Fang & Wilhelm, 2015), and further work is required to identify factors that may explain the symptomatology and can thus be targeted in interventions. Two models of BDD have emphasised the role of selective attention in exacerbating BDD symptomatology (Fang & Wilhelm, 2015; Veale, 2004). The more recent model has also suggested a role for central coherence, interpretive biases, and memory deficits.

#### **Do Specific Cognitive Deficits Account for BDD Symptomology?**

The twenty-three studies included in this meta-analysis provided 80 tests of four different categories of cognitive function. Three categories showed a significant difference between BDD and control groups, namely selective attention and memory deficits with medium effect sizes, and interpretive biases with a small difference. These results confirm the central role of selective attention highlighted in the Veale (2004) and Fang and Wilhelm (2015) models and also point to the importance of memory impairment and interpretive biases in explaining BDD psychopathology. Selective attention toward perceived threats, such as flaws in appearance, is hypothesised to be the trigger for feelings of anxiety and disgust, which then results in a range of behaviours to regulate emotion. Memory deficits are thought to account for inaccurate coding and recall of face or body stimuli. Moreover, abnormalities to memory function might interfere with problem-solving abilities (Newell & Simon, 1972), which could then exacerbate maladaptive coping strategies, such as seeking out cosmetic procedures or incessant mirror checking used to manage symptoms of anxiety. Moreover, the misinterpretation of ambiguous stimuli and overvaluation of the importance of beauty might also play an important role in the development and maintenance of BDD psychopathology. There were insufficient studies and power to separate the constructs of misinterpretation and overvaluation, and the relative contribution of these two will require further studies to be conducted.

There was no support for abnormalities related to local processing in BDD, suggesting that this aspect of cognitive functioning is not useful to include in theories seeking to inform the development of interventions for BDD. However, null findings might be partly due to methodological challenges. For example, there appear to be some discrepancies concerning the predicted direction of the effect on facial recognition tasks (Buhlmann et al., 2004; Jefferies, 2012; Monzani et al., 2013), and some measures assessing central coherence make the assumption that low scores on local processing necessitate high scores on global processing and *vice versa*. It is also possible that moderators play a role (i.e., subgroups within BDD populations may exhibit specific deficits), but addressing this question would require substantially more studies and those that include measurement of potential moderators that may influence cognitive functioning, such as medication status, severity of BDD, age, age of onset and duration of BDD.

Analyses revealed significant heterogeneity for the categories of local processing and selective attention. Potential sources of heterogeneity might relate to differences in methodology. Three studies produced results outside the 95% CI and each is examined in turn. In the study by Jefferies et al. (2012), a methodology that taps into additional aspects of cognitive processing abnormalities might help to explain the large effect size observed. For example, given that the task used to measure local processing was made up of stimuli depicting images of famous people, and that celebrities are often perceived as being aesthetically appealing, it is possible that heightened symmetry detection for these images played a role in the superior processing of facial stimuli in the BDD group. Moreover, what follows is the overvaluation of outward appearance that may have also played a role in the superior processing of these images. Compared to controls, the BDD group may have had a tendency to more readily attend to stimuli within their environment that relate to famous people perceived as attractive. Thus, the large effect size might be explained by the use of a cognitive task that taps into various cognitive biases (local processing, selective attention, and interpretive biases), which may have resulted in superior facial recognition abilities.

Although some of the studies included in the local processing analyses controlled for the effects of medication (Deckersbach et al., 2000; Monzani et al., 2013) on cognitive performance, Kerwin et al. (2014) was the only study to exclude medicated BDD participants. It is possible that non-medicated BDD sufferers have specific characteristics, such as greater symptom severity or lower socioeconomic status, that distinguish them from the medicated cohort, thereby reducing homogeneity of the sample. Another possible source of heterogeneity in this study involved the recruitment of participants from three different sources (dermatology, plastic surgery, and mental health clinics; posted advertisements; internet advertisements). Conversely, the other studies included under the local processing category recruited primarily through outpatient clinics or hospitals.

There were several important differences between the Lambrou et al. (2011) study and other studies included under the selective attention category. The main factor that distinguished the research by Lambrou et al. (2011) et al. from the other studies in this cognitive category was the inclusion of three separate measures of symmetry preference (i.e., selective attention) with various task conditions. Thus, it is possible that a broader construct of selective attention was captured by these measures. Furthermore, Lambrou et al. (2011) was the only study to use the BDD participant's own facial stimuli, detecting a response bias for self-referent information. This finding is consistent with the pilot study by Yaryura-Tobias et al. (2002) who found that compared to controls, the BDD group detected non-existing symmetry differences in facial stimuli and that this response-bias applied only to personally salient information. Thus, these results appear to suggest that the strength of the manipulation of cognitive tasks used to assess cognitive processing abnormalities in BDD may be influenced by the incorporation of self-referent stimuli. Furthermore, this may reflect an important underlying factor common across other cognitive deficits outlined in the Fang and Wilhelm (2015) BDD model. For example, although not included in the current meta-analysis due to the use of fMRI technology, Feusner et al. (2011) found that compared to controls, BDD participants were less able to deactivate the default mode network (DMN) when performing an executive task. The DMN is thought to be involved in self-referential thinking that is less active when engaged in tasks involving the use of executive functioning resources and most

active during resting states (Whitfield-Gabrieli & Ford, 2012). Thus, the authors concluded that less deactivation during task performance in the BDD group might reflect the inability to inhibit self-related disorder-relevant thoughts. Furthermore, in the Buhlmann et al. (2006) study, the authors found that compared to the “other-referent” scenarios, the BDD group was more likely to misinterpret neutral facial expressions as contemptuous when given a self-referent scenario.

### **Limitations**

There are several limitations that may influence the interpretation of results from the current meta-analysis. Firstly, many of the included studies failed to adjust for comorbid diagnoses of depression, eating disorders, and anxiety disorders and included participants who were receiving pharmacological interventions. This is problematic because it confounds the effects on cognitive performance with BDD symptomatology. However, due to the extreme shame and poor insight characteristic of BDD, sufferers are often reluctant to participate in research, limiting the power of such studies, and making it difficult to adjust for other factors (Phillips, Didie, Feusner, & Wilhelm, 2008).

Furthermore, Stangier et al. (2008) did not include a healthy control group, thus we had to compare differences in selective attention between a BDD and a non-disfigured dermatological group. The authors also reported recruiting female participants exclusively, who may also have had lower levels of symptom severity. However, results of the current meta-analysis did not detect significant heterogeneity with the inclusion of this study. Nevertheless, an important source of heterogeneity was that inclusion criteria for BDD varied among studies, (see **Supplementary Table**).

The current meta-analysis included studies reporting inconsistencies in measuring central coherence. In the Buhlmann et al. (2002) study, the Benton Facial Recognition Task was used to measure global-local processing, and it was hypothesised that due to preferential processing of specific, local facial features, the BDD group would be less accurate at recognising faces, and low scores on this measure would be indicative of an affinity for local processing. This is inconsistent with hypotheses made when administering an Inverted Face Task and similar variations of this task, as researchers predicted that due to heightened local processing of facial stimuli, BDD participants would be better at

recognising faces in an inverted position (Feusner, Muller, et al., 2010; Jefferies et al., 2012; Monzani et al., 2013). Furthermore, apart from the Navon, Embedded Figures Task, Composite tasks, and Mooney Faces Task, which provided independent scores on measures of global-local processing, the other cognitive tasks used to assess central coherence measured global-local processing on a continuum, with a single score representing these processes. In effect, cognitive measures, like the Inverted Face Task, make the assumption that global-local processing is mutually exclusive. This appears to be problematic, as evidenced by the Kerwin et al. (2014) study which used the Navon task and found that compared to controls, the BDD group scored worse on both global and local trials. Thus, given that many of the tasks used to assess central coherence measured this construct continuously, we were unable to analyse central coherence and instead chose to focus on local processing in isolation. Consequently, it is possible that the non-significant effect observed in the local processing category could be attributed, in part, to inconsistencies in the methodology used to measure this construct. Further, the inclusion of a variety of different tasks used to measure similar constructs across the four cognitive categories might have confounded the overall findings reported in this meta-analysis. Upon the accumulation of more research in this field, future meta-analytic studies might consider using a stricter inclusion criterion for the cognitive tasks of interest.

It should also be noted that our Cohen's  $d$  estimates were calculated using the pooled standard deviation rather than the standard deviation of the control group. Thus, rather than evaluating group differences against natural variation in the cognitive tasks that is uncontaminated by variation resulting from BDD, estimates for the group differences will include more variability in cognitive tasks that come from both controls and BDD. In effect, in some sense, this confounds variability in the task with variability created by BDD. This conservative strategy will result in wider confidence intervals, which may have obscured some significant findings.

Finally, the current meta-analysis only included research published in English, which may have biased the results (Jüni et al., 2002). Furthermore, failure of most of the included research to blind experimenters to treatment groups, report attrition rates, and disclose all variables omitted from

analyses, may have led to a reporting of inaccurate effect sizes, thereby confounding the results. Future research should pay more attention to reporting possible sources of individual bias in BDD-related studies.

### **Future directions**

One of the issues encountered in conducting the meta-analysis was the lack of consistency in reporting results, and the heterogeneity of cognitive tasks utilised. Future research should incorporate reporting more consistent metrics, such as effect sizes, and indices required to calculate effect sizes (i.e., means and standard deviations) for all conditions of all cognitive tasks administered. For studies involving comparisons of groups (i.e., BDD *vs* control), it would be ideal for researchers to report on Cohen's *d*, as it provides a standardised difference between groups. In an effort to better assess individual biases across studies, future research should consider disclosing all questionnaires administered to participants, including those that were omitted from the analyses, blinding experimenters to treatment groups, and reporting attrition rates. It might also be advisable to test the proposed cognitive deficits outlined in the Fang and Wilhelm (2015) model before moving on to other constructs and to do this initially in non-clinical populations. The advantage of this approach is to determine whether there are suggestive differences that can profitably be followed up in a clinical population. It would also be useful to agree on a small group of important cognitive tasks to investigate, such that a critical mass of studies can accumulate and inform the area. For example, preliminary research appears to suggest that the inclusion of self-referent information when analysing group differences in cognitive task performance might be an important area warranting further investigation. Furthermore, to address the limitation of heterogeneity created as a result of including studies that evaluated BDD differently, future research might consider coming to a consensus on a uniform way of assessing symptomology. Given the small size of this field, it could be advisable to conduct a working party to discuss and agree on such issues, such as was achieved by the Obsessive Compulsive Cognitions Working Party (Obsessions Compulsions Cognitions Working Group, 1997).

There has been much debate about which underlying cognitive processes are captured when administering the Emotional Stroop Task, with more recent theories suggesting that the task captures the parallel processing of irrelevant and relevant information (MacLeod, 1991). In effect, computerised Dot-Probe Tasks have largely replaced the Stroop Task in the recent literature, which also includes modified versions in which emotionally salient words are matched with neutral words. According to Wells and Matthews (1994), the Dot Probe Task is a more direct measure of attention bias than the Stroop paradigm. To date, selective attention toward disorder-relevant stimuli captured by Modified Dot Probe Tasks has been detected in eating disorder populations (Shafran, Lee, Cooper, Palmer, & Fairburn, 2007; Shafran, Lee, Cooper, Palmer, & Fairburn, 2008). Further, selective attention abnormalities have been reported in one non-clinical study involving the administration of a Dot Probe Task made up of BDD-relevant stimuli (Onden-Lim, Wu, & Grisham, 2012).

Given that Buhlmann et al. (2002) and Rossell et al. (2014) produced inconsistent results when using the Emotional Stroop task to assess selective attention in BDD populations, future studies using a Modified Dot Probe Task might yield more consistent findings. Another potential advantage of using the Dot Probe Paradigm is that results can be compared with disorders that share similar underlying psychopathology, such as OCD and anorexia nervosa, where there is evidence of attention bias toward threatening stimuli (e.g., Amir, Najmi, & Morrison, 2009; Blechert, Ansorge, & Tuschen-Caffier, 2010).

**Treatment Implications.** The results of this meta-analysis have implications for developing adjuncts to current treatment modalities for BDD. Implementation of cognitive bias modification techniques could be used to target specific maladaptive cognitions that maintain symptoms of BDD, as it has in related disorders. Cognitive bias modification has been used with some promise in anorexia nervosa (Cardi et al., 2015) where there is overvaluation of the importance of appearance (Hartmann et al., 2015) as there is in BDD. Attentional probe tasks have been used to retrain attention toward positive stimuli and to reduce negative interpretations of ambiguous information. Moreover, our findings are consistent with the existing preliminary evidence supporting a role of cognitive bias modification techniques in the alleviation of BDD symptomology (Premo, Sarfan, & Clerkin, 2016; Summers & Cogle, 2016). Our

results suggest that a combination of cognitive bias modification for attention and interpretation (MacLeod, 2012) warrants further investigation. Furthermore, given that there is preliminary evidence for the efficacy of Metacognitive Therapy in alleviating symptoms of OCD (Moritz, Jelinek, Hauschildt, & Naber, 2010) and BDD (Rabei, Mulkens, Kalantari, Molavi, & Bahrami, 2012), and that the mechanism of action involves increasing awareness of cognitive biases, the utility of Metacognitive Therapy in targeting BDD obsessions warrants further investigation. Cognitive Remediation Therapy could also be used to target memory impairment in BDD populations by strengthening executive functioning and mental flexibility (Fang & Wilhelm, 2015). Enhancing these processes may thereby serve to ameliorate problem-solving abilities, and minimise reliance on BDD compulsions used to manage anxiety. Although traditionally, Cognitive Remediation Therapy has been used as a treatment for psychotic disorders, brain injuries, and attention deficit hyperactivity disorder, a 2014 review by Tchanturia, Lounes, and Holtum found that this therapy was a promising new development in the treatment of anorexia nervosa and OCD. These results provide further justification for Cognitive Remediation Therapy as an adjunct to traditional BDD treatment modalities.

Examination of the effectiveness of these approaches can also be used to inform the development of existing models (Craig et al., 2008). Given the difficulty of engaging BDD populations in treatment and research, the most efficient way to test and modify promising models may be to control for any foreseeable variables, so as to better establish any unknown group differences. Due to the paucity of existing research in this field, it might also be beneficial to first test specific aspects of this model in non-clinical populations who have significant concerns about appearance prior to evaluation in BDD populations. Results from these studies could then be used to inform treatment studies, which could later inform how models might be modified to reflect a greater understanding of the specific underlying cognitive mechanisms that maintain symptoms.

## **Conclusions**

The results of the current meta-analysis suggest that specific cognitive processing abnormalities involving selective attention, interpretive biases, and memory deficits may play a key role in the

development and maintenance of BDD psychopathology. Although local processing failed to produce significant differences between BDD and control groups, these results should be interpreted with caution. Some explanations for this null finding include possible moderators and methodological challenges. It is also worth noting that brain-imaging studies used to investigate this construct were not included in our analyses. Researchers and clinicians might also consider the use of Modified Dot Probe Tasks to investigate selective attention, and interventions such as Cognitive Bias Modification Therapy and Cognitive Remediation Therapy in order to target specific cognitive deficits that might be triggering and maintaining symptoms of BDD.

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Table 1

*Summary of Deficits in Cognitive Processing in BDD*

<b>Cognitive Deficits</b>	<b>Clinical Features</b>	<b>Cognitive Measures</b>
Local Processing	Preferential processing of local details, resulting in preoccupations with specific flaws in face or body parts	Composite Task Electroencephalogram Embedded Figures Task Famous Faces Task Functional Magnetic Resonance Imaging Inversion Task Inverted Face Task Magnetic Resonance Imaging Mooney Faces Task Navon Task Rey Osterrieth Complex Figures Task (copy) Short Form Benton Facial Recognition Task
Selective attention	Fixation on threat and/or disorder-relevant stimuli/ biased attention to aesthetic details (e.g. symmetry)	Attractiveness ratings for high spatial frequency images Discrimination tasks (Aesthetic Perceptual Sensitivity; Aesthetic Evaluative Sensitivity; Aesthetic Emotional Sensitivity) Dot Symmetry Detection Task Emotional Stroop Task Eye Tracker Facial Discrimination Task Facial Symmetry Detection Task Video Face Distortion Task
Interpretation Bias	Overvalued ideas about attractiveness/ misinterpretation of neutral facial expressions as representing negative emotions	Emotion Recognition Task Go/No-go Association Task Implicit Association Test Interpretation Questionnaire Values-Scale Questionnaire
Memory deficits	Inaccurate coding and recall of facial features or body parts	California Verbal Learning Test Category Fluency Task Controlled Oral Word Association Test Pattern Recognition Test Rey Osterrieth Complex Figures Task (recall) Sentence Verification Task Rey Auditory Verbal Learning Task Repeatable Battery of Neuropsychological Status (immediate and delayed recall)

Spatial Span Test  
Spatial Working Memory Test

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Table 2

*Meta-analysis statistics used in the analyses for each cognitive category*

Studies and mean weighted values	Outcome Measure	<i>g</i> (95% CI)	Standard Error	Variance	Z	p
<b>Local Processing</b>						
Buhmann et al., 2004	BFRT	-.16 (-.76: .45)	.31	.10	-.50	.61
Deckersbach et al., 2000	RCFT	.80 (.12: 1.48)	.35	.12	2.30	.02
Jefferies et al., 2012	FFT	1.66 (.81-2.51)	.43	.19	3.84	.00
Kerwin et al., 2014	EFT, Navon	-.68 (-1.35: -.00)	.34	.12	-1.97	.05
Monzani et al., 2013	Navon, Composite, IFT	-.05 (-.60: .50)	.28	.08	-.18	.86
Toh et al., 2017	MFT	.70 (.09: 1.31)	.31	.10	2.24	.02
<i>Mean weighted values</i>		.35 (-.25: .95)	.31	.09	1.14	.25
<b>Selective Attention</b>						
Buhmann et al., 2002	Emotional Stroop	.93 (.22: 1.64)	.36	.13	2.56	.01
Buhmann et al., 2014	ODT, FDT	.20 (-.26: .67)	.24	.06	.85	.39
Hübner et al., 2016	FDT	.18 (-.31: .66)	.25	.06	.72	.47
Lambrou et al., 2011	APS, AES, AEmS	1.22 (.79: 1.65)	.22	.05	5.58	.00
Reese et al., 2010	FSD, DSD	.20 (-.41: .80)	.31	.10	.63	.53
Rossell et al., 2014	Emotional Stroop	.39 (-.34: 1.11)	.37	.14	1.05	.29
Stangier et al., 2008	FDT	1.14 (.49: 1.79)	.33	.11	3.44	.00
Toh et al., 2017a	Emotional Stroop	.54 (-.06: 1.15)	.31	.09	1.76	.08
<i>Mean weighted values</i>		.60 (.26: .93)	.17	.03	3.50	.00
<b>Interpretive Biases</b>						
Buhmann et al., 2004	ERT	.00 (-.61: .61)	.31	.10	.00	1.00
Buhmann et al., 2006	ERT self-referent	.82 (.15: 1.49)	.34	.12	2.41	.02
Buhmann et al., 2008	IAT	.21 (-.46: .88)	.34	.12	.61	.54
Buhmann et al., 2009	IAT	.00 (-.59: .59)	.30	.09	.00	1.00
Buhmann, Gleiß et al., 2011	ERT	.33 (-.14: .80)	.24	.06	1.37	.17
Buhmann, Teachman et al., 2011	GNAT	.64 (.17: 1.11)	.24	.06	2.69	.01
Hartmann et al., 2015	GNAT	.03 (-.54: .60)	.29	.09	.10	.92
<i>Mean weighted values</i>		.30 (.07-.54)	.12	.01	2.52	.01
<b>Memory Deficits</b>						
Deckersbach et al., 2000	CVLT, RCFT	.50 (-.17: 1.18)	.34	.12	1.46	.14
Dunai et al., 2010	PR, SWM, SOC, SS	.82 (.06: 1.58)	.39	.15	2.12	.03
Hanes, 1998	RAVLT, NTL, CFT, RCFT	.13 (-.52: .78)	.33	.11	.38	.70
Rossell et al., 2014	COWAT, SVT	.51 (-.23: 1.24)	.38	.14	1.34	.18
Toh et al., 2015	RBANS	.88 (.26: 1.51)	.32	.10	2.76	.01
<i>Mean weighted values</i>		.56 (.26: .87)	.16	.02	3.61	.00

Note: BFRT= Benton Facial Recognition Task; RCFT= Rey Complex Figures Task; FFT= Famous Faces Task; EFT=Embedded Figures Task; IFT=Inverted Face Task; MFT= Mooney Faces Task; FSD= Facial Symmetry Detection; DSD= Dot Symmetry Detection; FDT= Facial Discrimination Task; ODT=Object Discrimination Task; AES= Aesthetic Evaluative Sensitivity; AemS= Aesthetic Emotional Sensitivity; APS= Aesthetic Perceptual Sensitivity; FDT PCR= Facial Discrimination Task proportion of correct responses; FDT ACR= FDT accuracy change ratings; ERT= Emotion Recognition Task; IAT= Implicit Association Task; GNAT= Go/No-go Association Task; CVLT PR= California Verbal Learning Test percent recall; RCFT PR= Rey Complex Figures Task percent recall; SWM bse= Spatial Working Memory Test between search error; SWM wse= within search error; SWM ss= search strategy; SOC #psol= Stocking of Cambridge Task number of problems solved; SOC #perf sol= SOC number of perfect solutions; SOC tmem= SOC total moves in excess of the minimum; SST= Spatial Span Test; COWAT= Controlled Oral Word Association Test; RAVLT= Rey Auditory Verbal Learning Task; NTL= New Tower of London Task; CFT= Category Fluency Task; SVT= Sentence Verification Task; RBANS= Repeatable Battery for Neuropsychological Status

Table 3

*Analysis of heterogeneity ( $Q$ ;  $I^2$ ) and publication bias ( $ERI$ ) for each cognitive category*

Cognitive categories	Q-test <sup>a</sup>	$I^2$ -test <sup>a</sup>	$ERI^b$
<b><i>Local Processing</i></b>	25.35*	80.27*	9.49
<b><i>Selective Attention</i></b>	19.33*	63.79*	-.32
<b><i>Interpretive Biases</i></b>	7.24	17.13	-1.87
<b><i>Memory Deficits</i></b>	3.22	.00	1.15

Note: \* $p < .05$ ; <sup>a</sup> indicates tests of heterogeneity; <sup>b</sup> indicates publication bias where  $ERI =$

Egger's regression intercept

**Listing of titles for figures***Figure 1*

PRISMA diagram of the selection process of studies included in the meta-analysis

*Figure 2*

Forest plot displaying all local processing studies

*Figure 3*

Forest plot displaying all selective attention studies

*Figure 4*

Forest plot displaying all interpretive biases studies

*Figure 5*

Forest plot displaying all memory deficits studies

Figure 1

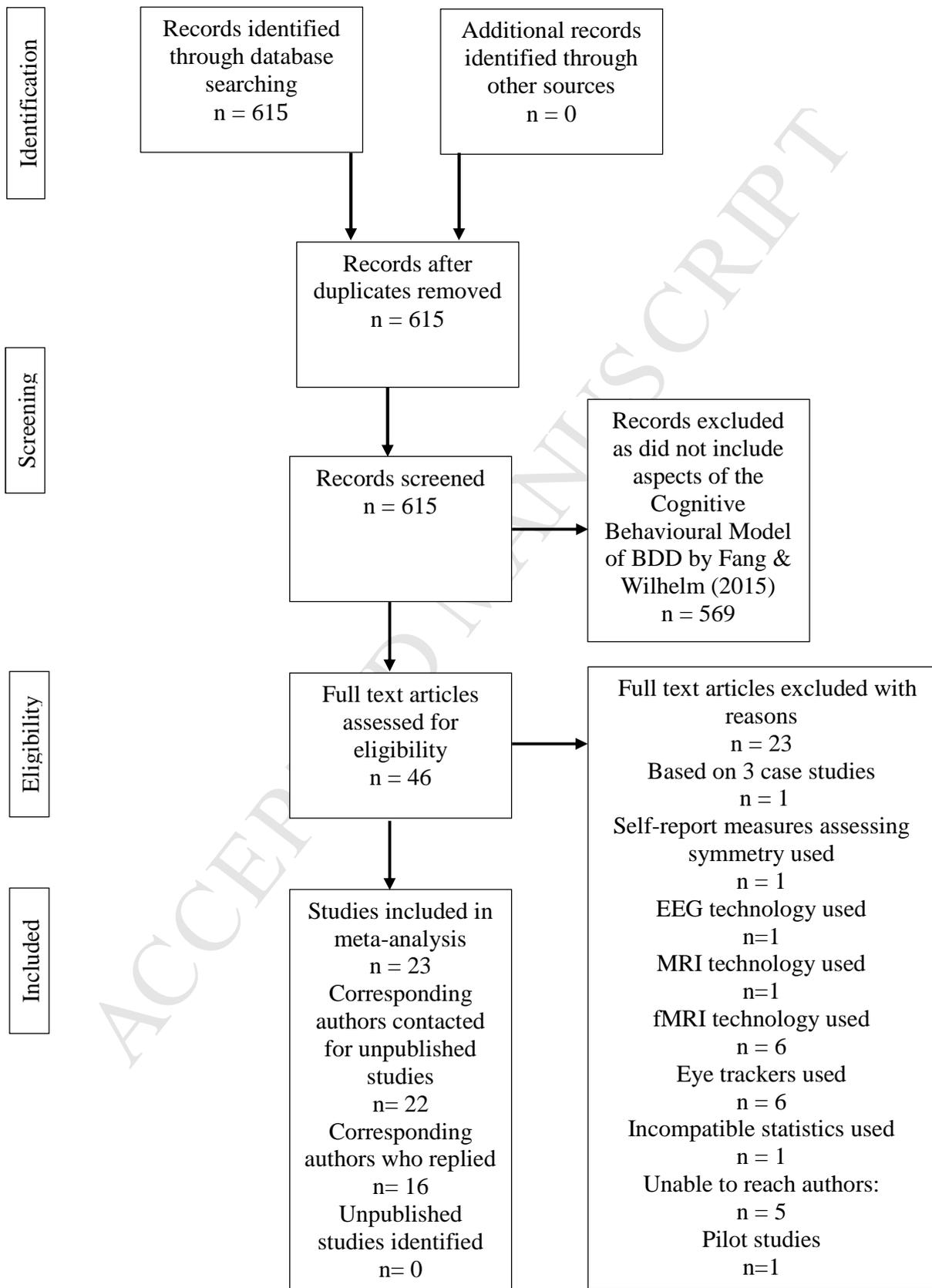
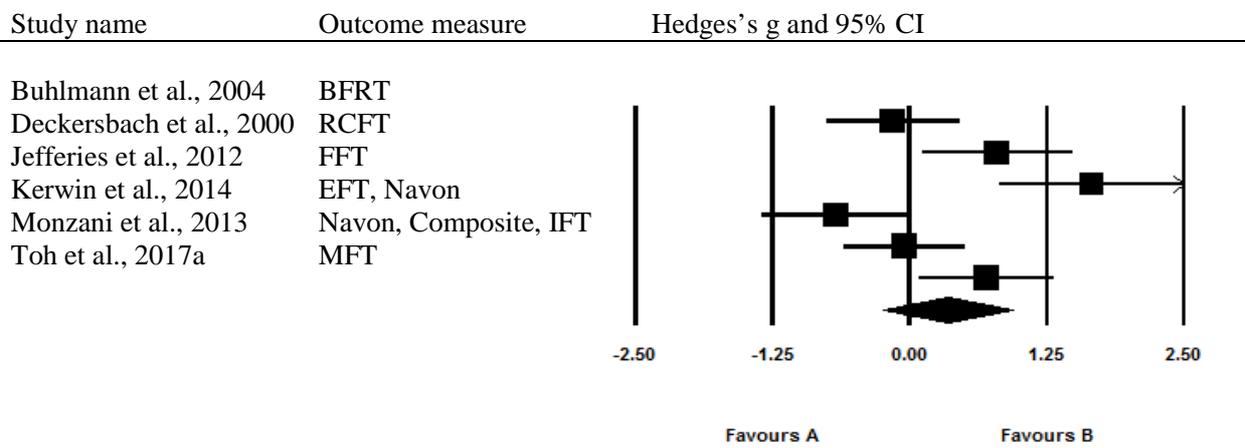


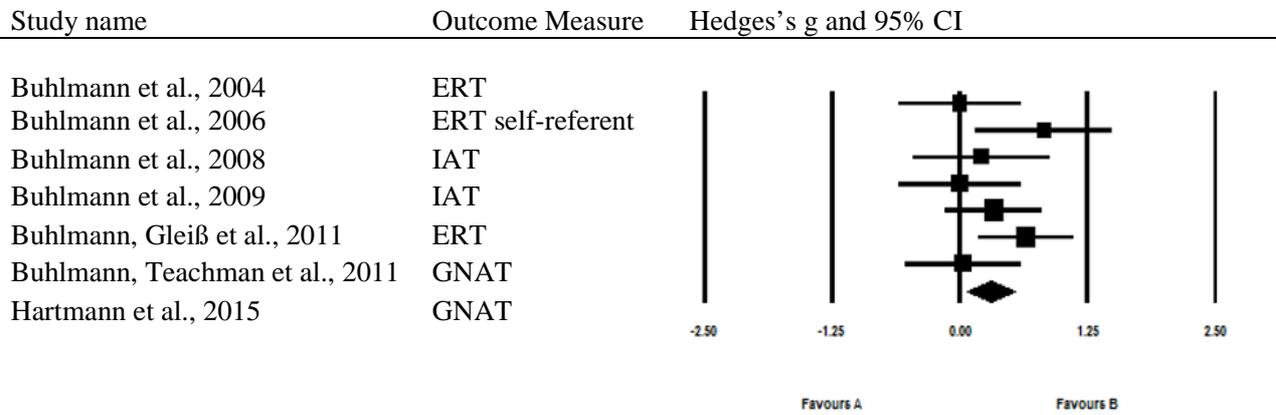
Figure 2



Note: BFRT= Benton Facial Recognition Task; RCFT= Rey Complex Figures Task; FFT= Famous Faces Task; EFT= Embedded Figures Task; IFT= Inverted Face Task; MFT= Mooney Faces Task



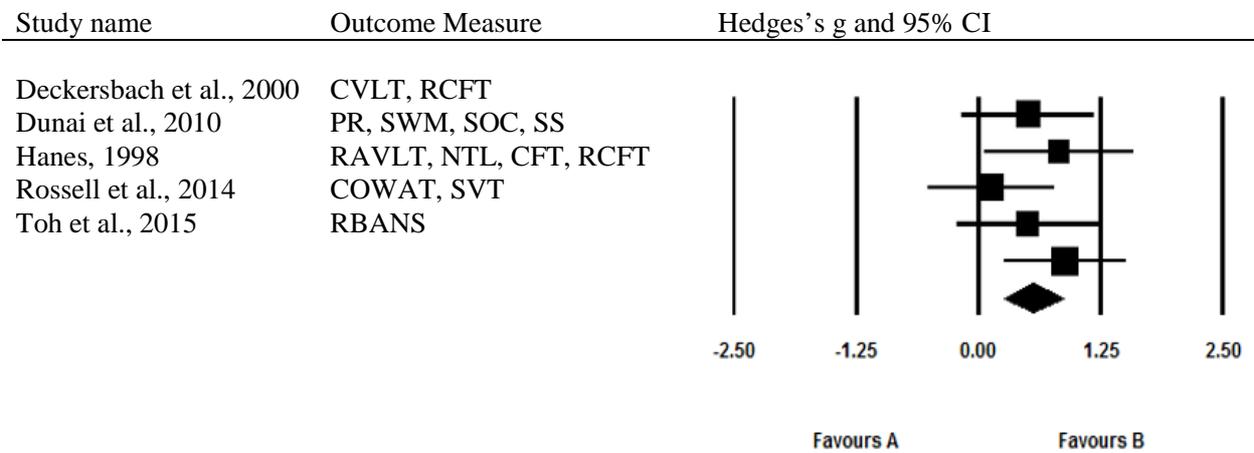
Figure 4



Note: ERT= Emotion Recognition Task; IAT= Implicit Association Task; GNAT= Go/No-go

Association Task

Figure 5



Note: CVLT= California Verbal Learning Test; RCFT= Rey Complex Figures Task; PR= Pattern Recognition Test; SWM= Spatial Working Memory Test; SOC= Stacking of Cambridge Task; SS= Spatial Span Test; RAVLT= Rey Auditory Verbal Learning Test; NTL= New Tower of London Task; CFT= Category Fluency Task; COWAT= Controlled Oral Word Association Test; SVT= Sentence Verification Task; RBANS= Repeatable Battery for Neuropsychological Status

**Highlights**

- Cognitive processing abnormalities in Body Dysmorphic Disorder (BDD) were examined
- BDD groups were compared to controls
- Medium effect sizes for selective attention and memory deficits were found
- A small effect size for interpretive biases was found
- Use of Dot Probe Tasks to measure selective attention in BDD is proposed