Running head: INTEROCEPTIVE DEFICITS IN EATING DISORDERS

Self-Reported Interoceptive Deficits in Eating Disorders: A Meta-analysis of studies using the Eating Disorder Inventory

Paul M. Jenkinson*, Lauren Taylor & Keith R. Laws

School of Life and Medical Sciences, University of Hertfordshire, UK.

*Corresponding author:

Dr Paul Jenkinson: p.jenkinson@herts.ac.uk

School of Life and Medical Sciences

University of Hertfordshire

Hatfield

Hertfordshire

AL10 9AB

Abstract

Objective: An impairment of the ability to sense the physiological condition of the body – interoception – has long been proposed as central to the onset and maintenance of eating disorders. More recent attention to this topic has generally indicated the presence of interoceptive deficits in individuals with an eating disorder diagnosis; however, possible links with specific diagnosis, BMI, age, illness duration, depression, and alexithymia remain unclear from individual studies. This meta-analysis aimed to provide a necessary quantitative overview of self-reported interoceptive deficits in eating disorder populations, and the relationship between these deficits and the previously mentioned factors. **Methods:** Using a random effects model, our meta-analysis assessed the magnitude of differences in interoceptive abilities as measured using the Eating Disorder Inventory in 41 samples comparing people with eating disorders (n=4308) and healthy controls (n=3459). Follow-up and moderator analysis was conducted, using group comparisons and meta-regressions. **Results:** We report a large pooled effect size of 1.62 for eating disorders with some variation between diagnostic groups. Further moderator analysis showed that BMI, age and alexithymia were significant predictors of overall effect size. **Conclusion:** This meta-analysis is the first to confirm that large interoceptive deficits occur in a variety of eating disorders and crucially, in those who have recovered. These deficits may be useful in identifying and distinguishing eating disorders. Future research needs to consider both objective and subjective measures of interoception across different types of eating disorders and may fruitfully examine interoception as a possible endophenotype and target for treatment.

Keywords: interoception, eating disorder, meta-analysis, endophenotype, anorexia, bulimia

Self-Reported Interoceptive Deficits in Eating Disorders: A Meta-analysis of studies using the Eating Disorder Inventory

Eating disorders (EDs) are characterised by an ongoing disturbance of eating or eating-related behaviour, which leads to changes in the consumption or absorption of food, and significantly impaired physical health or psychosocial functioning (American Psychiatric Association, 2013). EDs are a pervasive psychiatric disturbance, associated with severe negative consequences, including significant distress, depression, suicide, substance abuse and even death (Arcelus, Mitchell, Wales, & Nielsen, 2011; Stice, Gau, Rohde, & Shaw, 2017; Swanson, Crow, Le Grange, Swendsen, & Merikangas, 2011). As such, EDs represent a major clinical challenge, and priority for research to identify their aetiology, and develop effective treatments. Unfortunately, the cause of EDs remains poorly understood, with several biological, social and psychological factors identified as important in the onset and maintenance of different EDs (Culbert, Racine, & Klump, 2015).

The task of identifying the causal mechanisms underlying EDs is complicated by the fact that a different combination of factors may contribute to various subtypes of ED. The current Diagnostic and Statistical Manual (DSM-5; APA 2013) identifies three primary ED diagnoses: Anorexia Nervosa (AN; characterised by restrictive eating, severe weight loss, and an intense fear of gaining weight), Bulimia Nervosa (BN; characterised by a preoccupation with body weight and shape, normal body weight, and episodes of binge eating with compensatory behaviours such as purging), and Binge Eating Disorder (BED; characterised by frequent binge eating with feelings of loss of control, but no use of compensatory behaviours). Two further categories (Other Specified Feeding or Eating Disorder (OSFED),

and Unspecified Feeding or Eating Disorder (UFED)[1]), also exist to classify EDs that do not more accurately fit into AN, BN, or BED, such as atypical presentations of the above or other feeding and eating disorders.

Notably, early clinical descriptions of EDs highlighted "disturbances in accuracy of perception or cognitive interpretation of stimuli arising from the body" (Bruch, 1962, p. 189). These dual aspects have been examined under the modern-day concepts of interoception (i.e. the ability to sense the physiological condition of the body (Craig, 2003), and alexithymia (i.e. difficulty identifying and describing feelings / emotions; see Westwood, Kerr-Gaffney, Stahl, & Tchanturia, 2017). Such difficulties in perceiving signals arising from the body and / or identifying and interpreting emotional states have since been established as a core psychopathological element of several ED (Fassino, Pierò, Gramaglia, & Abbate-Daga, 2004; Westwood et al., 2017).

Difficulties with somatic perception/awareness may contribute to EDs because individuals incorrectly interpret bodily signals referring to hunger and satiety cues (Bruch, 1962). A difficulty perceiving hunger cues may result in skipped meals, or the restriction of food intake until intense feelings of hunger occur. By contrast, difficulty in detecting normal levels of fullness could cause binging or overeating (Fassino et al., 2004; Klabunde, Acheson, Boutelle, Matthews, & Kaye, 2013). In addition, deficits in identifying emotional states may contribute to difficulties with emotional regulation; a multidimensional construct characterised by flexible modulation strategies, behavioural control, emotional awareness and distress tolerance (Gratz & Roemer, 2004; Lattimore et al., 2017). ED patients may confuse their internal bodily signals with emotions, and have difficulties experiencing and differentiating different emotions, or modulating or attenuating their intensity (Cameron,

[1] the latter two categories replace the earlier category of Eating Disorders Not Otherwise Specified (EDNOS), which previously also incorporated the now-distinct category of BED.

2001; Lattimore et al., 2017). Such maladaptive emotion regulation or *emotional dysregulation* is a key psychological problem in EDs, related to mood instability, impulsivity, recklessness, anger and self-destructiveness (Lattimore et al., 2017).

The majority of data concerning interoceptive deficits in EDs is based on self-reports obtained from the Eating Disorder Inventory (EDI; Garner, Olmstead, & Polivy, 1983), which primarily assesses the interpretative component of interoceptive deficits rather than somatic awareness. The EDI includes an "Interoceptive Awareness" subscale, comprising 10 questions reflecting "a lack of confidence in recognising and accurately identifying emotions and sensations of hunger or satiety" (Garner et al., 1983, p. 18). Using the EDI and subsequent revisions (EDI-2, Garner, 1991, EDI-2, Garner, 2004; EDI-VS, Maïano, Morin, Monthuy-Blanc, Garbarino, & Ninot, 2016), self-reported interoceptive deficits of this interpretative kind have been found consistently across patients with various EDs (Fassino et al., 2004; Lattimore et al., 2017).

Importantly, although interoceptive deficits are widely reported as being a core psychopathological component of several EDs, it is not known whether the effect size is the same across the spectrum of EDs, or whether a particular diagnosis is associated with greater interoceptive deficits. In addition, several variables are known to interact and overlap with interoceptive processing and EDs, such as age, disease duration, Body Mass Index (BMI), depression and alexithymia (Amianto, Bertorello, Migliore, Abbate-Daga, & Fassino, 2016; Herbert, Blechert, Hautzinger, Matthias, & Herbert, 2013; Herbert, Herbert, & Pollatos, 2011; Longarzo et al., 2015; Murphy, Geary, Millgate, Catmur, & Bird, 2017; Pollatos & Georgiou, 2016; Taylor, Parker, Bagby, & Bourke, 1996). However, these factors have not consistently been taken into account when examining interoceptive processes in patients with ED. Taking these factors into consideration, and identifying to what extent and how deficits in the interpretation of signals arising from the body contribute to different EDs, might allow

for more targeted and effective interventions to be administered. Therefore, the current study first aimed to compare the magnitude of interoceptive deficits (as measured using the EDI) across different types of ED. Secondly, we aimed to examine whether age, illness duration, BMI, depression, and alexithymia serve as moderators for any interoceptive deficits observed in ED overall, and whether these were further specific to different subtypes of ED. We did not have any a-priori predictions regarding the directionality of interoceptive deficits across different ED subtypes, or how these deficits might be moderated by the factors mentioned above, since individual studies have often not specifically examined or had statistical power to address such questions in an ED population, have used different measures to assess interception, or have produced contradictory results in healthy and ED populations (e.g. see Longarzo et al., 2015 for interesting work on the relationship between interoception and alexitymia); as such, our meta-analyses represent a novel, quantitative exploration into these questions.

Method

Identification and Selection of Studies

A systematic literature search was conducted in accordance with PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). The electronic databases Scopus and PubMed were selected and searched systematically for peer-reviewed papers published prior to March 2017 (inclusive) using the terms "interocept*" and "eating disorders". A total of 328 articles were found using these terms, 124 from PubMed and 204 from Scopus. This was reduced to 253 articles when duplicates were removed.

The inclusion criteria were: (1) full text available in English, (2) a clinical sample with a prior diagnosis, or meeting a current diagnosis, of an eating disorder according to the DSM or ICD, (3) a control group with no current diagnosis of an eating disorder or any other

psychiatric diagnosis, (4) reporting mean and standard deviation Interoceptive Awareness scores from the EDI (any version; see Data Extraction, below), and sample size, for both clinical and control groups. Papers not meeting these criteria were excluded from analysis (see Figure 1).

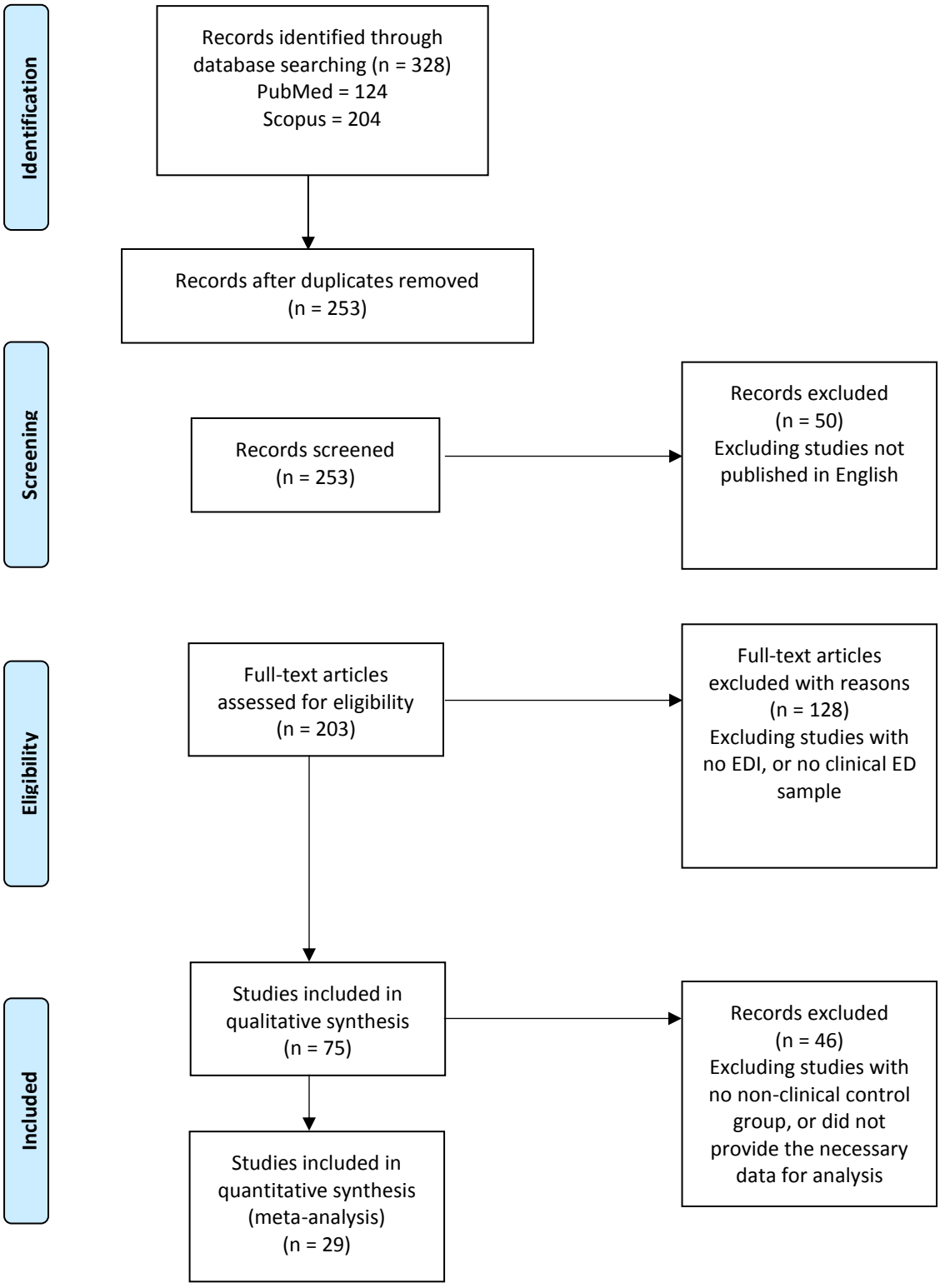


Figure 1. Flow diagram demonstrating the identification and selection process of studies for the analysis.

Data Extraction and Meta-Analysis Procedure

Data extracted from each paper were: ED diagnosis (AN, BN, BED or EDNOS); mean and standard deviations for: EDI Interoceptive Awareness (IA) score, age, ED duration, BMI, depression score (as measured using the BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and alexithymia score (as measured using the TAS-20; Bagby, Taylor, & Parker, 1994).

Data analysis was conducted using Comprehensive Meta-Analysis Version 2.0 for Windows (Borenstein, Hedges, Higgins, & Rothstein, 2005). The standardised mean difference (SMD; also known as Cohen's *d*) was used as an effect size, with values of 0.2, 0.5 and 0.8 corresponding to small, medium and large effects respectively (Cohen, 1988). For ease of interpretation, these can also be stated as a *Common Language Effect Size* (McGraw & Wong, 1992), also referred to as the probability of superiority, which expresses the probability that a randomly sampled person from one group (e.g. ED group) will have a higher observed score than a randomly sampled person from the another group (e.g. control group). The following guidelines apply: SMD: 0.2 = 56%, SMD: 0.5 = 64%, and SMD: 0.8 = 71% chance that a randomly sampled person with an eating disorder will have a greater interoceptive deficit than a person picked at random from the control group. Heterogeneity was examined using I^2 (Higgins, Thompson, Deeks, & Altman, 2003). The I^2 values describe the percentage of total variation across trials that is due to heterogeneity rather than sampling error (i.e. the proportion of variation that can be attributed to the actual differences between studies rather than within-study variance). The value of I^2 ranges from 0% (no inconsistency) and 100% (high heterogeneity) with values of 25%, 50%, and 75% suggested as low, moderate, and high heterogeneity. All analyses used a Random Effects model owing to the high level of heterogeneity identified (see Results). Publication bias was examined using

Duval and Tweedie's (2000) Trim and Fill technique, which aims to estimate the number of potentially missing studies and adjusts the effect size accordingly.

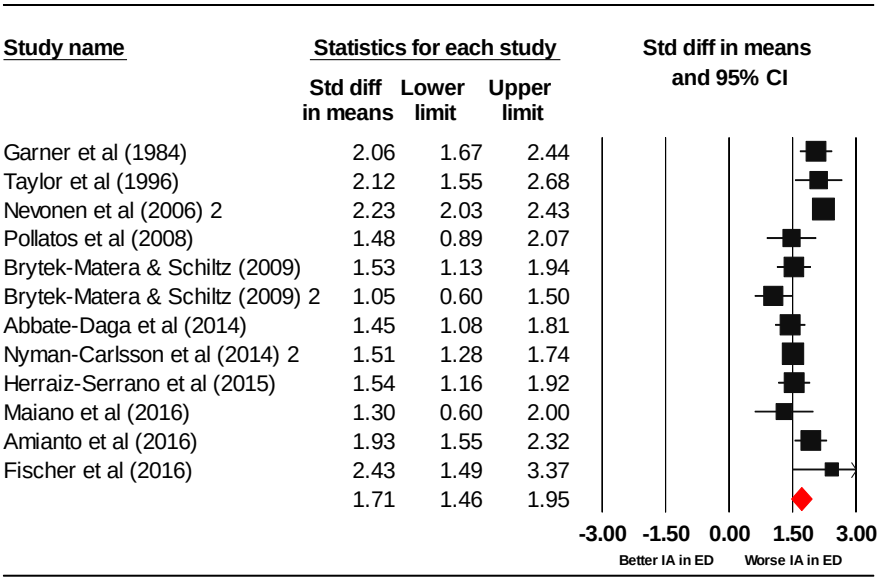
The impact of ED type on effect size was examined by splitting studies according to ED diagnoses: AN, BN, BED, EDNOS, and mixed eating disorder samples (i.e. containing patients with either AN, BN, BED or EDNOS). Studies including a separate recovered ED sample were also recorded and included in our overall meta-analyses. Meta-regressions were conducted to investigate whether age, duration of illness, BMI, depression and alexithymia were significant predictors of effect size. Although there is no definitive minimum number of studies required for meta-regression, we follow the general recommendation of at least 6 to 10 studies for a continuous variable (Fu et al., 2011; Higgins & Green, 2011); and for a (categorical) subgroup variable, a minimum of 4 studies per group (Fu et al., 2011).

Results

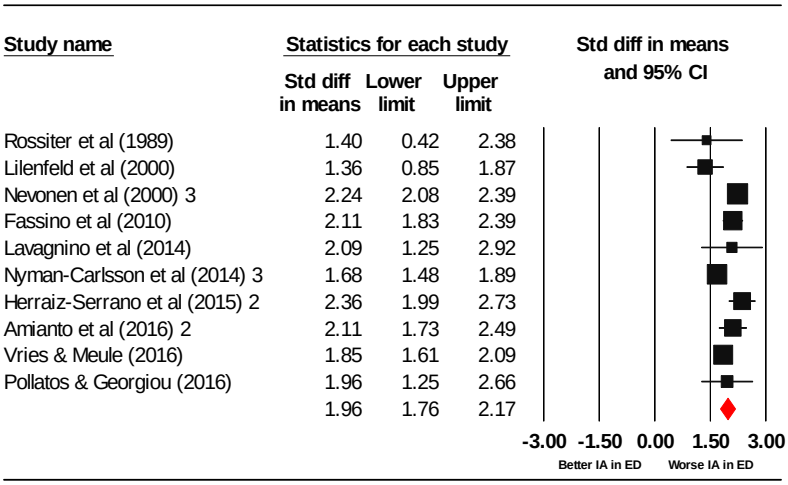
The analysis included 29 studies and 41 samples, providing a total sample of 4308 eating disorder participants and 3459 controls (7746 when controls are repeated in separate comparisons: see Table 1). The first, main analysis revealed significantly greater interoceptive deficits in the ED patients (SMD = 1.62: 95% CI = 1.46 to 1.77, $p < 0.001$)[2] compared with healthy controls, indicating an 87% chance that a person picked at random from the ED group will have a greater interoceptive deficit than a person picked at random from the control group (probability of superiority). The studies were heterogeneous, (Q (40) = 386.10, $p < 0.001$) with an I^2 value of 89.64. The high level of heterogeneity validated the suitability of a random-effects model and suggested the possible existence of moderating

[2] Two samples (Ciccolo & Johnsson, 2002, sample 2; Fitzgibbon, Sánchez-Johnsen, & Martinovich, 2003) were excluded as outliers showing no overlap of 95% CI with any other studies (the former also documented worse interoception in controls) and so, were excluded.

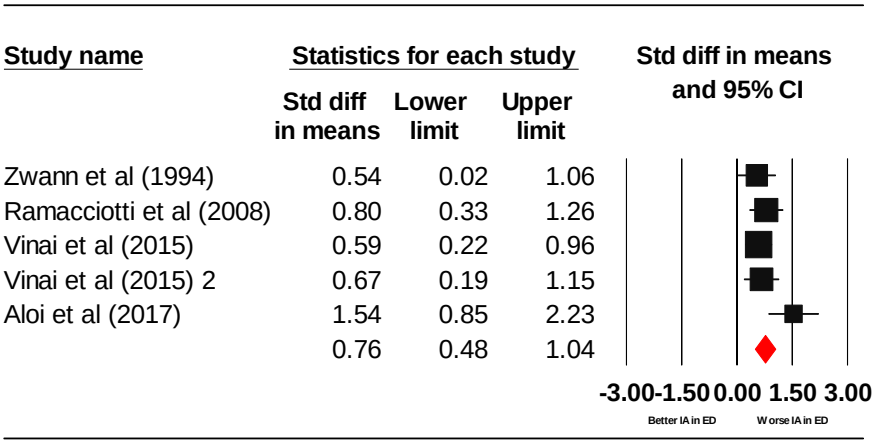
variables contributing to heterogeneity that required further investigation. Examination for publication bias Using Duval and Tweedie's (2000) Trim and Fill method highlighted two potentially missing studies, though it made no substantive difference to the effect size (SMD = 1.57: 95% CI = 1.41 to 1.73, $p < 0.001$).



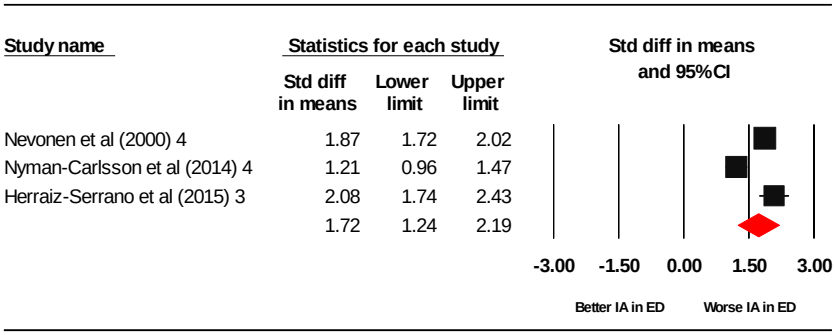
(A) Anorexia Nervosa



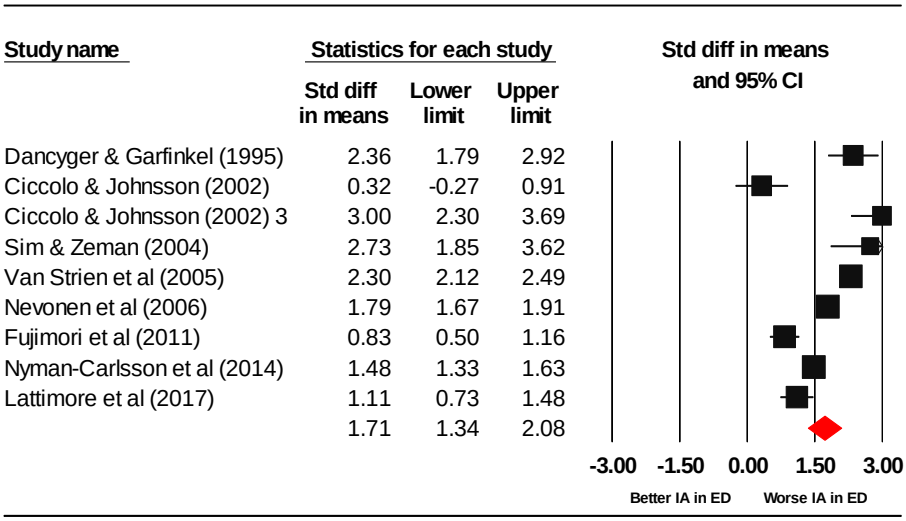
(B) Bulimia Nervosa



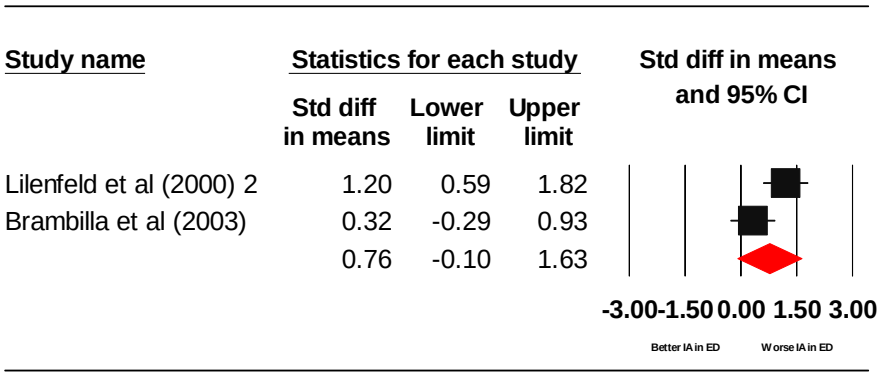
(C) Binge Eating Disorder



(D) Eating Disorder Not Otherwise Specified



(E) Mixed



(F) Recovered

Figure 2. Forest plots of interoceptive awareness in different ED diagnoses: A) Anorexia nervosa, B) Bulimia nervosa, C) Binge eating disorder, D) Eating disorder not otherwise specified, E) Mixed eating disorders, F) Recovered. (2014; 2017; 2016; 2003; 2009; 2002; 1995; 2016; 2010; 2016; 2011; 2015; 2013; 2017; 2014; 2000; 2016; 2006; 2015; 2008; 2016; 2008; 2004; 1996; 2005; 2015)

Interceptive deficits in different types of ED

Moderator analysis was undertaken to examine the impact of ED type on interoceptive deficit effect size (see Figure 2). The initial analysis included all 29 studies and 41 samples. The samples comprised: AN (k=12), BN (k=10), BED (k=5), EDNOS (k= 3), Mixed ED (k= 9) and participants recovered from AN or BN (k=2). A significant difference in pooled effect size was found amongst the various diagnostic groups ($Q(5) = 50.30$, $p < 0.001$).

We subsequently compared the size of interoceptive deficits across different ED diagnoses (see Figure 2 for individual forest plots). In accordance with the minimum study criteria for moderator analysis specified above (k≥4), patients with EDNOS (k=3) and participants recovered from AN or BN (k=2) were not analysed as part of subsequent comparisons. In addition, as the mixed group combined several types of ED (including AN,

BN and BED) it could not be meaningfully compared with the separate ED subtypes, and was not included in follow-up comparisons. The remaining comparisons between AN, BN and BED indicated that patients with BN report the greatest deficit overall, with interoceptive awareness being significantly lower in BN than BED ($Q(1) = 41.72$, $p < 0.001$), but not compared with AN ($Q(1) = 2.57$, $p= 0.11$. In addition, patients with AN showed a significantly greater interoceptive deficit compared with BED ($Q(1) = 25.27$, $p = 0.001$). The level of heterogeneity (I^2) was lower in each of these separate ED subsamples (AN = 77.91%, BN = 71.17%, BED = 38.31%) compared to when all ED types were grouped and analysed together (89.64%), as might be expected; however, the relatively high level of heterogeneity remaining in these sub-samples suggests that there may still be other unidentified sources of heterogeneity. We explored these factors in further moderator analyses below.

Further Moderator Analysis

The influence of age, illness duration, BMI, depression, and alexithymia on interoceptive awareness were analysed using meta-regression. As indicated above, meta-regressions were not run with subsamples fewer than six or in mixed samples. In addition, analyses were not run where the target measure was not reported or sufficiently variable for analyses to be run on the sample. Table 1 provides a summary of the meta-regressions conducted.

Table 1. Summary of the findings of the meta-regressions for each moderator variable.

Moderator Variable	**Diagnoses**	**k**	***p* value**
Average Age (16.7 to 43.8)	All	28	*Q=32.72, p < 0.001*
	AN	9	*Q=7.83 p =0.005*
	BN	6	*Q= 3.89 p=0.04*

BMI (15.7 to 44.82)	All	17	*Q=57.92 p < 0.001*
TAS score (54.1 to 67.05)	AN, BN and BED	6	*Q=1.71 p=.19*
BDI score (12.78 to 28.70)	AN, BN, BED and EDNOS	8	*Q= 0.26 p = 0.61*

Age*:* Meta-regression revealed greater interoceptive deficits in younger samples when samples of all ED subtypes were included in the analyses (k=28). However, sub-analysis of patients with BN (k=6) and AN (k=9) separately indicated that interoceptive deficits were, contrastingly, significantly larger in older groups.

Illness Duration: There were too few samples to run regression analysis on illness duration.

BMI: Across 17 samples that included all types of ED diagnoses, significantly greater interoception deficits occurred in samples with lower mean BMI.

Depression: Depression was recorded in 8 ED samples which included the diagnoses AN, BN, EDNOS and BED. Meta-regression of these samples revealed that average depression score was not a significant predictor of effect size.

Alexithymia: A meta-regression of 6 samples which included the diagnoses AN, BN and BED found significantly greater interoception deficits in samples with lower mean alexithymia scores (i.e. less alexithymia / better at identifying and labelling emotions).

Discussion

The aim of the current meta-analysis was to investigate the extent of self-reported interoceptive deficits in EDs, and examine how various factors (i.e. ED diagnosis, age, illness duration, BMI, depression and alexithymia) may influence interoceptive deficits in ED. We identified 41 ED samples comprising 4308 people with various types of ED (including AN, BN, BED, and EDNOS), and compared these with 3459 healthy controls. A significant

interoceptive deficit was found across this ED sample, with a very large effect size (SMD) of 1.62. This equates to there being approximately 87% chance that a person picked at random from the ED group will have a greater interoceptive deficit compared with a person picked at random from the control group. Furthermore, comparison across different ED subtypes revealed the novel finding that interoceptive deficits appear to exist on a continuum in EDs, with BN and AN patients experiencing significantly more pronounced interoceptive deficits compared to patients with BED. Our analyses also revealed that interoceptive deficits are greater in ED patients with a lower BMI and younger age. Separate moderator analyses of BN and AN patients, however, revealed a contrasting pattern in which interoceptive deficits are greater in older patients. Finally, we found that interoceptive deficits across several EDs were not related to levels of depression; however, individuals with lower levels of alexithymia report greater interoceptive deficits. We discuss these findings in greater detail below

Our first, overall finding of an interoceptive deficit in patients with ED is consistent across samples and studies, and accords with the long proposed disturbance of interoception in EDs (Bruch, 1962). More importantly, we document for the first time that a large and significant interoception deficit occurs across a wide range of eating disorders. Analysis of specific EDs revealed large effect sizes in each group: AN (SMD = 1.71), BN (SMD = 1.96), BED (SMD = 0.76); EDNOS (SMD = 1.72), mixed diagnoses (SMD = 1.71) and those who had recovered from eating disorders (SMD = 0.76). We also present the hitherto unreported finding that BN and AN samples experience the *greatest* impairment of interoceptive abilities, whereas BED samples were found to report the *smallest*. Interestingly, even recovered AN and BN samples displayed a large effect size (Figure 2F). The observation that substantial interoceptive deficits remain after recovery suggests a relative trait stability of such deficits and may have clinical implications for defining recovery from an eating

disorder. For example, recovery of interoceptive abilities may not be a useful indicator for assessing ED recovery; however, the modest number of recovered samples (K=2) means this finding should be interpreted cautiously.

Our finding that significant interoception deficits occur in all ED diagnoses lends support to a continuum or transdiagnostic approach to ED, which supposes that ED lie on a spectrum of dieting and weight concerns rather than being qualitatively distinct (Dancyger & Garfinkel, 1995; Ruderman & Besbeas, 1992). The core symptomology of EDs is the same, but can be expressed differently through the varying severity and kinds of eating behaviours displayed throughout the course of the disorder (Fairburn, Cooper, & Shafran, 2003). In line with this approach, we found that although interoceptive deficits are consistent across all EDs, significant inter-diagnostic differences emerge in the degree of impairment. Previous research has explored a variety of endophenotypes[3] in EDs (for a discussion see Bulik et al., 2007; Thornton, Mazzeo, & Bulik, 2011) and the accumulated evidence presented here points to interoception deficits as a candidate endophenotype for EDs. However, it remains unclear whether these deficits play a role in the onset and maintenance of the disorders, or are caused in some way by the disorder and its symptoms. In this context, Lilenfeld and colleagues (2000) posit an interesting distinction regarding traits that persist after recovery from an eating disorder and in particular to whether such traits reflect either "…a potential vulnerability factor contributing to the development of the ED or a ' scar' (i.e. consequence) of the illness." (p. 1400). Lilenfeld et al. found diminished interoceptive awareness amongst previously eating-disordered relatives of bulimic probands when compared to their never-ill relatives. They interpret this as consistent with their 'scar' model, i.e. that having had an

[3] "Endophenotypes are considered to be measureable biological markers for a disease which are associated with the illness in the general population, are observable regardless of whether the illness is active, are observed in unaffected family members of probands at a higher rate than in the general population, and are heritable" (Thornton et al., 2011, p. 4)

eating disorder leaves a 'scar'; however, as they later note "…it is impossible to definitively determine which may be 'scar effects' and which may be predisposing factors at the present time" (Lilenfeld, Wonderlich, Riso, Crosby, & Mitchell, 2006, p. 313). Nonetheless, a large prospective study of junior high and high school students found that poor interoceptive awareness (from the EDI) predicted risk of eating disorders one year later (Leon, Fulkerson, Perry, & Early-Zald, 1995). Thus, a next step to further explore this line of thinking would be for future studies to assess interoception in the unaffected first degree relatives of those with EDs.

We found that mean age was a significant predictor of interoception deficit, being greater in younger samples; however separate analyses of AN and BN samples revealed contrastingly greater interoceptive deficits in older samples. The separate analysis of age and interoceptive deficit in BN patients included only a small number of samples, and this limits the conclusions that can be drawn regarding this finding. It is possible that the overall analysis may have been influenced by diagnosis, as BED samples typically had a higher average sample age and were found to have significantly smaller effect sizes, which may explain the difference in direction of the relationship found in the overall and sub-analyses. Unfortunately, there were too few samples to also analyse the effect of illness duration on interoceptive deficits, and so it is not possible to determine whether the link between age and interoceptive deficit is simply a result of the illness length, or if interoceptive deficits are a stable trait that do not change over time. In order to draw such conclusions, future studies are needed that record illness duration.

We also found that individuals with lower BMIs have significantly greater interoceptive deficits; however, the finding of a negative relationship between effect size and BMI may have again been influenced by ED subtype. Unfortunately, it was not possible to carry out further analysis of individual ED subtypes because of limitations in the recorded

range of BMI and / or too few studies reporting BMI for meta-regression to be performed. Nevertheless, we note that the samples with larger BMIs were those with a BED diagnoses, which were also found in the current analyses to have significantly smaller interoceptive deficits than samples with BN or AN. Our attempts to analyse BMI and interoceptive deficits in EDs highlights potential difficulties in examining the influence of BMI across ED samples more generally. The link between interoceptive deficits, BMI and EDs may be more complex than is currently understood based on the limited evidence available, and additional research, which includes a range of BMIs and weight-recovered AN patients, is needed to examine these relationships.

Our meta-regression of alexithymia indicated that individuals with poor emotional awareness do not necessarily have poor interoception. Surprisingly, we found that greater levels of alexithymia (i.e. poorer ability to identify / label emotions / feelings) predicted fewer self-reported interoception deficits (i.e. better interoception). This finding is based on the results of only six studies and samples with relatively high levels of alexithymia overall (the mean across our samples ranged between 54.1 and 67.05, and a TAS-20 score of 61 or above indicates high levels of alexithymia; Bagby et al., 1994), and so should be interpreted with care and/or limited to individuals with relatively high alexithymia. Nevertheless, the analysis included several types of ED, and confirms the high occurrence of alexithymia in EDs (Westwood et al., 2017). Moreover, this finding is particularly notable given similarities between the interpretative aspect of interoception (as measured by the EDI) and alexithymia (see Eshkevari, Rieger, Musiat, & Treasure, 2014). Our result provides further insight into current debates and contrasting findings regarding the relationship between alexithymia and interoception (see Longarzo et al., 2015; Zamariola, Vlemincx, Luminet, & Corneille, 2018). The findings are consistent with previous research suggesting that greater levels of alexithymia are related to better interoception (i.e. individuals with poor emotional awareness

report greater somatic awareness; Ernst, Northoff, Böker, Seifritz, & Grimm, 2013; Longarzo et al., 2015). This seemingly counterintuitive relationship can be explained by the suggestion that paying attention to interoceptive sensations (i.e. high interoception) may hamper the interpretation of one's emotional feelings (i.e. high alexithymia), and contribute to somatoform disorders via the misinterpretation of physical sensations (Longarzo et al., 2015).

Finally, we found that depression, as measured by the BDI (Beck et al., 1961), was not a significant predictor of interoception deficit effect size. Indeed, the association between depressive symptoms and interoceptive abilities has not always been consistent in previous research. For example, Dunn, Dalgleish, Ogilvie, and Lawrence (2007) found a significant difference in interoception (as measured using a heartbeat perception task; see Schandry, 1981) between individuals with moderate depression and controls, but no significant difference between severely depressed individuals and controls. Pollatos, Traut-Mattausch, and Schandry (2009) found evidence of a significant negative relationship between depression and scores on a heartbeat perception measure of interoception in healthy participants, however also found a significant interaction with anxiety, where this relationship only remained significant at high levels of anxiety. Therefore, both the severity of depressive symptoms and levels of anxiety in the samples used in this analysis may have had an influence over the relationship between depression symptoms and effect size, and may explain why no significant relationship was found. The average BDI scores of the samples analysed were also within the minimal-to-moderate range according to established BDI cut-offs. This limited variability in depression scores necessarily limits the generalisability of our findings to individuals with mild to moderate depression.

Limitations and Recommendations

An important caveat of our findings is that the conclusions drawn relate only to self-reported interoceptive deficits measured by the Interoceptive Awareness subscale of the

Eating Disorder Inventory (EDI). This leads to two potential limitations. Firstly, the EDI has been criticised as an assessment of interoception, as it primarily considers the interpretative, emotional aspect of interoception (Eshkevari et al., 2014), and fails to differentiate between a confusion or lack of clarity regarding internal experiences and non-acceptance of affective arousal (Merwin, Zucker, Lacy & Elliott, 2010). Moreover, it is possible that, despite self-reporting more interoceptive deficits, individuals with certain types of ED lack insight and consequently underreport the true extent of their interoceptive deficits. This would, for example, be consistent with the differing symptomology of AN and BN, where patients with AN often lack insight into or deny their illness and symptoms, whereas patients with BN are typically more motivated to recover (Konstantakopoulos, Tchanturia, Surguladze, & David, 2011). This difference in awareness may, therefore, account to some extent for the differences found in interoceptive deficits between AN and BN patients.

Second, recent research distinguishes between different types or levels of interoceptive ability (Garfinkel, Seth, Barrett, Suzuki, & Critchley, 2015), with *interoceptive sensibility* referring to the subjective, self-evaluation of interoceptive ability; *interoceptive accuracy* referring to an individual's objective accuracy in detecting and tracking internal bodily sensations; and *interoceptive awareness* referring to the a meta-cognitive measure of the correspondence between the objective and subjective measures (see also Ceunen, Vlaeyen, & Van Diest, 2016 for discussion of the origin and development of interoception as a concept). As mentioned above, Bruch (1962) also distinguished between two kinds of interoceptive ability in ED (perception vs. interpretation of body signals). Importantly, the different dimensions of interoception may be distinct and dissociable (Garfinkel et al., 2016; Garfinkel & Critchley, 2013). Unfortunately, our systematic search identified only three studies that examined interoceptive ability objectively in an ED sample (Fischer et al., 2016; Klabunde et al., 2013; Pollatos et al., 2008), using a heartbeat detection task (Schandry,

1981), and so it was not possible to include these in our meta-analysis and/or conduct any meaningful comparisons. Therefore, an important aim for future ED research should be to include both objective and subjective measures of interoceptive ability, to look at awareness across different modalities (e.g. cardiovascular, gastrointensinal, pain and pleasant touch; see Crucianelli, Cardi, Treasure, Jenkinson, & Fotopoulou, 2016; Herbert, Muth, Pollatos, & Herbert, 2012 for examples), and to see how deficits relate to body image and ownership (see Badoud & Tsakiris, 2017; Crucianelli, Krahé, Jenkinson, & Fotopoulou, 2016). Although no 'gold standard' measure of interoception exists, new methods have been developed to capture the multidimensional nature of interoception (see Garfinkel et al., 2015; Longarzo et al., 2015; Mehling et al., 2009, 2012), and validated in a clinical eating disorder sample (e.g. Brown et al., 2017)

The current review also highlighted how most existing ED studies have assessed samples of AN and BN, with only three samples of EDNOS, despite this being the most common eating disorder seen in outpatient settings (Fairburn & Bohn, 2005). Our review also identified only a limited number of studies involving recovered and BED samples, again highlighting a clear gap in the current literature. Understandably, fewer studies have focused on BED in comparison to other diagnoses, since it was only recently introduced as a diagnostic category in DSM-5 (American Psychiatric Association, 2013). A particular focus is required on future studies with recovered eating disorder samples, EDNOS and BED in order to more accurately determine the pathogenesis of these EDs, and to assess the validity of introception as an endophenotype.

Finally, in additional to the limited number of studies looking at certain ED subtypes, our review of the literature identified that important clinical variables, such as illness duration and BMI, were not always reported by existing studies. Our meta-analysis was unable to examine the potentially important relationships between illness duration, overall disorder

severity and interoceptive abilities, as the majority of studies did not report on the illness duration or severity of their samples. Overall, these issues highlight the need for future research to consistently report on key clinical variables, as well as the need for more research to examine the relationship between the variables and interoception directly using multiple measures.

Conclusion

We confirm the existence of a substantial, self-reported interoceptive deficit in all types of EDs examined. Impaired interoception may, therefore, be considered a transdiagnostic characteristic of EDs and a possible endophenotype. The degree of interoceptive deficit varies across ED subtypes and may provide a useful distinguishing feature of different EDs. They may also play a maintenance role in eating disorders, and consequently be an appropriate target for treatment or prevention. The extent of interoceptive deficit may be influenced by several factors, such as age, BMI, and alexithymia; however, further evidence is needed to substantiate these conclusions, with future studies reporting these factors as well as illness duration, and employing both objective and subjective measures in direct examinations of interoceptive process across all types of EDs.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interest Statement

The authors have no competing interests to report.

References

Abbate-Daga, G., Buzzichelli, S., Marzola, E., Amianto, F., & Fassino, S. (2014). Clinical investigation of set-shifting subtypes in anorexia nervosa. *Psychiatry Research, 219*(3), 592–597. http://doi.org/10.1016/j.psychres.2014.06.024

Aloi, M., Rania, M., Caroleo, M., De Fazio, P., & Segura-Garcia, C. (2017). Social Cognition and Emotional Functioning in Patients with Binge Eating Disorder. *European Eating Disorders Review*, *25*(3), 172–178. http://doi.org/10.1002/erv.2504

American Psychiatric Association. (2013). *American Psychiatric Association, 2013. Diagnostic and statistical manual of mental disorders (5th ed.). American Journal of Psychiatry*. http://doi.org/10.1176/appi.books.9780890425596.744053

Amianto, F., Bertorello, A., Migliore, F., Abbate-Daga, G., & Fassino, S. (2016). Alexithymia in anorexia and bulimia: Ubiquitous and primary trait? *Cogent Psychology*, *3*(1), 1–15. http://doi.org/10.1080/23311908.2016.1185994

Arcelus, J., Mitchell, A. J., Wales, J., & Nielsen, S. (2011). Mortality rates in patients with anorexia nervosa and other eating disorders: A meta-analysis of 36 studies. *Archives of General Psychiatry*, *68*(7), 724–731. http://doi.org/10.1001/archgenpsychiatry.2011.74

Badoud, D., & Tsakiris, M. (2017). From the body's viscera to the body's image: Is there a link between interoception and body image concerns? *Neuroscience and Biobehavioral Reviews*, *77*(April), 237–246. http://doi.org/10.1016/j.neubiorev.2017.03.017

Bagby, R. M., Taylor, G. J., & Parker, J. D. (1994). The Twenty-item Toronto Alexithymia Scale--II. Convergent, discriminant, and concurrent validity. *Journal of Psychosomatic Research*, *38*, 33–40 ST–The Twenty–item Toronto Alexithymia Sc. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8126688

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561–71. http://doi.org/10.1001/archpsyc.1961.01710120031004

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2005). Comprehensive Meta-Analysis. Englewood, NJ: Biostat.

Brambilla, F., Monteleone, P., Bortolotti, F., Dalle Grave, R., Todisco, P., Favaro, A., … Maj, M. (2003). Persistent amenorrhoea in weight-recovered anorexics: Psychological and biological aspects. *Psychiatry Research, 118*(3), 249–257. http://doi.org/10.1016/S0165-1781(03)00074-X

Brown, T. A., Berner, L. A., Jones, M. D., Reilly, E. E., Cusack, A., Anderson, L. K., … Wierenga, C. E. (2017). Psychometric Evaluation and Norms for the Multidimensional Assessment of Interoceptive Awareness (MAIA) in a Clinical Eating Disorders Sample. *European Eating Disorders Review*, *25*(5), 411–416. http://doi.org/10.1002/erv.2532

Bruch, H. (1962). Perceptual and conceptual disturbances in anorexia nervosa. *Psychosomatic Medicine*, *24*(2), 187–194. http://doi.org/10.1097/00006254-196210000-00037

Brytek-Matera, A., & Schiltz, L. (2009). A cross-cultural examination of the relationship between negative mood states, body image and eating disorders. *Bulletin de La Société Des Sciences Médicales Du Grand-Duché de Luxembourg*, *33*(1), 11–25. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/21940855

Bulik, C. M., Hebebrand, J., Keski-Rahkonen, A., Klump, K. L., Reichborn-Kjennerud, T., Mazzeo, S. E., & Wade, T. D. (2007). Genetic epidemiology, endophenotypes, and eating disorder classification. *International Journal of Eating Disorders*. http://doi.org/10.1002/eat.20398

Cameron, O. G. (2001). Interoception: The inside story--a model for psychosomatic

processes. *Psychosomatic Medicine*, *63*, 697–710. http://doi.org/0033-3174/01/6305-0697

Ceunen, E., Vlaeyen, J. W. S., & Van Diest, I. (2016). On the origin of interoception. *Frontiers in Psychology*, *7*(MAY), 1–17. http://doi.org/10.3389/fpsyg.2016.00743

Ciccolo, E. B. F., & Johnsson, P. (2002). Personality and self-concept in subgroups of patients with anorexia nervosa and bulimia nervosa. *Social Behavior and Personality*, *30*(4), 347–357.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences. *Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc*, *474*.

Craig, A. D. (2003). Interoception: The sense of the physiological condition of the body. *Current Opinion in Neurobiology*, *13*(4), 500–505. http://doi.org/10.1016/S0959-4388(03)00090-4

Crucianelli, L., Cardi, V., Treasure, J., Jenkinson, P. M., & Fotopoulou, A. (2016). The perception of affective touch in anorexia nervosa. *Psychiatry Research*, *239*, 72–78. http://doi.org/10.1016/j.psychres.2016.01.078

Crucianelli, L., Krahé, C., Jenkinson, P. M., & Fotopoulou, A. (2016). Interoceptive ingredients of body ownership: Affective touch and cardiac awareness in the rubber hand illusion. *Cortex*. http://doi.org/10.1016/j.cortex.2017.04.018

Culbert, K. M., Racine, S. E., & Klump, K. L. (2015). Research Review: What we have learned about the causes of eating disorders - a synthesis of sociocultural, psychological, and biological research. *Journal of Child Psychology and Psychiatry*, *56*(11), 1141–1164. http://doi.org/10.1111/jcpp.12441

Dancyger, I. F., & Garfinkel, P. E. (1995). The relationship of partial syndrome eating disorders to anorexia nervosa and bulimia nervosa. *Psychological Medicine*, *25*(5), 1019–25. http://doi.org/10.1017/S003329170003751X

de Vries, S. K., & Meule, A. (2016). Food Addiction and Bulimia Nervosa: New Data Based on the Yale Food Addiction Scale 2.0. *European Eating Disorders Review*, *24*(6), 518–522. http://doi.org/10.1002/erv.2470

Dunn, B. D., Dalgleish, T., Ogilvie, A. D., & Lawrence, A. D. (2007). Heartbeat perception in depression. *Behaviour Research and Therapy*, *45*(8), 1921–1930. http://doi.org/10.1016/j.brat.2006.09.008

Duval, S., & Tweedie, R. (2000). Trim and Fill: A Simple Funnel-Plot-Based Method of Testing and Adjusting for Publication Bias in Meta-Analysis. *Biometrics*, *56*(2), 455–463. http://doi.org/10.1111/j.0006-341X.2000.00455.x

Ernst, J., Northoff, G., Böker, H., Seifritz, E., & Grimm, S. (2013). Interoceptive awareness enhances neural activity during empathy. *Human Brain Mapping*, *34*(7), 1615–24. http://doi.org/10.1002/hbm.22014

Eshkevari, E., Rieger, E., Musiat, P., & Treasure, J. (2014). An Investigation of Interoceptive Sensitivity in Eating Disorders Using a Heartbeat Detection Task and a Self-report Measure. *European Eating Disorders Review*, *22*(5), 383–388. http://doi.org/10.1002/erv.2305

Fairburn, C. G., & Bohn, K. (2005). Eating disorder NOS (EDNOS): an example of the troublesome "not otherwise specified" (NOS) category in DSM-IV. *Behaviour Research and Therapy*, *43*(6), 691–701. http://doi.org/10.1016/j.brat.2004.06.011

Fairburn, C. G., Cooper, Z., & Shafran, R. (2003). Cognitive behaviour therapy for eating disorders: A "transdiagnostic" theory and treatment. *Behaviour Research and Therapy*. http://doi.org/10.1016/S0005-7967(02)00088-8

Fassino, S., Amianto, F., Rocca, G., & Daga, G. A. (2010). Parental bonding and eating psychopathology in bulimia nervosa: Personality traits as possible mediators. *Epidemiology and Psychiatric Sciences*, *19*(3), 214–222.

http://doi.org/10.1017/S1121189X00001147

Fassino, S., Pierò, A., Gramaglia, C., & Abbate-Daga, G. (2004). Clinical, psychopathological and personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and obesity. *Psychopathology*, *37*(4), 168–174. http://doi.org/10.1159/000079420

Fischer, D., Berberich, G., Zaudig, M., Krauseneck, T., Weiss, S., & Pollatos, O. (2016). Interoceptive processes in anorexia nervosa in the time course of cognitive-behavioral therapy: A pilot study. *Frontiers in Psychiatry*, *7*(DEC). http://doi.org/10.3389/fpsyt.2016.00199

Fitzgibbon, M. L., Sánchez-Johnsen, L. A. P., & Martinovich, Z. (2003). A test of the continuity perspective across bulimic and binge eating pathology. *International Journal of Eating Disorders*, *34*(1), 83–97. http://doi.org/10.1002/eat.10160

Fu, R., Gartlehner, G., Grant, M., Shamliyan, T., Sedrakyan, A., Wilt, T. J., … Trikalinos, T. A. (2011). Conducting quantitative synthesis when comparing medical interventions: AHRQ and the Effective Health Care Program. *Journal of Clinical Epidemiology*, *64*(11), 1187–97. http://doi.org/10.1016/j.jclinepi.2010.08.010

Fujimori, A., Wada, Y., Yamashita, T., Choi, H., Nishizawa, S., Yamamoto, H., & Fukui, K. (2011). Parental bonding in patients with eating disorders and self-injurious behavior. *Psychiatry and Clinical Neurosciences*, *65*(3), 272–279. http://doi.org/10.1111/j.1440-1819.2011.02192.x

Garfinkel, S. N., & Critchley, H. D. (2013). Interoception, emotion and brain: new insights link internal physiology to social behaviour. Commentary on:: “Anterior insular cortex mediates bodily sensibility and social anxiety” by Terasawa et al. (2012). *Social Cognitive and Affective Neuroscience*. http://doi.org/10.1093/scan/nss140

Garfinkel, S. N., Seth, A. K., Barrett, A. B., Suzuki, K., & Critchley, H. D. (2015). Knowing

your own heart: Distinguishing interoceptive accuracy from interoceptive awareness. *Biological Psychology*, *104*, 65–74. http://doi.org/10.1016/j.biopsycho.2014.11.004

Garfinkel, S. N., Tiley, C., O'Keeffe, S., Harrison, N. A., Seth, A. K., & Critchley, H. D. (2016). Discrepancies between dimensions of interoception in autism: Implications for emotion and anxiety. *Biological Psychology*, *114*, 117–126. http://doi.org/10.1016/j.biopsycho.2015.12.003

Garner, D. M. (1991). *Eating disorder inventory-2. Professional manual*. Odessa, FL: Psychological Assessment Research, Inc.

Garner, D. M. (2004). *Eating Disorder Inventory-3. Professional Manual*. Lutz, FL: Psychological Assessment Resources, Inc.

Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders*, *2*(2), 15–34. http://doi.org/10.1002/1098-108X(198321)2:2<15::AID-EAT2260020203>3.0.CO;2-6

Gratz, K. L., & Roemer, L. (2004). Multidimensional Assessment of Emotion Regulation and Dysregulation: Development, Factor Structure, and Initial Validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54. http://doi.org/10.1023/B:JOBA.0000007455.08539.94

Herbert, B. M., Blechert, J., Hautzinger, M., Matthias, E., & Herbert, C. (2013). Intuitive eating is associated with interoceptive sensitivity. Effects on body mass index. *Appetite*, *70*, 22–30. http://doi.org/10.1016/j.appet.2013.06.082

Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality*, *79*(5), 1149–1175. http://doi.org/10.1111/j.1467-6494.2011.00717.x

Herbert, B. M., Muth, E. R., Pollatos, O., & Herbert, C. (2012). Interoception across modalities: On the relationship between cardiac awareness and the sensitivity for gastric functions. *PLoS ONE*, *7*(5), 1–9. http://doi.org/10.1371/journal.pone.0036646

Herraiz-Serrrano, C., Rodríguez-Cano, T., Beato-Fernández, L., Latorre-Postigo, J. M., Rojo-Moreno, L., & Vaz-Leal, F. J. (2015). Parental rearing and eating psychopathology. *Actas Espanolas de Psiquiatria*, *43*(3), 91–98.

Higgins, J. P. T., Green, S., & (editors). (2011). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. *The Cochrane Collaboration*. Retrieved from www.handbook.cochrane.org

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ*, *327*(7414), 557–560. http://doi.org/10.1136/bmj.327.7414.557

Klabunde, M., Acheson, D. T., Boutelle, K. N., Matthews, S. C., & Kaye, W. H. (2013). Interoceptive sensitivity deficits in women recovered from bulimia nervosa. *Eating Behaviors*, *14*(4), 488–492. http://doi.org/10.1016/j.eatbeh.2013.08.002

Konstantakopoulos, G., Tchanturia, K., Surguladze, S. A., & David, A. S. (2011). Insight in eating disorders: clinical and cognitive correlates. *Psychological Medicine*, *41*(9), 1951–1961. http://doi.org/10.1017/S0033291710002539

Lattimore, P., Mead, B. R., Irwin, L., Grice, L., Carson, R., & Malinowski, P. (2017). "I can"t accept that feeling': Relationships between interoceptive awareness, mindfulness and eating disorder symptoms in females with, and at-risk of an eating disorder. *Psychiatry Research*, *247*(November 2016), 163–171. http://doi.org/10.1016/j.psychres.2016.11.022

Lavagnino, L., Amianto, F., D'Agata, F., Huang, Z., Mortara, P., Abbate-Daga, G., … Northoff, G. (2014). Reduced resting-state functional connectivity of the somatosensory

cortex predicts psychopathological symptoms in women with bulimia nervosa. *Frontiers in Behavioral Neuroscience*, *8*(August), 270. http://doi.org/10.3389/fnbeh.2014.00270

Leon, G. R., Fulkerson, J. A., Perry, C. L., & Early-Zald, M. B. (1995). Prospective analysis of personality and behavioral vulnerabilities and gender influences in the later development of disordered eating. *Journal of Abnormal Psychology*, *104*(1), 140–149. http://doi.org/10.1037/0021-843X.104.1.140

Lilenfeld, L. R. R., Stein, D., Bulik, C. M., Strober, M., Plotnicov, K., Pollice, C., … Kaye, W. H. (2000). Personality traits among currently eating disordered, recovered and never ill first-degree female relatives of bulimic and control women. *Psychological Medicine*, *30*, 1399–410. http://doi.org/10.1017/S0033291799002792

Lilenfeld, L. R. R., Wonderlich, S., Riso, L. P., Crosby, R., & Mitchell, J. (2006). Eating disorders and personality: A methodological and empirical review. *Clinical Psychology Review*, *26*(3), 299–320. http://doi.org/10.1016/j.cpr.2005.10.003

Longarzo, M., D'Olimpio, F., Chiavazzo, A., Santangelo, G., Trojano, L., & Grossi, D. (2015). The relationships between interoception and alexithymic trait. The Self-Awareness Questionnaire in healthy subjects. *Frontiers in Psychology*, *6*, 1149. http://doi.org/10.3389/fpsyg.2015.01149

Maïano, C., Morin, A. J. S., Monthuy-Blanc, J., Garbarino, J. M., & Ninot, G. (2016). Development and validity of a very short form of the Eating Disorder Inventory. *Comprehensive Psychiatry*, *65*, 141–149. http://doi.org/10.1016/j.comppsych.2015.11.004

McGraw, K. O., & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin*, *111*(2), 361–365. http://doi.org/10.1037/0033-2909.111.2.361

Merwin, R. M., Zucker, N. L., Lacy, J. L., & Elliott, C. A. (2010). Interoceptive awareness in eating disorders: Distinguishing lack of clarity from non-acceptance of internal

experiences. *Cognition and Emotion*, *24*(5), 892-902. https://doi.org/10.1080/02699930902985845

Mehling, W. E., Gopisetty, V., Daubenmier, J., Price, C. J., Hecht, F. M., & Stewart, A. (2009). Body awareness: Construct and self-report measures. *PLoS ONE*, *4*(5). http://doi.org/10.1371/journal.pone.0005614

Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLoS ONE*, *7*(11). http://doi.org/10.1371/journal.pone.0048230

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, T. P. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine*, *6*(7), e1000097. http://doi.org/10.1371/journal.pmed.1000097

Murphy, J., Geary, H., Millgate, E., Catmur, C., & Bird, G. (2017). Direct and indirect effects of age on interoceptive accuracy and awareness across the adult lifespan. *Psychonomic Bulletin and Review*, pp. 1–10. http://doi.org/10.3758/s13423-017-1339-z

Nevonen, L., Clinton, D., & Norring, C. (2006). Validating the EDI-2 in three Swedish female samples: Eating disorders patients, psychiatric outpatients and normal controls. *Nordic Journal of Psychiatry*, *60*(1), 44–50. http://doi.org/10.1080/08039480500504537

Nyman-Carlsson, E., Engström, I., Norring, C., & Nevonen, L. (2015). Eating Disorder Inventory-3, validation in Swedish patients with eating disorders, psychiatric outpatients and a normal control sample. *Nordic Journal of Psychiatry*, *69*(2), 142–151. http://doi.org/10.3109/08039488.2014.949305

Pollatos, O., & Georgiou, E. (2016). Normal interoceptive accuracy in women with bulimia nervosa. *Psychiatry Research*, *240*, 328–332. http://doi.org/10.1016/j.psychres.2016.04.072

Pollatos, O., Kurz, A. L., Albrecht, J., Schreder, T., Kleemann, A. M., Schöpf, V., …

Schandry, R. (2008). Reduced perception of bodily signals in anorexia nervosa. *Eating Behaviors*, *9*(4), 381–388. http://doi.org/10.1016/j.eatbeh.2008.02.001

Pollatos, O., Traut-Mattausch, E., & Schandry, R. (2009). Differential effects of anxiety and depression on interoceptive accuracy. *Depression and Anxiety*, *26*(2), 167–173. http://doi.org/10.1002/da.20504

Ramacciotti, C. E., Coli, E., Bondi, E., Burgalassi, A., Massimetti, G., & Dell'Osso, L. (2008). Shared psychopathology in obese subjects with and without binge-eating disorder. *International Journal of Eating Disorders*, *41*(7), 643–649. http://doi.org/10.1002/eat.20544

Ruderman, A. J., & Besbeas, M. (1992). Psychological characteristics of dieters and bulimics. *Journal of Abnormal Psychology*. US: American Psychological Association. http://doi.org/10.1037/0021-843X.101.3.383

Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology*, *18*(4), 483–488. http://doi.org/10.1111/j.1469-8986.1981.tb02486.x

Sim, L., & Zeman, J. (2004). Emotion Awareness and Identification Skills in Adolescent Girls with Bulimia Nervosa. *Journal of Clinical Child and Adolescent Psychology*, *33*(4), 760–771. http://doi.org/10.1207/s15374424jccp3304

Stice, E., Gau, J. M., Rohde, P., & Shaw, H. (2017). Risk factors that predict future onset of each DSM–5 eating disorder: Predictive specificity in high-risk adolescent females. *Journal of Abnormal Psychology*, *126*(1), 38–51. http://doi.org/10.1037/abn0000219

Swanson, S. A., Crow, S. J., Le Grange, D., Swendsen, J., & Merikangas, K. R. (2011). Prevalence and correlates of eating disorders in adolescents: Results from the national comorbidity survey replication adolescent supplement. *Archives of General Psychiatry*, *68*(7), 714–723. http://doi.org/10.1001/archgenpsychiatry.2011.22

Taylor, G. J., Parker, J. D. A., Bagby, R. M., & Bourke, M. P. (1996). Relationships between

alexithymia and psychological characteristics associated with eating disorders. *Journal of Psychosomatic Research, 41*(6), 561–568. http://doi.org/10.1016/S0022-3999(96)00224-3

Thornton, L. M., Mazzeo, S. E., & Bulik, C. M. (2011). The Heritability of Eating Disorders: Methods and Current Findings. *Current Topics in Behavioral Neurosciences*, *6*, 141–156. http://doi.org/10.1007/7854_2010_91

Van Strien, T. Van, Engels, R. C. M. E., Leeuwe, J. Van, & Snoek, H. M. (2005). The Stice model of overeating: Tests in clinical and non-clinical samples. *Appetite, 45*(3), 205–213. http://doi.org/10.1016/j.appet.2005.08.004

Vinai, P., Da Ros, A., Speciale, M., Gentile, N., Tagliabue, A., Vinai, P., … Cardetti, S. (2015). Psychopathological characteristics of patients seeking for bariatric surgery, either affected or not by binge eating disorder following the criteria of the DSM IV TR and of the DSM 5. *Eating Behaviors*, *16*, 1–4. http://doi.org/10.1016/j.eatbeh.2014.10.004

Westwood, H., Kerr-Gaffney, J., Stahl, D., & Tchanturia, K. (2017). Alexithymia in eating disorders: Systematic review and meta-analyses of studies using the Toronto Alexithymia Scale. *Journal of Psychosomatic Research, 99*(March), 66–81. http://doi.org/10.1016/j.jpsychores.2017.06.007

Zamariola, G., Vlemincx, E., Luminet, O., & Corneille, O. (2018). Relationship between interoceptive accuracy, interoceptive sensibility, and alexithymia. *Personality and Individual Differences*, *125*, 14–20. http://doi.org/10.1016/j.paid.2017.12.024