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A Meta-Analysis on the Relationship Between Interoceptive Awareness and Alexithymia: Distinguishing Interoceptive Accuracy and Sensibility

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Alexithymia—a trait associated with difficulties understanding one's own emotions—is theorized to stem from deficits in *interoceptive awareness*, or the ability to detect, accurately monitor, and regulate internal bodily processes. The present meta-analysis analyzed all studies that empirically examined the relationship between alexithymia and interoceptive awareness. Across 66 independent samples (N = 7,146), alexithymia had a small, negative correlation with interoceptive awareness (r = −.162, p = .001, 95% CI [−.252, −.068]), but additional analyses revealed that the strength and directionality of this association was heavily influenced by the specific interoceptive awareness components measured (e.g., interoceptive accuracy vs. sensibility) and the methods used to measure interoceptive awareness (e.g., objective vs. self-report measures). The strength of this relationship was also moderated by diagnosis of participants such that alexithymia was moderately associated with interoceptive awareness in samples with psychiatric and developmental disorders, but the relationship was nonsignificant in healthy, typically developing samples. Results suggest interoception may represent a shared transdiagnostic vulnerability that underlies atypical emotional processing in a variety of disparate clinical populations but that current operationalization and measurement of interoceptive awareness continues to create confusion and inconsistency in the literature.

General Scientific Summary

This meta-analysis summarized existing studies that examined whether difficulties understanding one's own emotions stem from a general impairment in detecting and interpreting internal bodily signals (that could represent emotional arousal, among other physiological states like hunger or nausea). This relationship was heavily influenced by the ways in which interpretation of internal body signals were measured. In addition, the relationship was much stronger in people with clinical conditions, such as autism spectrum disorder or eating disorders, despite no relationship in the general population, suggesting that difficulties processing one's own bodily signals play a particularly adverse role in emotion understanding in clinical populations.

Keywords: alexithymia, interoception, autism, ASD, meta-analysis

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Alexithymia is a trait that translates from Greek to mean "no words for emotions" (Sifneos, 1973). It is a multifaceted construct consisting of (a) difficulties identifying and describing one's emotions, (b) difficulty distinguishing emotional feelings from bodily sensations, (c) an "externally-oriented thinking style" focused on external realities with limited self-reflective thought toward inner experience, and (d) limited imagination and fantasy life (Nemiah, Freybarger, & Sifneos, 1976). Interest in alexithymia has increased

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Data from this article have not been published elsewhere, but the majority of the analyses were presented as a poster at the Annual Conference of the International Society for Autism Research (see Trevisan et al., 2019 for more information). Institutional ethics review was not required for this study because it reviewed existing published data and did not involve collection of original human participant data.

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in fields related to psychology, psychiatry, medicine and neuroscience due to findings of high co-occurrence between alexithymia and a wide range of seemingly disparate psychopathologies and physical diseases (see Bird & Cook, 2013; Murphy, Brewer, Catmur, & Bird, 2017 for reviews). More recently, researchers have begun to investigate the neurological and cognitive underpinnings of alexithymia, with "interoception" emerging as a leading candidate.

Interoception refers to the conscious and subconscious processing by which the nervous system senses, interprets, and integrates signals originating from one's own body (Khalsa et al., 2018). It is thought to be critical for maintaining homeostasis, or healthy bodily and cognitive functioning (Murphy et al., 2017). Interoceptive signals originate in the peripheral nervous system—namely visceral organs, muscle fibers, skin, and taste receptors—and are sent to the central nervous system via interoceptive pathways such as spinal and vagal afferents (Craig, 2004; Critchley & Harrison, 2013; Khalsa et al., 2018). With a putatively critical role in maintaining homeostasis, it is essential that researchers and clinicians investigate individual differences in interoceptive processes and understand the specific interoceptive failures that may play causal roles in the onset of various psychopathologies and disease. However, interoceptive processes have proven challenging to measure. Indeed, many, if not most, interoceptive processes operate beneath conscious awareness and control (e.g., circadian, respiratory, and cardiac cycles, salivation, and digestive processes), making the study of individual variability of these interoceptive processes difficult to operationalize and quantify. Thus, aside from brain imaging and electrophysiological methods, researchers must measure interoceptive processes that are available to conscious report, which has been termed *interoceptive awareness*.

As Khalsa et al., 2018 noted, the term *interoceptive awareness* is quite broad and has been inconsistently defined and conceptualized since initially introduced by Garner, Olmstead, and Polivy (1983). In an effort to clarify the methodological and conceptual issues that have hindered both the progress of interoception research and its application to medicine, leading interoception experts recently introduced a more useful and coherent terminology, separating the interoceptive awareness construct into meaningful components: namely, *attention* (the ability to direct one's attention to internal bodily cues), *detection* (the ability to detect the presence or absence of an internal bodily cue), *magnitude* (the intensity with which an internal body cue is perceived), *discrimination* (the ability to differentiate a specific bodily cue from other bodily cues and sensations, such as discriminating between hunger pangs and gastric discomfort), *accuracy* (correct and precise monitoring of bodily cues), *insight* (metacognitive evaluation of one's own interoceptive accuracy), *sensibility* (a tendency to focus one's attention on internal bodily cues), and finally, Interoceptive Self-Report Scales, which reflect autobiographical experiences of interoceptive states pertaining to one's self-perceived ability to accurately monitor and discriminate interoceptive cues as well as one's self-perceived general awareness and judgments about interoceptive cues (see Khalsa et al., 2018, the online supplemental material for a full description of each component).

Following Khalsa et al. (2018) framework, in the present study we use interoceptive awareness as an umbrella term encompassing all the aforementioned components of this construct, and we modify Khalsa et al.'s framework by breaking Interoceptive Self-Report Scales into "subjective interoceptive accuracy" and "sensibility." This adaption improves internal consistency of the framework, as Khalsa et al.'s description of sensibility (which was separate from Interoceptive Self-Report Scales) included two self-report measures, the Body Perception Questionnaire (BPQ; Porges, 1993) and the Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012). Conversely, many self-report scales used in the literature broadly measure interoceptive accuracy. As per Khalsa et al., we define *subjective interoceptive accuracy* as a broad component requiring detection and attention to interoceptive cues, correct and precise monitoring of interoceptive cues, the ability to discriminate interoceptive cues from other sensations, and localization of sensations to specific organs or body parts measured via self-report. The key distinction between these two categories of self-report scales is that, consistent with Khalsa et al.'s conceptualization, sensibility does not capture an ability dimension as is the case with interoceptive accuracy, but instead captures "the self-perceived dispositional tendency to focus on interoceptive stimuli across daily life" (see the online supplemental material). All other components of interoceptive awareness we examined in relation to alexithymia are consistent with Khalsa et al.'s framework.

Interoceptive Awareness and Alexithymia

The goal of the present study is to clarify the relationship between different components of interoceptive awareness and alexithymia. Although there is a growing theoretical consensus that interoceptive impairments play a critical role in the emergence of alexithymia, empirical research examining links between interoceptive awareness and alexithymia is inconclusive. Indeed, different studies examining the relationship between alexithymia and interoceptive awareness have found positive (Ernst et al., 2014; Scarpazza, Làdavas, & di Pellegrino, 2015), negative (Fiene, Ireland, & Brownlow, 2018; Shah, Catmur, & Bird, 2016), or null (Christensen, Gaigg, & Calvo-Merino, 2018; Zamariola, Vlemincx, Corneille, & Luminet, 2018) associations.

There are likely several reasons for this confusing pattern of findings. First, interoceptive awareness is difficult to measure. Measurement of interoceptive awareness and alexithymia has largely relied on self-report measures, which raises the concerning question of whether those on the lower ability ranges of interoceptive awareness and more severe alexithymia can accurately report on these abilities (Bird & Cook, 2013; Taylor, Bagby, & Parker, 2016). Second, objective measurement of interoceptive awareness has largely relied on heartbeat perception tasks (Schandry, 1981; Whitehead, Drescher, Heiman, & Blackwell, 1977), and performance on these tasks is confounded by numerous factors, such as body mass index, blood pressure, and resting heart rate (Murphy, Brewer, Hobson, Catmur, & Bird, 2018). Third, as described in the preceding text, interoceptive awareness is a multifaceted construct (Khalsa et al., 2018; Mehling et al., 2012), with individual facets of interoceptive awareness differing in their relationship to alexithymia. Finally, the etiology of alexithymia may vary according to sample characteristics. Alexithymia may emerge from both environmental (Way et al., 2010) and neurological vulnerabilities (van der Velde et al., 2013). Therefore, the true relationship between interoceptive awareness and alexithymia may

change according to sample characteristics such as the presence or absence of psychiatric and developmental disorders.

Present Study

The present meta-analysis aims to apply our adaptation of Khalsa et al. (2018) taxonomy to determine the extent to which various components of interoceptive awareness and alexithymia are related and to determine the methodological factors and sample characteristics that account for heterogeneity among studies. Identifying the interoceptive mechanisms that underlie alexithymia is critical for understanding the neurological and cognitive bases of alexithymia and for delineating shared psychophysiological risk factors for various disorders that co-occur with alexithymia.

A secondary aim was to determine whether clinical diagnosis of the participants moderates the relationship between interoceptive awareness and alexithymia. One possibility is that alexithymia co-occurring with psychiatric disorders is due to neurological vulnerabilities (such as interoceptive impairments), whereas alexithymia in the general population is more associated with environmental or other factors unrelated to interoception not accounted for in this study. This possibility leads to the prediction that the correlation between interoceptive abilities and alexithymia will be stronger in certain clinical populations than in the general population.

Method

Design

A meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009).

Search Strategy

Searches were conducted in October 2018 in PubMed, PsycINFO, EMBASE, Scopus, and Google Scholar. Depending on the database, search terms included "Interocept* AND alexithym*" or "Interoception OR Interoceptive AND Alexithymia OR alexithymic." A total of 2,361 articles were retrieved from the searches. After removing duplicates and screening titles and abstracts, 52 were determined to have empirically measured both interoceptive awareness and alexithymia and were selected for full-text screening. An additional 12 articles were identified from searching reference lists of recently published articles, yielding a total of 64 studies for full-text screening. Of the 64 articles screened, a final total of 44 were selected for inclusion in the meta-analysis. The other 20 articles were rejected for failing to report sufficient statistical information to estimate an effect size ($n = 4$), for reporting effect sizes after partialing out the effects of other variables ($n = 4$), for using measures that do not predominantly measure some component of interoceptive awareness as defined by Khalsa et al. (2018; $n = 7$), or for exclusively measuring associations between alexithymia and activation of neural regions thought to be associated with interoception ($n = 5$). See the exclusion criteria for a list of reasons why studies were rejected, and Figure 1 specifying how studies were screened and selected or excluded.

Study Coding Procedures

Codes were created for study descriptors and variables necessary for calculating effect sizes. Study descriptors establish external validity of the report and can be probed to account for variability in the average weighted effect sizes. Codes included: date of study, study location, study procedures, methods for assessing both interoceptive awareness and alexithymia, and sample characteristics (sample size, mean age, percentage female).

A rigorous coding process was applied to ensure reliability (Adesope, Trevisan, & Sundararajan, 2017). At the start of the coding phase, an experienced meta-analyst (author DAT) trained the other authors involved in the coding process and coded two studies together as a group. After the coders finished coding two studies by themselves, author DAT checked and provided detailed feedback on the accuracy of their coding and directed any changes that needed to be made. After the trained coders finished coding the remaining articles, author DAT confirmed the extracted effect size information from all coded studies, and randomly coded 30% of all other study descriptors yielding strong percentage agreement of 96.2%.

Inclusion Criteria

Studies were accepted in our review if they met the following criteria:

1. The study was written in English.
2. The study was published in a peer-reviewed journal article or was an unpublished thesis that was accessible from online databases through the authors' institutional libraries, or through the interlibrary loan system.
3. The study quantitatively measured both alexithymia and some aspect of interoceptive awareness in the participants.
4. Data in the study were collected at a time point that was prior to any intervention or experimental manipulation.
5. A correlation statistic was reported that characterized the strength of the relationship between interoceptive awareness and alexithymia or sufficient statistical information for an effect size to be estimated using meta-analytic conversion methods was available (e.g., means and standard deviations, t values or p values).

Exclusion Criteria

1. Studies were excluded if the statistics characterizing the relationship between interoceptive awareness and alexithymia were statistically controlled for—through the use of partialing methods or when entered into a multiple regression with other variables. This decision was made because different studies controlled for different variables which would bias the summary effect sizes, and

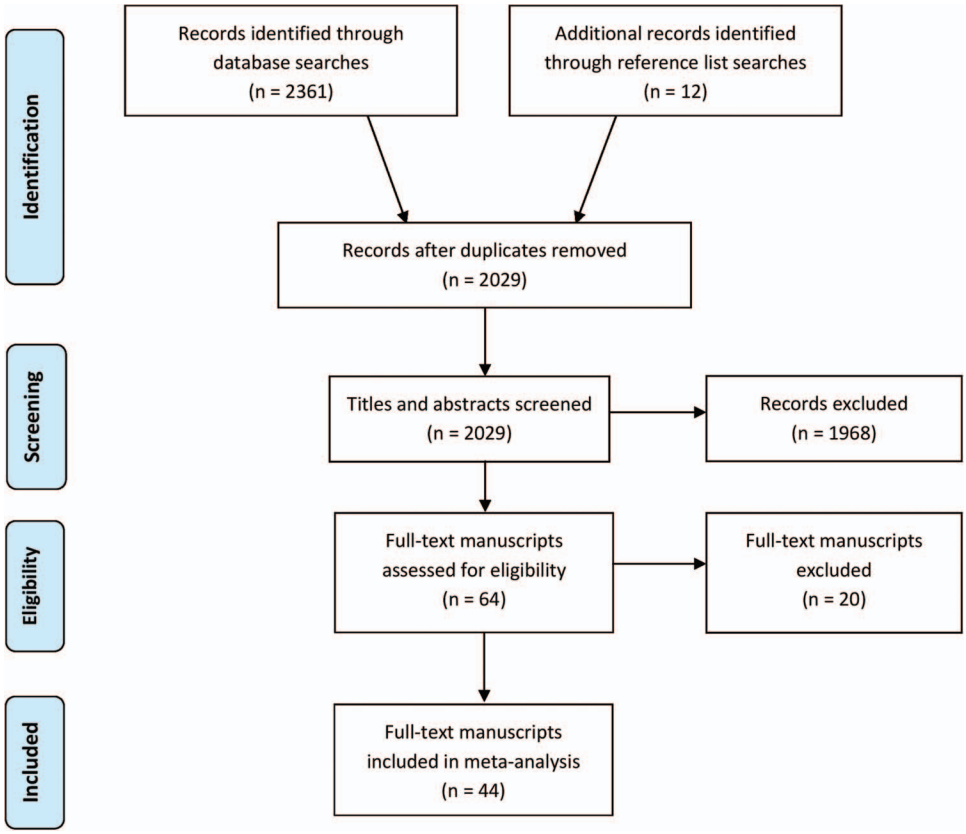

Figure 1. Flow diagram of article selection process. See the online article for the color version of this figure.

because prevailing meta-analytic methods for converting standardized betas to simple correlation coefficients (Peterson & Brown, 2005) tend to introduce more bias rather than reducing bias in estimating summary effect sizes (Roth, Le, Oh, Van Iddekinge, & Bobko, 2018).

2. We excluded studies that measure somatic symptom severity or perceptions of chronic pain as relevant measures tend to measure general health concerns not specific to interoceptive processes. Quantitative reviews of the relationship between alexithymia and somatization have been reported elsewhere (De Gucht & Heiser, 2003).

3. Studies that used measures that contain some items related to interoceptive awareness but largely measure other constructs were excluded.

4. We excluded neuro-imaging studies that exclusively examined associations between alexithymia and neural regions thought to be associated with interoception, as a meta-analysis on neural correlates of alexithymia has been published elsewhere (van der Velde et al., 2013).

5. Conference abstracts and presentations were excluded.

Effect Size Calculation

Data were analyzed using Comprehensive Meta-analysis Software (CMA; Borenstein, Hedges, Higgins, & Rothstein, 2013). Correlation coefficients were extracted from each study to represent the effect size strength of the association between interoceptive awareness and alexithymia. Where correlation coefficients were not reported, effect sizes were converted from other statistics using meta-analytic procedures. In situations where sufficient statistical information was not reported to estimate effect sizes, efforts were made to contact corresponding authors for needed information. After effect sizes for each study were extracted or estimated, these effects were entered into CMA which transforms all correlation coefficients into a Fisher's Z value, and then combines these Z values into an overall Z score adjusting for sample size. The resulting Z value is then transformed back into an aggregated correlation coefficient. We used a random effects models for all analyses which presumes that variability in effect sizes among studies is not simply an artifact of measurement error but is instead attributed to differences in sample and methodological characteristics (Borenstein, Hedges, Higgins, & Rothstein, 2009).

Outcome Variable: Interoceptive Awareness

To explain heterogeneity of effect sizes, we were primarily interested in how interoceptive awareness was measured. Our adaption of Khalsa et al. (2018) taxonomy was applied to categorize studies in this meta-analysis: objective interoceptive accuracy, subjective interoceptive accuracy, sensibility, magnitude, detection, and insight.

Objective interoceptive accuracy (IAcc). Objective IAcc is most often measured via heartbeat perception tasks (Schandry, 1981; Whitehead et al., 1977). In heartbeat tracking tasks, participants are required to count their heartbeats over varying time intervals, and their counts are compared to the actual number of heartbeats in that interval as measured by an objective pulsometer. In a related task, participants are asked to listen to two patterned auditory signals—one in-phase with their heartbeat and one slightly off beat—and are asked to identify the in-phase signal over a number of trials. Also included in this category were tasks that required participants to accurately monitor and assess their own breath exhalation, muscle exertion, and salinity of saltwater solutions (Murphy, Catmur, & Bird, 2018).

Subjective interoceptive accuracy (IAcc). Although Khalsa et al. (2018) did not specifically distinguish objective and self-reported interoceptive accuracy, we make this distinction in our study given the large number of studies that measured interoceptive accuracy using either objective or self-report methods. For this category, we use the same definition of interoceptive accuracy as defined in the previous paragraph but differentiate subjective IAcc (self-report) from objective measures. Example items from relevant questionnaires include, "I can always accurately perceive when I am hungry," (Murphy, Brewer, Plans, et al., 2018) or "Sometimes I don't know how to interpret sensations I feel within my body" (Fiene et al., 2018).

Sensibility. Sensibility was measured using questionnaires that predominantly capture respondents' self-perceived dispositional tendency to focus on interoceptive stimuli across daily life. Example items from relevant questionnaires include "During most situations, I am aware of how fast I am breathing" (Porges, 1993) or "I notice when I am uncomfortable in my body" (Mehling et al., 2012).

Magnitude. Magnitude was measured using self-reported intensity of sensation in response to an experimentally induced stimulus—such as the administration of pressure, heat, or cold stimuli to a specific muscle, digit, or localized area of skin. Ratings may also include the *point of pain threshold*, or the point at which a participant judges a stimulus increasing in intensity crosses the threshold to where the sensation is perceived as painful. In this meta-analysis, studies were only accepted into this category if the methodology combined objective, experimental administration of an interoceptive sensation combined with self-report perceptions about that stimulus administration.

Detection. Detection is a binary variable that is measured as a participant's perception of a stimulus as being present or absent. Like magnitude, studies were only included into the detection category when combining the experimental administration of a stimulus with self-perceived report of the point at which the stimulus could be detected.

Insight. Insight is a metacognitive measure operationalized as the correspondence between subjective and objective measures—for example, the correspondence between accuracy and performance confidence on specific tasks or the correspondence between objective and self-report arousal in response to emotionally arousing stimuli. A greater correspondence between self-report perceptions and objective realities represents greater metacognitive "insight" of one's own interoceptive awareness.

Moderator Variable: Clinical Diagnosis

Mentioned earlier, alexithymia is associated with many psychiatric, developmental and physical disorders and illnesses. While most independent samples incorporated into this meta-analysis included only healthy typically developing individuals ($k = 46$), smaller subsets of studies utilized samples with autism spectrum disorder (ASD; $k = 6$), eating disorders ($k = 8$), and other sporadically measured populations which we grouped as "other clinical" ($k = 5$). Described earlier, alexithymia is associated with both neurological and environmental risk factors.

Results

Summary Effects

In total, 66 independent samples from 44 separate published articles or unpublished dissertations met our inclusion criteria, yielding a total of 80 effect sizes. The total combined sample size of all participants in this meta-analysis was 7,146. A table specifying the authors, year of publication, sample characteristics, and details of how interoceptive constructs and alexithymia were measured for each independent sample can be found in the online supplemental material.

The overall summary effect size representing the average strength of the association between interoceptive awareness and alexithymia across all independent samples was $r = -.162$, $p = .001$, 95% CI [−.252, −.068]. There was statistically significant effect size heterogeneity, $Q(65) = 972.728$, $p < .001$, indicating statistically significant effect size heterogeneity. In addition, 93.3% of between-studies variance can be explained by study-level covariates ($I^2 = 93.318$), indicating that only 6.6% of the variance was due to sampling error. These statistics indicate substantial variability among effect sizes justifying further exploration of the study-level covariates that contribute to this variability. In the following section, we report the influence of two hypothesized covariates: (1) measurement methods for assessing interoceptive awareness (by categorizing interoceptive awareness into the different components theorized by Khalsa et al., 2018) and (2) participant diagnosis.

Interoceptive Awareness Components

In many cases, multiple effects characterizing relationships among alexithymia and different interoceptive awareness components were extracted from the same study. Thus, treating this variable as a moderator would involve including multiple effects from the same samples, which would violate the assumption of statistical independence. Thus, in Table 1, we report each interoceptive awareness construct in relation to alexithymia but do not directly compare effect size strength among the categories as part of a formal moderator analysis, as such an analysis would be biased by statistical dependence.

The results demonstrate that alexithymia is moderately associated with lower Subjective IAcc, $r(22) = -.437$, $p < .001$, 95% CI [−.551, −.307]. In contrast, there was a nonsignificant association between objective IAcc and alexithymia, $r(31) = -.049$, $p = .288$, 95% CI [−.138, −.041]. It should also be mentioned that two studies found significant positive associations between

Table 1
Associations Between Alexithymia and Various Interoceptive Awareness Constructs

Construct	*k*	Sample size	Pearson's *r*	*p*	95% CI Lower	95% CI Upper
Subjective IAcc	23	2314	−.437	<.001	−.551	−.307
Objective IAcc	32	2565	−.049	.288	−.138	.041
Sensibility	16	2741	.077	.211	−.044	.195
Magnitude	6	439	.095	.227	−.059	.246
Detection	2	99	−.085	.705	−.482	.341
Insight	1	26	−.570	.002	−.784	−.234

Note. *k* = number of effects; CI = confidence interval.

these two variables, while five found significant negative associations (see the online supplemental material), which may cancel effects when averaging all studies together. However, the majority of studies (25 out of 32) found nonsignificant associations, reducing the risk that the null association was purely due to meaningful positive and negative associations cancelling each other out.

Although there was no significant relationship between alexithymia and sensibility overall, $r(15) = .077$, $p = .211$, 95% CI [−.044, .195], the relationship between these two variables appears to be more complex. In a follow-up mixed effects moderator analysis, we found that the relationship between these variables was significantly moderated by the specific questionnaire that was used to measure sensibility, $Q(4) = 35.783$, $p < .001$. In particular, there was a significant positive relationship between alexithymia and sensibility averaged across the 6 studies that used the BPQ (Porges, 1993), $r(5) = .262$, $p < .001$, 95% CI [.126, .389], but there was a significant negative relationship between alexithymia and sensibility averaged across the four studies that used the Noticing and Emotional Awareness subscales of the MAIA (Mehling et al., 2012), $r(3) = -.213$, $p = .011$, 95% CI [−.366, −.050].

Nonsignificant associations of magnitude, $r(5) = .095$, $p = .227$, 95% CI [−.059, .246], and detection, $r(1) = -.085$, $p = .705$, 95% CI [−.482, .341], with alexithymia were found suggesting that alexithymia is not associated with a disposition toward experiencing externally administered stimuli with greater intensity or sensitivity. However, the small number of studies in the magnitude and detection categories prevent confidence in drawing conclusions about the true associations of these variables with alexithymia. Finally, while only one study examined the association between alexithymia and Insight, this study found a fairly strong association ($r = -.570$, $p = .002$, 95% CI [−.784, −.234]), suggesting that alexithymia is associated with greater discrepancies between self-reported and objective arousal in response to emotionally arousing stimuli.

Moderating Effect of Participant Diagnosis

The moderating effect of participant diagnosis was examined by categorizing this variable into four groups: (1) typically developing, (2) ASD, (3) eating disordered, or (4) other clinical. Other clinical included miscellaneous populations that did not have enough samples to justify creating their own category, including one sample that consisted of a variety of psychiatric disorders, one of functional motor disorders, one of depersonalization/derealization disorders, one of drug and alcohol addicts, and one of fibromyalgia syndrome. Some studies collapsed clinical and typically developing participants into a single group for correlational analyses. In such cases, we included these samples into the clinical categories. We confirmed that the same pattern of results was obtained when only including pure clinical samples, and therefore decided to include the combined samples groups to maximize statistical power.

For this analysis, effect sizes from the same samples were collapsed to maintain statistical independence which allowed us to test whether effect sizes from different diagnosis groups are statistically different from each other. The between-levels difference using a Mixed Effects model was statistically significant, $Q_B(3) = 23.057$, $p < .001$. Correlations between alexithymia and interoceptive awareness were strongest for samples with ASD, $r(5) = -.507$, $p < .001$, 95% CI [−.738, −.169] and eating disorders, $r(7) = -.521$, $p < .001$, 95% CI [−.676, −.320], followed by other clinical, $r(4) = -.214$, $p = .170$, 95% CI [−.484, .093], suggesting less interoceptive awareness is associated with alexithymia in these clinical populations. In contrast, there was a nonsignificant association between interoceptive awareness and alexithymia averaged across the typically developing samples, $r(46) = -.042$, $p = .294$, 95% CI [−.120, .036].

Publication Bias

As researchers are prone to reporting significant over nonsignificant results, and because journals are more likely to prioritize publication of significant findings, meta-analyses are subject to the risk of publication bias that tends to exaggerate aggregate effect sizes. This risk is also exacerbated by the tendency for some researchers to report nonsignificant associations (e.g., "there was no relationship" or $p > .05$) without providing the necessary statistical information needed for meta-analytic extraction. To mitigate this risk, we emailed all corresponding authors of articles that did not report the effect size information needed. We additionally examined the risk of publication bias by using Duval and Tweedie's (2000) trim and fill procedure using a funnel plot (see Figure 2). The trim and fill procedure identified no missing effect sizes to the right of the mean indicating the distribution of effect sizes in this sample is unlikely to be influenced by publication bias.

Discussion

The majority of effect sizes included in this meta-analysis fell into one of three categories—subjective interoceptive accuracy, objective interoceptive accuracy, and sensibility. We found that alexithymia is associated with poorer subjective interoceptive accuracy, suggesting that alexithymia is associated with difficulties linking physiological indicators of affective arousal with feeling states (e.g., recognizing heart-racing or bodily tension with fear or anxiety), or difficulties discriminating different patterns of affective arousal which may result in a general awareness of being "upset" but not being able to specify which emotion is being experienced. However, another possibility is that because alexithymia is also assessed via self-report, this relationship could be exaggerated by common-method variance attributed to systematic response biases (e.g., a tendency to respond to items in an excessively negative way).

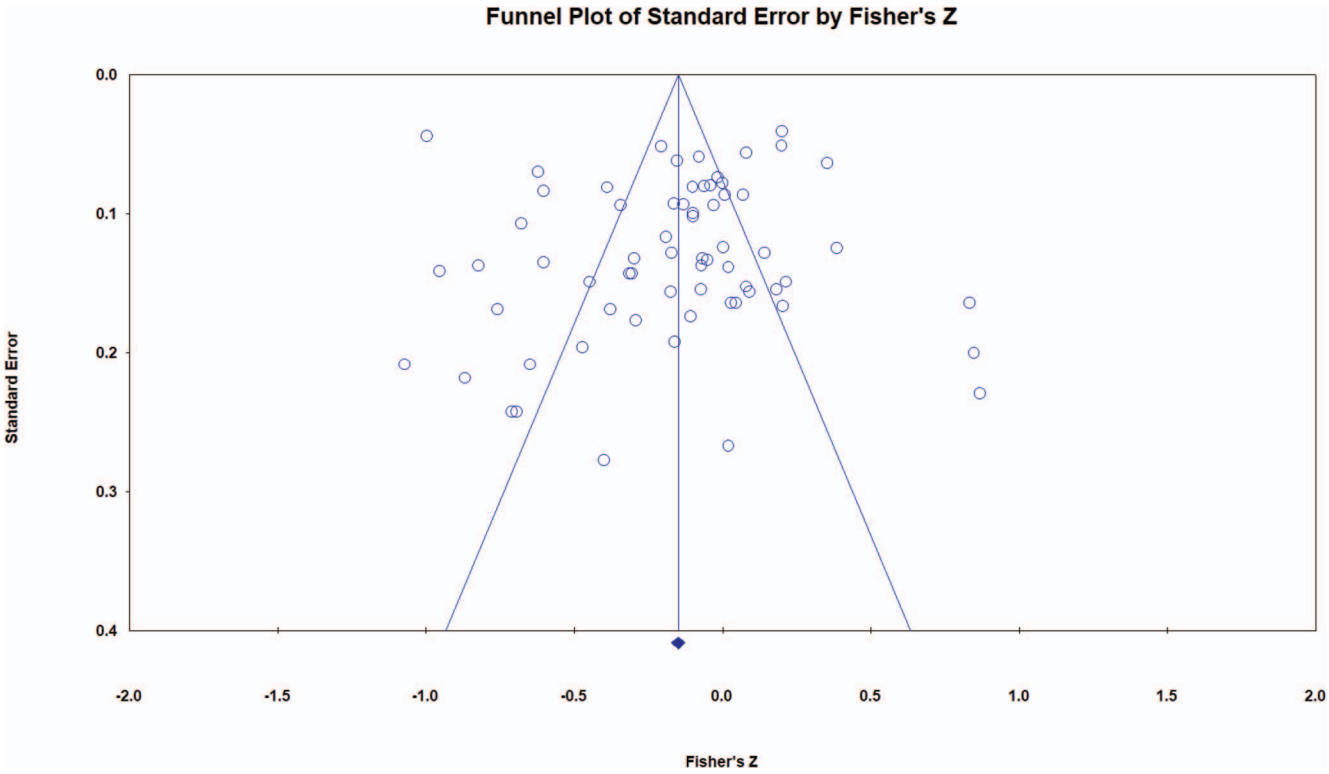

Figure 2. The funnel plot demonstrates that the effect sizes are relatively evenly distributed around the mean at all levels of the *y*-axis, suggesting a lack of evidence for publication bias. See the online article for the color version of this figure.

A related issue is an overreliance on self-report measures of alexithymia in the existing research. The most widely used tool to assess alexithymia in research contexts is the self-report Toronto Alexithymia Scale (TAS-20; Bagby, Taylor, & Parker, 1994). Self-report measures raise concerns about whether individuals with severe levels of alexithymia possess enough emotional awareness to accurately reflect and characterize their own emotional awareness (Lane, Weihs, Herring, Hishaw, & Smith, 2015). For example, it is possible that individuals with severe alexithymia may not know that they lack certain capacities that self-report tools like the TAS-20 attempt to measure (Taylor et al., 2016). It remains an urgent priority for future research to develop objective methods for measuring alexithymia in diverse populations.

No Association Between Alexithymia and Objective Interoceptive Accuracy

In contrast to self-reported interoceptive accuracy, we found a nonsignificant association between alexithymia and measures of objective interoceptive accuracy. It is possible that this nonsignificant association is true, challenging interoceptive explanations of alexithymia. A second possibility is that there is a true association that is masked either by large sources of measurement error or is confounded by other variables. The majority (28 of 32) studies in this category measured objective interoceptive accuracy using heartbeat tracking tasks described earlier (Schandry, 1981; Whitehead et al., 1977), and there is a growing awareness of the limitations of these measures. Indeed, up to 40% of healthy individuals have no conscious awareness of their own heartbeat (Khalsa et al., 2018), calling to question whether this task is appropriate for participants in the lower ability range. Moreover, performance on heartbeat tracking tasks can be confounded by a number of factors unrelated to interoceptive awareness, (Knapp-Kline & Kline, 2005; Murphy, Brewer, Hobson, et al., 2018; Murphy, Geary, Millgate, Catmur, & Bird, 2018). For example, in a large sample of 287 typically developing adults, Murphy, Brewer, Hobson, et al. (2018) reported that the relationship between heartbeat perception and alexithymia marginally increased from $r = -.079$, $p = .182$ to $r = -.192$, $p = .014$, in the expected direction after controlling for age, gender, knowledge of typical heartrates and accuracy in estimating time, depression, anxiety, body mass index, systolic blood pressure, heartrate variability, and mean heartrate. Although a formal analysis to examine how simple correlations change as a function of controlling for various variables (as in Murphy, Brewer, Hobson, et al., 2018) could be beneficial, we do not report partialed correlation coefficients in our study because (a) the majority of studies only reported simple correlations without controlling for potential confounds, (b) the studies that did control for potential confounds partialed out the effects of different variables yielding inconsistency across studies, and (c) because prevailing methods for converting standardized betas from multiple regression outputs into simple correlation coefficients (Peterson & Brown, 2005) tend to introduce large

sources of bias, which led Roth et al. (2018) to recommend only using existing correlations in meta-analysis. If studies are to continue to use heartbeat perception tasks, then it should become standard practice for researchers to control for a particular set of confounding variables, such as those methods used in Murphy, Brewer, Hobson, et al. (2018). Future research is needed to validate these measures and to develop new methods for objectively measuring interoceptive accuracy that encapsulate a variety of interoceptive domains to reduce overreliance on the rather narrow domain of heartbeat perception.

Alexithymia and Sensibility

There was no overall significant association between sensibility and alexithymia, but this appears to be due to positive and negative relationships among different measures cancelling each other out. The majority of studies (10 of 16) that examined sensibility in relation to alexithymia used either the MAIA or the BPQ. These two measures may be the most widely used measures of sensibility and are the two measures that Khalsa et al. (2018) featured in their detailed description of sensibility in their article's supplement. Comparing studies that used these respective measures, there was a significant negative association between the MAIA Noticing and Emotional Awareness subscales—the subscales that most closely measure Khalsa et al.'s definition of sensibility related to awareness bodily and emotional feelings. In contrast, there was a significant positive association between BPQ and alexithymia. The BPQ captures general awareness of specific bodily sensations such as "mouth being dry" or "noises associated with digestion." As the MAIA and BPQ comprise the majority of sensibility research but differ in their relation to alexithymia, one possibility is that they are measuring distinct underlying constructs. Future work is needed to determine the key differences between these respective scales to better understand the relationship between sensibility and alexithymia.

Moderating Effects of Diagnosis and Implications for Psychiatric Disorders

A key finding from this study was the moderating effect of participant diagnosis. Although alexithymia was moderately associated with reduced interoceptive awareness across participants with diagnoses of ASD, eating disorders or other clinical diagnoses, there was a nonsignificant association between interoceptive awareness and alexithymia in typically developing, healthy participants. Clinical characterizations of alexithymia have sometimes distinguished between primary and secondary alexithymia, where *primary alexithymia* is a result of neurological and genetic vulnerabilities, whereas *secondary alexithymia* emerges as a coping mechanism to distance oneself from distressing negative affect, often as a result of psychological trauma (Krystal, 1988; Sifneos, 1983). The pattern of results in this meta-analysis provides indirect support for the intriguing possibility that alexithymia in the general population is driven by psychological trauma or other environmental factors not accounted for in the present study, whereas alexithymia in clinical populations may be largely manifested by atypical signaling of internal bodily information to the brain (i.e., interoceptive deficits).

In the case of ASD, Quattrocki and Friston (2014) presented a theoretical framework proposing that the emergence of atypical development seen in ASD stems in part from dysfunctional interoceptive processing. Although the present meta-analysis did not examine interoceptive processes in ASD compared with other populations (see, DuBois, Ameis, Lai, Casanova, & Desarkar, 2016, for a review of this topic) our data show that interoceptive awareness is moderately and negatively related to alexithymia within this population, suggesting that interoceptive differences may play a particular role in atypical emotion processing observed in ASD. Quattrocki and Friston (2014) suggest that alexithymia may stem in part from a failure to attenuate interoceptive signals. This possibility would suggest that alexithymia may result from an overloading of interoceptive sensory information which leads to a failure to habituate trivial interoceptive sensations, a failure to differentiate trivial from meaningful interoceptive cues, and difficulties making implicit and explicit paired associations between interoceptive cues and physiological states. In turn, this interoceptive confusion would inhibit one's ability to regulate bodily, emotional and cognitive functioning—possibly contributing to the high co-occurrence of alexithymia in ASD. It is critical to emphasize that while alexithymia appears to be significantly heightened in the ASD population, approximately half of this population may be relatively unaffected by clinically relevant levels of alexithymia (Hill, Berthoz, & Frith, 2004; Samson, Huber, & Gross, 2012). In a similar vein, interoceptive deficits may be more prevalent in ASD than in the general population and associated with elevated levels of certain emotion-processing symptoms (Bird & Cook, 2013) but may not be elevated in all individuals with ASD and, therefore, may not play a direct causal role in the onset of ASD or its core symptoms (Brewer, Happé, Cook, & Bird, 2015). In the case of eating disorders, the link between interoceptive failures and alexithymia appears more straightforward. Anorexia may be associated with feeling overly full after eating a small meal or with poor perception of hunger signals. Conversely, obesity, binge eating disorder, and bulimia may result in part from poor perception of satiety. Thus, interoceptive difficulties that disorganize feelings of hunger or satiation may also play a role in interoceptive confusion related to emotion (i.e., alexithymia).

Of the studies in this meta-analysis conducted on clinical samples, the majority were conducted on samples of participants with either ASD or eating disorders. However, it is important to consider the relationship between interoceptive awareness and alexithymia in other clinical populations. Higher alexithymic traits have been implicated in a wide array of physical and psychological illnesses. This has led some authors to suggest that interoceptive processes may represent the *p* factor (Caspi et al., 2014), representing common disruption in neural circuitry that gives rise to disordered bodily and mental functioning across conditions (see Murphy et al., 2017 for a relevant argument). Although this cannot be ruled out, additional factors are implicated given the multiple phenotypes deriving from this putatively common cause. A more likely possibility is that the *p* factor is not domain-general but relatively domain-specific, calling for additional research to clarify the disparate dimensions of interoception and their potential influence on different psychological and physical illnesses.

It is important that researchers always report and consider the role of variance in evaluating the relationship between interoceptive awareness and alexithymia. It is possible that restricted ranges of scores in typically developing samples or more extreme scores in the clinical samples exaggerated effect size strength differences

between the groups in our meta-analysis to some extent. This was difficult for us to directly assess, as many studies included in this meta-analysis did not report any metric of variance. A related issue is that many researchers did not report reliability coefficients of their measures, which may have attenuated correlations in some instances where reliabilities were low. Nevertheless, where standard deviations were reported, there was still substantial variance in interoceptive awareness and alexithymia scores in the typically developing groups, so there is little evidence to suggest that the strong differences in effect size strength we observed are due purely to differences in variances.

Conclusion

Difficulties conceptualizing and measuring interoceptive awareness continue to hamper theoretical and empirical understanding of this construct and its relation to alexithymia. The present meta-analysis advances understanding by meta-analyzing extant research in the context of a novel theoretical framework of interoceptive awareness (Khalsa et al., 2018). Results provide insights about the manner in which various components of interoceptive awareness relate to alexithymia and how these associations may differ according to the presence or absence of other conditions. We found that poorer interoceptive accuracy is associated with alexithymia but only when measured via self-report and not using objective methods, and that a dispositional tendency to focus on interoceptive stimuli (i.e., sensibility) can be either positively or negatively associated with alexithymia depending on the measurement tools used. We also found that across studies poorer interoceptive awareness is much more strongly related to alexithymia in participants with various psychiatric disorders (predominantly eating disorders and ASD) than in the general population.

The study of interoceptive processes may be fruitful in applying a dimensional approach to the study of psychopathology, such as transdiagnostic perspectives provided by the research domain criteria (Insel et al., 2010). Neither interoceptive processes nor alexithymia are currently represented in the *DSM–5* (American Psychiatric Association, 2013), but both may play a useful role in defining and identifying shared and distinct symptomology among developmental and psychological disorders at a biological level by bridging neural, physiological and psychological factors (Khalsa et al., 2018).

References

References marked with an asterisk are included in the meta-analysis.

Adesope, O. O., Trevisan, D. A., & Sundararajan, N. (2017). Rethinking the use of tests: A meta-analysis of practice testing. *Review of Educational Research, 87,* 659–701. http://dx.doi.org/10.3102/0034654316689306

*Aloi, M., Rania, M., Caroleo, M., De Fazio, P., & Segura-García, C. (2017). Social cognition and emotional functioning in patients with binge eating disorder. *European Eating Disorders Review, 25,* 172–178. http://dx.doi.org/10.1002/erv.2504

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: Author.

Anderson, L. M. (2017). *Does what you think you feel, impact what you actually eat? An examination of alexithymia, interoceptive awareness, and loss of control eating in young women*. Albany, NY: State University of New York at Albany.

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. http://dx.doi.org/10.1016/0022-3999(94)90006-X

*Beales, D. L., & Dolton, R. (2000). Eating disordered patients: Personality, alexithymia, and implications for primary care. *The British Journal of General Practice, 50,* 21–26.

*Betka, S., Pfeifer, G., Garfinkel, S., Prins, H., Bond, R., Sequeira, H., . . . Critchley, H. (2018). How do self-assessment of alexithymia and sensitivity to bodily sensations relate to alcohol consumption? *Alcoholism, Clinical and Experimental Research, 42,* 81–88. http://dx.doi.org/10.1111/acer.13542

Bird, G., & Cook, R. (2013). Mixed emotions: The contribution of alexithymia to the emotional symptoms of autism. *Translational Psychiatry, 3*(7), e285. http://dx.doi.org/10.1038/tp.2013.61

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. Chichester, UK: Wiley. http://dx.doi.org/10.1002/9780470743386

Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2013). Comprehensive meta-analysis (Version 3) [Computer software]. Englewood, NJ: Biostat.

*Borhani, K., Làdavas, E., Fotopoulou, A., & Haggard, P. (2017). "Lacking warmth": Alexithymia trait is related to warm-specific thermal somatosensory processing. *Biological Psychology, 128,* 132–140. http://dx.doi.org/10.1016/j.biopsycho.2017.07.012

*Bornemann, B., & Singer, T. (2017). Taking time to feel our body: Steady increases in heartbeat perception accuracy and decreases in alexithymia over 9 months of contemplative mental training. *Psychophysiology, 54,* 469–482. http://dx.doi.org/10.1111/psyp.12790

*Brewer, R., Cook, R., & Bird, G. (2016). Alexithymia: A general deficit of interoception. *Royal Society Open Science, 3,* 150664. http://dx.doi.org/10.1098/rsos.150664

Brewer, R., Happé, F., Cook, R., & Bird, G. (2015). Commentary on "Autism, Oxytocin and Interoception": Alexithymia, not autism spectrum disorders, is the consequence of interoceptive failure. *Neuroscience and Biobehavioral Reviews, 56,* 348–353. http://dx.doi.org/10.1016/j.neubiorev.2015.07.006

*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,* 411–416. http://dx.doi.org/10.1002/erv.2532

Caspi, A., Houts, R. M., Belsky, D. W., Goldman-Mellor, S. J., Harrington, H., Israel, S., . . . Moffitt, T. E. (2014). The *p* factor: One general psychopathology factor in the structure of psychiatric disorders? *Clinical Psychological Science, 2,* 119–137. http://dx.doi.org/10.1177/2167702613497473

*Christensen, J. F., Gaigg, S. B., & Calvo-Merino, B. (2018). I can feel my heartbeat: Dancers have increased interoceptive accuracy. *Psychophysiology, 55*(4), e13008. http://dx.doi.org/10.1111/psyp.13008

*Costa, R. M., Oliveira, G., Pestana, J., Costa, D., & Oliveira, R. F. (2018). Do psychosocial factors moderate the relation between testosterone and female sexual desire? The role of interoception, alexithymia, defense mechanisms, and relationship status. *Adaptive Human Behavior and Physiology, 5,* 13–30.

Craig, A. D. B. (2004). Human feelings: Why are some more aware than others? *Trends in Cognitive Sciences, 8,* 239–241. http://dx.doi.org/10.1016/j.tics.2004.04.004

Critchley, H. D., & Harrison, N. A. (2013). Visceral influences on brain and behavior. *Neuron, 77,* 624–638. http://dx.doi.org/10.1016/j.neuron.2013.02.008

*de Galan, M., Sellaro, R., Colzato, L. S., & Hommel, B. (2014). Conflict adaptation is predicted by the cognitive, but not the affective alexithymia

dimension. *Frontiers in Psychology, 5,* 768. http://dx.doi.org/10.3389/fpsyg.2014.00768

De Gucht, V., & Heiser, W. (2003). Alexithymia and somatisation: Quantitative review of the literature. *Journal of Psychosomatic Research, 54,* 425–434. http://dx.doi.org/10.1016/S0022-3999(02)00467-1

DuBois, D., Ameis, S. H., Lai, M. C., Casanova, M. F., & Desarkar, P. (2016). Interoception in autism spectrum disorder: A review. *International Journal of Developmental Neuroscience, 52,* 104–111. http://dx.doi.org/10.1016/j.ijdevneu.2016.05.001

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,* 455–463. http://dx.doi.org/10.1111/j.0006-341X.2000.00455.x

*Ernst, J., Böker, H., Hättenschwiler, J., Schüpbach, D., Northoff, G., Seifritz, E., & Grimm, S. (2014). The association of interoceptive awareness and alexithymia with neurotransmitter concentrations in insula and anterior cingulate. *Social Cognitive and Affective Neuroscience, 9,* 857–863. http://dx.doi.org/10.1093/scan/nst058

Fiene, L., Ireland, M. J., & Brownlow, C. (2018). The Interoception Sensory Questionnaire (ISQ): A scale to measure interoceptive challenges in adults. *Journal of Autism and Developmental Disorders, 48,* 3354–3366. http://dx.doi.org/10.1007/s10803-018-3600-3

*Forrest, L. N., Smith, A. R., White, R. D., & Joiner, T. E. (2015). (Dis)connected: An examination of interoception in individuals with suicidality. *Journal of Abnormal Psychology, 124,* 754–763. http://dx.doi.org/10.1037/abn0000074

*Gaigg, S. B., Cornell, A. S., & Bird, G. (2018). The psychophysiological mechanisms of alexithymia in autism spectrum disorder. *Autism: An International Journal of Research and Practise, 22,* 227–231. http://dx.doi.org/10.1177/1362361316667062

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,* 15–34. http://dx.doi.org/10.1002/1098-108X(198321)2:2<15::AID-EAT2260020203>3.0.CO;2-6

*Greenberg, S. J. (1997). *Alexithymia in an anorexic population: Prevalence and predictive variables* (Doctoral dissertation). New York, NY: Department of Psychology, Pace University.

*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,* 1149–1175. http://dx.doi.org/10.1111/j.1467-6494.2011.00717.x

Hill, E., Berthoz, S., & Frith, U. (2004). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of Autism and Developmental Disorders, 34,* 229–235. http://dx.doi.org/10.1023/B:JADD.0000022613.41399.14

*Huber, A., Suman, A. L., Biasi, G., & Carli, G. (2009). Alexithymia in fibromyalgia syndrome: Associations with ongoing pain, experimental pain sensitivity and illness behavior. *Journal of Psychosomatic Research, 66,* 425–433. http://dx.doi.org/10.1016/j.jpsychores.2008.11.009

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D. S., Quinn, K., . . . Wang, P. (2010). Research domain criteria (RDoC): Toward a new classification framework for research on mental disorders. *American Journal of Psychiatry, 167,* 748–751. http://dx.doi.org/10.1176/appi.ajp.2010.09091379

*Jackson, T., Nagasaka, T., Fritch, A., & Gunderson, J. (2002). Alexithymia is not related to tolerance for cold pressor pain. *Perceptual and Motor Skills, 94,* 487–488. http://dx.doi.org/10.2466/pms.2002.94.2.487

*Kano, M., Hamaguchi, T., Itoh, M., Yanai, K., & Fukudo, S. (2007). Correlation between alexithymia and hypersensitivity to visceral stimulation in human. *Pain, 132,* 252–263. http://dx.doi.org/10.1016/j.pain.2007.01.032

*Katz, J., Martin, A. L., Pagé, M. G., & Calleri, V. (2009). Alexithymia and fear of pain independently predict heat pain intensity ratings among undergraduate university students. *Pain Research & Management, 14,* 299–305. http://dx.doi.org/10.1155/2009/468321

Khalsa, S. S., Adolphs, R., Cameron, O. G., Critchley, H. D., Davenport, P. W., Feinstein, J. S., . . . Zucker, N. (2018). Interoception and mental health: A roadmap. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 3,* 501–513. http://dx.doi.org/10.1016/j.bpsc.2017.12.004

Knapp-Kline, K., & Kline, J. P. (2005). Heart rate, heart rate variability, and heartbeat detection with the method of constant stimuli: Slow and steady wins the race. *Biological Psychology, 69,* 387–396. http://dx.doi.org/10.1016/j.biopsycho.2004.09.002

Krystal, H. (1988). *Integration and self-healing: Affect, trauma, alexithymia*. Hillsdale, NJ: Analytic Press.

Lane, R. D., Weihs, K. L., Herring, A., Hishaw, A., & Smith, R. (2015). Affective agnosia: Expansion of the alexithymia construct and a new opportunity to integrate and extend Freud's legacy. *Neuroscience and Biobehavioral Reviews, 55,* 594–611. http://dx.doi.org/10.1016/j.neubiorev.2015.06.007

*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://dx.doi.org/10.3389/fpsyg.2015.01149

*Lundh, L. G., & Simonsson-Sarnecki, M. (2001). Alexithymia, emotion, and somatic complaints. *Journal of Personality, 69,* 483–510. http://dx.doi.org/10.1111/1467-6494.00153

Mangelli, L., Semprini, F., Sirri, L., Fava, G. A., & Sonino, N. (2006). Use of the Diagnostic Criteria for Psychosomatic Research (DCPR) in a community sample. *Psychosomatics, 47,* 143–146. http://dx.doi.org/10.1176/appi.psy.47.2.143

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), e48230. http://dx.doi.org/10.1371/journal.pone.0048230

Miller, L. C., Murphy, R., & Buss, A. H. (1981). Consciousness of body: Private and public. *Journal of Personality and Social Psychology, 41,* 397–406. http://dx.doi.org/10.1037/0022-3514.41.2.397

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G., & the PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097. http://dx.doi.org/10.1371/journal.pmed.1000097

*Muir, K., Madill, A., & Brown, C. (2017). Individual differences in emotional processing and autobiographical memory: Interoceptive awareness and alexithymia in the fading affect bias. *Cognition and Emotion, 31,* 1392–1404.

*Mul, C. L., Stagg, S. D., Herbelin, B., & Aspell, J. E. (2018). The feeling of me feeling for you: Interoception, alexithymia and empathy in autism. *Journal of Autism and Developmental Disorders, 48,* 2953–2967. http://dx.doi.org/10.1007/s10803-018-3564-3

Murphy, J., Brewer, R., Catmur, C., & Bird, G. (2017). Interoception and psychopathology: A developmental neuroscience perspective. *Developmental Cognitive Neuroscience, 23,* 45–56. http://dx.doi.org/10.1016/j.dcn.2016.12.006

*Murphy, J., Brewer, R., Hobson, H., Catmur, C., & Bird, G. (2018). Is alexithymia characterised by impaired interoception? Further evidence, the importance of control variables, and the problems with the Heartbeat Counting Task. *Biological Psychology, 136,* 189–197. http://dx.doi.org/10.1016/j.biopsycho.2018.05.010

Murphy, J., Brewer, R., Plans, D., Khalsa, S. S., Catmur, C., & Bird, G. (2018). *Validation of the Interoceptive Accuracy Scale (IAS) supports distinction between self-reported interoceptive accuracy and awareness*. Retrieved from http://dx.doi.org/10.31234/osf.io/fqgu4

*Murphy, J., Catmur, C., & Bird, G. (2018). Alexithymia is associated with a multidomain, multidimensional failure of interoception: Evidence from novel tests. *Journal of Experimental Psychology: General, 147,* 398–408. http://dx.doi.org/10.1037/xge0000366

Murphy, J., Geary, H., Millgate, E., Catmur, C., & Bird, G. (2018). Direct and indirect effects of age on interoceptive accuracy and awareness across the adult lifespan. *Psychonomic Bulletin & Review, 25,* 1193–1202. http://dx.doi.org/10.3758/s13423-017-1339-z

Nemiah, J. C., Freybarger, H., & Sifneos, P. E. (1976). Alexithymia: A view of the psychosomatic process. In O. W. Hill (Ed.), *Modern trends in psychosomatic medicine* (Vol. 3, pp. 430–439). London, UK: Butterworths.

*Nicholson, T. M., Williams, D. M., Grainger, C., Christensen, J. F., Calvo-Merino, B., & Gaigg, S. B. (2018). Interoceptive impairments do not lie at the heart of autism or alexithymia. *Journal of Abnormal Psychology, 127,* 612–622. http://dx.doi.org/10.1037/abn0000370

*Niesluchowski, P. K. (2003). *An examination of the interrelationship among interoceptive awareness, internal state awareness, and alexithymia* (Doctoral dissertation). Washington, DC: Department of Psychology, Chicago School of Professional Psychology.

*Nyklíček, I., & Vingerhoets, A. J. (2000). Alexithymia is associated with low tolerance to experimental painful stimulation. *Pain, 85,* 471–475.

*Ozcan, A., Subasi, S. S., Yemez, B., & Celiker, O. (2005). The relationship of pressure–pain threshold with alexithymia in healthy young subjects. *Journal of Musculoskeletal Pain, 13,* 27–32. http://dx.doi.org/10.1300/J094v13n03_05

*Palser, E. R., Palmer, C. E., Galvez-Pol, A., Hannah, R., Fotopoulou, A., & Kilner, J. M. (2018). Alexithymia mediates the relationship between interoceptive sensibility and anxiety. *PLoS ONE, 13*(9), e0203212. http://dx.doi.org/10.1371/journal.pone.0203212

Peterson, R. A., & Brown, S. P. (2005). On the use of beta coefficients in meta-analysis. *Journal of Applied Psychology, 90,* 175–181. http://dx.doi.org/10.1037/0021-9010.90.1.175

*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,* 381–388. http://dx.doi.org/10.1016/j.eatbeh.2008.02.001

Porges, S. (1993). *Body Perception Questionnaire* (Doctoral dissertation). College Park, MD: Department of Psychology, University of Maryland.

Quattrocki, E., & Friston, K. (2014). Autism, oxytocin and interoception. *Neuroscience and Biobehavioral Reviews, 47,* 410–430. http://dx.doi.org/10.1016/j.neubiorev.2014.09.012

*Ricciardi, L., Demartini, B., Crucianelli, L., Krahé, C., Edwards, M. J., & Fotopoulou, A. (2016). Interoceptive awareness in patients with functional neurological symptoms. *Biological Psychology, 113,* 68–74. http://dx.doi.org/10.1016/j.biopsycho.2015.10.009

Rolke, R., Magerl, W., Campbell, K. A., Schalber, C., Caspari, S., Birklein, F., & Treede, R. D. (2006). Quantitative sensory testing: A comprehensive protocol for clinical trials. *European Journal of Pain (London, England), 10,* 77–88. http://dx.doi.org/10.1016/j.ejpain.2005.02.003

Roth, P. L., Le, H., Oh, I. S., Van Iddekinge, C. H., & Bobko, P. (2018). Using beta coefficients to impute missing correlations in meta-analysis research: Reasons for caution. *Journal of Applied Psychology, 103,* 644–658. http://dx.doi.org/10.1037/apl0000293

Samson, A. C., Huber, O., & Gross, J. J. (2012). Emotion regulation in Asperger's syndrome and high-functioning autism. *Emotion, 12,* 659–665. http://dx.doi.org/10.1037/a0027975

*Scarpazza, C., Làdavas, E., & di Pellegrino, G. (2015). Dissociation between emotional remapping of fear and disgust in alexithymia. *PLoS ONE, 10*(10), e0140229. http://dx.doi.org/10.1371/journal.pone.0140229

*Scarpazza, C., Sellitto, M., & di Pellegrino, G. (2017). Now or not-now? The influence of alexithymia on intertemporal decision-making. *Brain and Cognition, 114,* 20–28. http://dx.doi.org/10.1016/j.bandc.2017.03.001

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

*Schulz, A., Köster, S., Beutel, M. E., Schächinger, H., Vögele, C., Rost, S., . . . Michal, M. (2015). Altered patterns of heartbeat-evoked potentials in depersonalization/derealization disorder: Neurophysiological evidence for impaired cortical representation of bodily signals. *Psychosomatic Medicine, 77,* 506–516. http://dx.doi.org/10.1097/PSY.0000000000000195

*Shah, P., Catmur, C., & Bird, G. (2016). Emotional decision-making in autism spectrum disorder: The roles of interoception and alexithymia. *Molecular Autism, 7,* 43. http://dx.doi.org/10.1186/s13229-016-0104-x

*Shah, P., Hall, R., Catmur, C., & Bird, G. (2016). Alexithymia, not autism, is associated with impaired interoception. *Cortex, 81,* 215–220. http://dx.doi.org/10.1016/j.cortex.2016.03.021

Shields, S. A., Mallory, M. E., & Simon, A. (1989). The Body Awareness Questionnaire: Reliability and validity. *Journal of Personality Assessment, 53,* 802–815. http://dx.doi.org/10.1207/s15327752jpa5304_16

Sifneos, P. E. (1973). The prevalence of 'alexithymic' characteristics in psychosomatic patients. *Psychotherapy and Psychosomatics, 22,* 255–262. http://dx.doi.org/10.1159/000286529

Sifneos, P. E. (1983). Psychotherapies for psychosomatic and alexithymic patients. *Psychotherapy and Psychosomatics, 40,* 66–73. http://dx.doi.org/10.1159/000287754

*Sönmez, M. B., Kahyacı Kılıç, E., Ateş Çöl, I., Görgülü, Y., & Köse Çınar, R. (2017). Decreased interoceptive awareness in patients with substance use disorders. *Journal of Substance Use, 22,* 60–65. http://dx.doi.org/10.3109/14659891.2016.1143048

Taylor, G. J., Bagby, R. M., & Parker, J. D. A. (2016). What's in the name 'alexithymia'? A commentary on "Affective agnosia: Expansion of the alexithymia construct and a new opportunity to integrate and extend Freud's legacy." *Neuroscience and Biobehavioral Reviews, 68,* 1006–1020. http://dx.doi.org/10.1016/j.neubiorev.2016.05.025

Taylor, G. J., Ryan, D., & Bagby, R. M. (1985). Toward the development of a new self-report alexithymia scale. *Psychotherapy and Psychosomatics, 44,* 191–199. http://dx.doi.org/10.1159/000287912

*Taylor, R. S. (2009). *Body responsiveness, body awareness, alexithymia and eating attitudes and behaviors in university students* (Doctoral dissertation). Chicago, IL: Adler School of Professional Psychology, Adler University.

Trevisan, D. A., Altschuler, M. R., Bagdasarov, A., Carlos, C., Duan, S., Hamo, E., . . . McPartland, J. C. (2019, May 1–4). *Alexithymia is associated with impaired interoceptive accuracy but not interoceptive signal perception in ASD and other populations*. Poster session presented at the Annual Meeting of the International Society for Autism Research, Montreal, Canada.

Van den Bergh, O., Bogaerts, K., Walentynowicz, M., & Van Diest, I. (2012, September 28–30). *The interoceptive awareness questionnaire: Unraveling the distinction between awareness of neutral and negative bodily sensations*. Poster presented at the Annual Meeting of the International Society for the Advancement of Respiratory Psychophysiology (ISARP), Orlando, FL.

van der Velde, J., Servaas, M. N., Goerlich, K. S., Bruggeman, R., Horton, P., Costafreda, S. G., & Aleman, A. (2013). Neural correlates of alexithymia: A meta-analysis of emotion processing studies. *Neuroscience and Biobehavioral Reviews, 37,* 1774–1785. http://dx.doi.org/10.1016/j.neubiorev.2013.07.008

Vorst, H. C., & Bermond, B. (2001). Validity and reliability of the Bermond–Vorst alexithymia questionnaire. *Personality and Individual Differences, 30,* 413–434. http://dx.doi.org/10.1016/S0191-8869(00)00033-7

Way, I. F., Applegate, B., Cai, X., Franck, L. K., Black-Pond, C., Yelsma, P., . . . Muliett, M. (2010). Children's Alexithymia Measure (CAM): A new instrument for screening difficulties with emotional expression. *Journal of Child & Adolescent Trauma, 3,* 303–318. http://dx.doi.org/10.1080/19361521.2010.523778

Whitehead, W. E., Drescher, V. M., Heiman, P., & Blackwell, B. (1977). Relation of heart rate control to heartbeat perception. *Biofeedback and Self-Regulation, 2,* 317–392. http://dx.doi.org/10.1007/BF00998623

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

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