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Review article

The relationship between self-reported interoception and depression: A systematic review and multilevel meta-analysis

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ABSTRACT

Background: Emerging research highlights interoceptive dysfunction as a potential mechanism underlying depression. Whereas physiological measures of interoception (e.g., cardiac accuracy tasks) have shown inconsistent associations with depression, subjective self-report measures may provide greater insight. However, no previous meta-analysis has synthesised evidence on self-reported interoception and depression.

Methods: Following PRISMA guidelines, a systematic search of PubMed, Scopus and Web of Science identified 49 studies ($N = 21{,}755$) meeting our inclusion criteria. A three-level meta-analysis was conducted to account for nested effect sizes. Primary analyses focused on the Multidimensional Assessment of Interoceptive Awareness (MAIA), with secondary analyses including other self-report tools. Moderator analyses tested study design, depression and interoception measures, age, sex, and publication year. Study quality was evaluated using the AXIS tool. The review was preregistered on the OSF (https://osf.io/vq62p/?view_only=6fb11fb930194eb e9a67091154023fe0).

Results: Self-reported interoception was significantly associated with depression as assessed using the MAIA and several other measures of interoception. Depression measure moderated the strength of association, as did study design (for the MAIA only), with larger effect sizes for between-group designs than within-group designs. Participant age, sex and publication year were not significant moderators in any analyses.

Conclusions: Depression is reliably linked to self-reported interoceptive dysfunction, particularly in domains that involve the metacognitive evaluation and regulation of bodily states. Our findings reinforce the view of interoception as a multidimensional construct and identifies specific interoceptive capacities, such as trust in bodily signals, self-regulation, and not worrying, as promising targets for psychological interventions aimed at reducing depression.

1. Introduction

Depression is one of the most prevalent mental health disorders worldwide [1], affecting millions of individuals and significantly impacting their quality of life [2]. Despite its prevalence and negative impact, understanding the underlying mechanisms of depression remains a major challenge and focus of research, as it is crucial for developing effective and tolerable treatments. Indeed, current pharmacological treatments for Major Depressive Disorder, are related to a wide range of side effects, negative outcomes [3], and problems related to withdrawal at decrease or discontinuation [4]. Psychotherapies are largely effective, although research is still needed to identify their underlying mechanisms and 'active' components [5], and to allow more targeted intervention, especially for those with severe, treatment-resistant forms of depression. Consequently, efforts to identify the causes of depression and develop innovative treatments continue to be of great importance. For example, an increasing number of studies have focused on the inflammatory mechanisms involved in the development of mental health conditions, repurposing the use of anti-inflammatory drugs, including NSAIDs, statins and monoclonal antibodies for the treatment of psychiatric disorders [6,7]. Alongside pharmacological advances, recent developments in psychotherapy emphasise enhanced

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and precision psychotherapy, which integrate data-informed monitoring, mechanism-based treatment components, and personalised adaptation of interventions to improve outcomes [8].

One emerging area of research identifies interoception as a key transdiagnostic marker and mechanism underlying a range of mental health disorders, including depression [9]. Interoception broadly refers to the brain's ability to perceive and interpret internal bodily signals, which plays a vital role in both emotional and physiological regulation, particularly through its integration with allostasis, the anticipatory process that adjusts bodily functions to meet changing environmental demands [10]. Interoception is often conceptualised using a three-level taxonomy that includes: interoceptive accuracy (the objective ability to detect internal bodily signals, such as heartbeat), interoceptive sensibility (self-evaluated assessment of subjective interoception via questionnaires), and interoceptive awareness (the metacognitive correspondence between perceived and actual interoceptive accuracy) [11], although the concept continues to evolve (see discussions by [12–14]). This tripartite framework highlights the different dimensions of interoception, and how interoception is not just about accurately detecting bodily signals but also involves how such signals are consciously experienced and interpreted. Importantly, the different levels and dimensions of interoception have been shown to dissociate (see e.g. [11,14–16]), with the ability to perceive internal events and states as assessed with behavioural tests (interoceptive accuracy) being largely independent of self-reported evaluations (interoceptive sensibility). As a result, researchers recommend a comprehensive assessment approach that spans multiple bodily domains, such as cardiac, respiratory, and gastrointestinal systems, and incorporates tools that capture distinct aspects of interoception, including accuracy, awareness, and sensibility. A multifaceted strategy is essential for fully understanding the role of interoception in any given condition [14], including depression [17].

Empirical research exploring the idea that interoception is affected in depression has focused on two key areas: cardiac interoceptive accuracy and self-reported interoception (corresponding to *interoceptive sensibility* in the taxonomy of [11]). The focus on cardiac signals has produced mixed findings, with some studies reporting impairments in individuals with depression, whereas others find no clear association. A meta-analysis by Desmedt et al. [18] provided surprising results, indicating no consistent relationship between cardiac interoceptive accuracy and depression. Their findings challenge earlier proposals that interoceptive impairments, particularly in cardiac awareness, are a reliable marker of depression (see e.g. [19]). The lack of association between cardiac interoceptive accuracy and depression raises questions about whether other dimensions of interoception, such as self-reports (i.e. interoceptive sensibility as defined above), might offer more relevant insights [17].

Despite the extensive focus on cardiac interoception, a notable gap in the literature exists regarding self-reported interoception; with no systematic review or meta-analysis previously examining self-reported interoceptive sensibility in depression. Self-reported measures, such as the Multidimensional Assessment of Interoceptive Awareness (MAIA), encompass a broad range of interoceptive experiences, including emotional and cognitive evaluations of bodily states [20,21]. These aspects may be more directly relevant to understanding the subjective interoceptive deficits reported by individuals with depression. Moreover, because different aspects of interoception can dissociate (as discussed above), depression might be related to aberrant self-reported interoceptive sensibility, despite accurate heartbeat perception. Indeed, meta-analyses looking at interoception in anxiety have reported a relationship between self-reported interoception and anxiety [22], despite evidence that heartbeat perception is unrelated to anxiety [17,23].

We sought to fill a critical gap in the literature, by systematically reviewing and meta-analysing self-reported interoceptive sensibility, in subclinical and clinical forms of depression. By focusing on self-reported interoceptive experiences, this research seeks to provide a more comprehensive understanding of interoceptive dysfunction in depression and explore the implications for future diagnostic and therapeutic strategies. We aimed to answer the question: is there an association between self-reported interoception and depression?

2. Methods

2.1. Transparency and openness

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [24]. Our study was pre-registered on the Open Science Framework (OSF; https://osf.io/vq62p/?view_only=6fb11fb930194ebe9a67091154023fe0), and all related study documentation, including the extracted data and analysis code, can be found on the OSF project page (https://osf.io/v6nhb/?view_only=c1b86796a08042c6a7f713c3ef7529f9).

2.2. Search strategy

We searched PubMed, Scopus and Web of Science[1] from database inception to 12th December 2025. We searched the title/abstract for the terms: interocep* AND depress* (OR anxi*). This search returned 5227 studies (see PRISMA flowchart in Fig. 1). In line with the preregistered protocol, we also examined the reference lists of all included studies to identify any additional eligible publications. Grey literature was not considered, as the review was restricted to published (peer-reviewed) sources. Results of the database searches were downloaded and uploaded to Covidence (a web-based collaboration software platform that streamlines the production of systematic reviews). 2132 duplicates were removed using Covidence's automated deduplication tool ($n = 2082$) and manual checking ($n = 50$). Note that, although our pre-registration and the initial steps of this study (i.e. searches and screening) examined both anxiety and depression, here we focused on results related to depression only, since a systematic review and meta-analysis [22] published after our pre-registration, reported on the relationship between self-reported interoception and anxiety.

2.3. Inclusion/exclusion criteria

Our population of interest was adults or children with a diagnosis of major depressive disorder (MDD) as assessed by a standardised diagnostic instrument and criteria (e.g. DSM or ICD), or individuals with subclinical levels of depression where symptoms were measured by a validated scale (e.g. Beck Depression Inventory-II). Although individuals with MDD may exhibit broader physiological and allostatic dysregulation (e.g. altered stress reactivity, disrupted bodily time perception), which could amplify interoceptive disturbances, this inclusive approach was adopted to capture the full continuum of depressive symptomatology, from subclinical to clinically diagnosed cases. It also reflects prior meta-analytic approaches in this field (e.g. [22,23]) and allows for examination of how associations generalise across populations. We included all validated self-report questionnaires assessing depressive symptom severity. These instruments vary in their emphasis, with some focusing on somatic and vegetative symptoms (e.g., Beck Depression Inventory; BDI) and others on cognitive–affective aspects (e.g., Hospital Anxiety and Depression Scale; HADS). This inclusive approach was adopted to capture the full spectrum of depressive symptomatology represented in the literature, recognising that different tools may index partly distinct facets of depression. We excluded papers reporting only individuals with a diagnosed psychological/psychiatric condition other than depression (e.g. psychotic disorder, OCD), neurological or neurodegenerative condition (e.g. stroke, chronic pain), and medical or neurodevelopmental condition where existing evidence indicates that

[1] Although not pre-registered, we added Web of Science to our search at the request of the Editor.

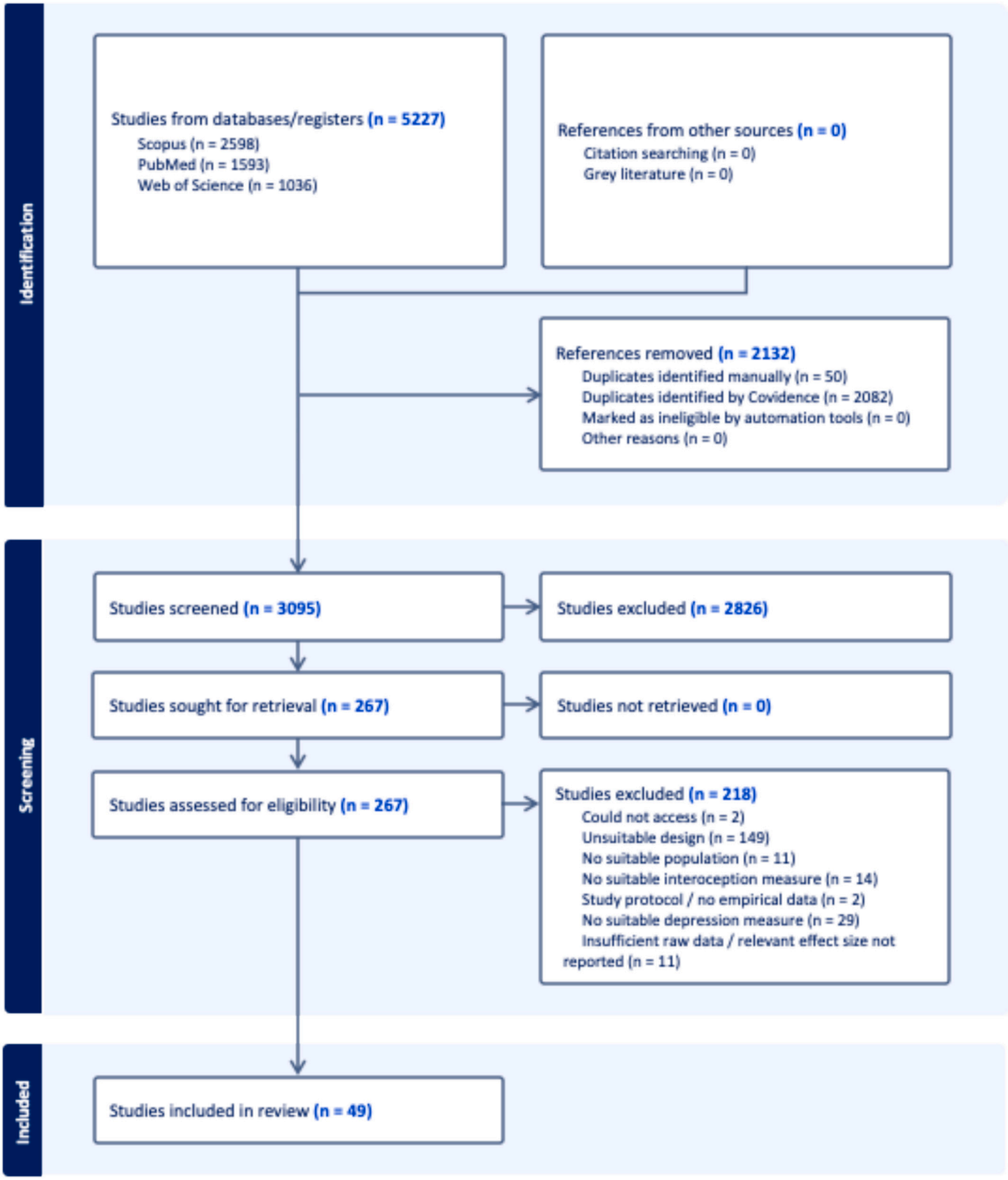

Fig. 1. PRISMA flow diagram.

interoceptive ability is affected (e.g. Irritable Bowel Syndrome, hypertension, autism, ADHD).

Our primary outcome of interest was self-reported interoceptive ability. We included any studies employing a validated or widely recognised measure of self-reported interoception (e.g. MAIA, Body Perception Questionnaire, etc). Our inclusion of a range of self-report questionnaires was both data-driven and conceptually grounded. Consistent with the approach taken by Clemente et al. [22], we included all validated instruments that can be considered measures of *interoceptive sensibility*, to capture the full scope of self-reported interoceptive

processes examined in the literature. This decision was further informed by recent analyses showing that these questionnaires assess related but distinct facets of interoceptive sensibility (e.g. adaptive/regulatory awareness vs. vigilance/physiological reactivity), and converge on the shared domain of subjective interoceptive experience [25]. Recognising this conceptual diversity, we treated these tools as complementary rather than interchangeable indices of self-reported interoception, and examined measure-related variability in our moderator analyses (see Section 2.6). Non-English reviews, theory papers, editorials, book chapters, single cases, qualitative studies, non-human studies, and studies where the primary focus was recreational drug use were excluded.

2.4. Selection and extraction

Initial screening based on title and abstract was conducted blind by two independent researchers (PMJ & RL). We resolved any disagreements or uncertainty through discussion with a third researcher (KRL). Subsequent screening of relevant full texts for inclusion followed the same method. Data extraction was conducted independently by the same three researchers (PMJ, RL & KRL) using a standard Excel data sheet. To ensure consistency and reliability of the extracted data, we conducted an initial calibration exercise after each researcher had extracted data from one paper, discussing any issues or ambiguity that arose. Calibration and clarification discussions occurred during weekly meetings held throughout the entire data extraction period. Extracted information comprised study identifier details (authors, title, year, country, journal, DOI), type (e.g. intervention, experimental, neuroimaging, correlational, cross sectional), inclusion/exclusion criteria, sample type (clinical/non-clinical) and size, mean age (SD), reported sex or sex, diagnostic criteria (for clinical samples), assessment measures (depression and interoception), summary of main findings of interest, and relevant effect sizes (r, Cohen's d, standardised regression beta values, or eta-squared) or values (mean & SD) needed to calculate effect size. We converted all effects to a standardised correlation coefficient (r) for comparison and interpretation purposes. Where data were missing or unclear, we contacted the authors of relevant studies via email. We contacted three authors and received no response to our queries and so, subsequently excluded those three studies.

2.5. Quality / risk of bias assessment

Study quality was assessed with the Appraisal Tool for Cross-Sectional Studies (AXIS) [26]. The AXIS contains 20 items that assess reporting quality, study design and possible risk of bias. Seven questions assess reporting quality (items: 1, 4, 10, 11, 12, 16 and 18), seven relate to study design quality (items: 2, 3, 5, 8, 17, 19 and 20) and six to possible biases in the study (items: 6, 7, 9, 13, 14 and 15). The AXIS checklist also considers the influence of funding sources or conflicts of interest on the interpretation of study results. Assessors are to comment *Yes, No, or Do Not Know* to each item of the checklist. In line with Antczak et al. [27], AXIS quality ratings were classified based on the number of "Yes" responses to the 20 items of the checklist for each study: 80% '*Yes*' responses indicated high quality, 60–80% indicated moderate quality, and < 60% indicated low study quality. Two authors (ATC & JM) independently assessed the quality of studies. Cohen's Kappa (k) was used to estimate the level of agreement between authors [28]; any discrepancies between ratings were discussed with the wider team.

2.6. Data synthesis and analysis

We conducted a narrative summary of study characteristics and study quality/risk of bias. Subsequent multilevel meta-analyses (MLMA) were run using the *metafor* package [29] in *R* [30] (version 4.4.2) to account for the hierarchical structure of the data, where effect sizes are nested within studies. This approach models both within-study and between-study variance, addressing the non-independence of effect sizes and capturing variability at multiple levels of analysis. Specifically, in the assessment of interoception via the Multidimensional Assessment of Interoceptive Awareness (MAIA), the eight subscales reflect interrelated, but distinct facets of interoception. By treating subscale scores as nested within studies, MLMA accounts for potential interrelations among subscales and ensures more accurate estimation of both individual subscale effects and overall patterns of interoception. The main MLMA examines effects obtained using the eight subscales of the MAIA/MAIA-2. Empirically this was by far the most widely used interoception questionnaire (see Results below). The MAIA is widely recognised as a comprehensive and validated measure of self-reported interoception, and our decision to focus our primary analysis on the MAIA is consistent with other recent meta-analytical work that has taken a similar approach of focusing analyses on the most frequently used measures [22].

In further, exploratory analysis (not pre-registered), a second MLMA examined the MAIA total score and all other self-report measures of interoception identified by our searches. This analytic approach was adopted to acknowledge the fact that different self-report interoception questionnaires assess overlapping but distinct constructs [25], which unfortunately could not be analysed individually, because of the limited number of studies reporting the MAIA total score or employing these alternative measures. By combining these measures into a single multilevel model, we could estimate a pooled effect size across all measures, while exploring the individual contributions of each scale as potential moderators. This approach permitted an examination of variations in effect sizes attributable to differences in the constructs measured by each questionnaire, providing a broader understanding of self-reported interoceptive processes. We included all self-report measures used in at least two studies (to allow for a combined effect to be calculated; see Interoception Measures, below). Further moderator analyses examined the effect of age, sex (proportion female), depression measure, and year of publication on the pooled effects of these two MLMAs.

We combined data from two types of study design: within-subject designs that examined the relationship between depression severity and interoceptive ability in non-depressed samples, and between-subject designs comparing depressed and non-depressed control groups. This decision was necessitated by the small number of studies using a between-subject design for each self-reported measure of interoception, which made separate analyses of these groups impractical and underpowered. Study design (i.e. within- or between-subject) was examined as a moderator in both MLMAs to assess whether the pattern and direction of effects were consistent across type of study-design. For the purpose of analysis, all effect sizes were converted to a common metric (Fisher's z), as required by the *metafor* software. For interpretation of results, effect sizes are reported as correlation coefficients (r). We followed Cohen's [28] guidelines of $r = 0.10$, 0.30, and 0.50 for small, medium and large correlation effect sizes respectively.

Heterogeneity was assessed using the I^2 statistic and following Cochrane guidance [31] we interpreted I^2 values of 0–40% as indicating that heterogeneity may not be important, 30–60% representing moderate heterogeneity, 50–90% substantial heterogeneity, and 75–100% as potentially representing considerable heterogeneity. Publication bias was assessed with Egger's test, calculated with robust standard errors using the coef_test() function from the *clubSandwich* package [32], and contour-enhanced funnel plots. Supplementary analyses excluding outlying effect sizes (i.e. any whose 95% CIs did not overlap with other studies) was pre-registered, but not carried out as no outliers were identified.

3. Results

3.1. Study characteristics

A total of 49 studies were included, encompassing 21,755 participants contributing relevant data (see study summary details in Table 1). Twelve studies used a between-subject design comparing interoception in depressed and non-depressed groups, while the remaining 37 studies used a within-subject design assessing the relationship between levels of interoceptive ability and depressive symptoms in non-depressed samples. Studies were conducted across 15 countries, including: Turkey, the USA, Australia, the UK, New Zealand, Sweden, Spain, Italy, Russia, Germany, Japan, Portugal, China, Peru and the Netherlands. Participant average (mean) age ranged from 16.25 to 55.89 years. The proportion of female participants was greater than males in most extracted samples, with a reported range of 26.3% female to 100% female participants.

3.2. Interoception measures

The Multidimensional Assessment of Interoceptive Awareness (MAIA; [20]) was the most often used measure, appearing in 27 studies, including 9 that used its updated MAIA-2 version [21]. Less commonly employed measures included the Body Perception Questionnaire (BPQ; [85]; 10 studies), Eating Disorder Inventory – Interoceptive Awareness subscale (EDI-IA; [86]; 4 studies), Body Awareness Questionnaire (BAQ; [87]; 3 studies), Body Vigilance Scale (BVS; [88]; 2 studies), Interoceptive Accuracy Scale (IAS; [89]; 2 studies), Self Awareness Questionnaire (SAQ; [90]; 1 study), Body Consciousness Questionnaire (BCQ; [91]; 1 study), Interoceptive Awareness Questionnaire Expanded (IAQ-E; [92]; 1 study), and the Body Responsiveness Questionnaire (BRQ; [93]; 1 study). See Table 1 for study details.

3.3. Depression measures

The Beck Depression Inventory (BDI; [94]; 6 studies) and its revised version, the BDI-II ([95]; 8 studies), were together the most frequently used measures of depression, followed by the Depression Anxiety Stress Scales (DASS-21; [96]; 8 studies). The Center for Epidemiological Studies Depression Scale (CES-D; [97]) was used in 6 studies, the Patient Health Questionnaire (PHQ-9; [98]) in 4 studies, and the Hospital Anxiety and Depression Scale (HADS; [99]) in 2 studies. Less commonly used measures included the Patient Health Questionnaire 2-Item version (PHQ-2; [100]), Zung Self-Rating Depression Scale (ZSRDS; [101]), Edinburgh Postnatal Depression Scale (EPDS; [102]), and Rasch-based Depression Screening version 1 (DESC-I; [103]), all of which were used in only 1 study. Additionally, 7 studies used clinical diagnostic criteria such as the Diagnostic and Statistical Manual (DSM) or International Statistical Classification of Diseases and Related Health Problems (ICD). See Table 1 for test details.

3.4. Meta-analysis – multidimensional assessment of interoceptive awareness (MAIA & MAIA-2)

A three-level MLMA was conducted to examine the association between interoception as measured using the MAIA/MAIA-2 and depression across 22 samples (168 effect sizes, 19 individual studies). Egger's test did not indicate significant publication bias or small-study effects ($p = .70$), although visual inspection of funnel plots (see Supplementary Fig. S2) displayed some asymmetry, possibly driven by heterogeneity across studies, which we examined further via moderator analysis (detailed below).

Overall, interoception showed a significant negative association with depression ($r = -0.17$, 95% CI [−0.22, −0.12], $p < .001$), indicating that poorer self-reported interoceptive ability was linked to greater depression levels (Fig. 2). Heterogeneity was high ($I^2 = 94.84\%$), with most variability attributable to within-study (67.55%) rather than between-study differences (27.29%; Fig. S1). We used moderator analyses to explore sources of heterogeneity. The MAIA subscales significantly moderated the interoception-depression relationship ($F(8,160) = 31.30$, $p < .001$). In particular, significant negative associations with depression were observed for the attention regulation ($r = -0.18$, $p < .001$), body-listening ($r = -0.13$, $p < .001$), not-distracting ($r = -0.19$, $p < .001$), not-worrying ($r = -0.25$, $p < .001$), self-regulation ($r = -0.27$, $p < .001$), and trusting subscales ($r = -0.35$, $p < .001$), but not emotional awareness ($r = -0.02$, $p = .58$), or noticing ($r = -0.01$, $p = .70$) subscales, although the effects were in the same (negative) direction.

Study design also emerged as a significant moderator ($F(2,166) = 23.66$, $p < .001$), with stronger negative associations observed in between-subjects ($r = -0.23$, $p < .001$) compared to within-subjects designs ($r = -0.15$, $p < .001$). Depression assessment tools significantly moderated the effect sizes as well ($F(10,158) = 5.54$, $p < .001$), with significant negative associations noted for the BDI-II ($r = -0.27$, $p < .001$), DASS-21 ($r = -0.19$, $p = .004$), DESC-I ($r = -0.33$, $p = .003$), and DSM criteria ($r = -0.21$, $p < .001$), but not the BDI ($r = -0.10$, $p = .17$), BDI-13 ($r = -0.08$, $p = .50$), HADS ($r = -0.17$, $p = .07$), EPDS ($r = -0.04$, $p = .72$), PHQ-9 ($r = -0.11$, $p = .06$), or ZSDS ($r = -0.11$, $p = .31$), although the effects were in the same (negative) direction. Continuous moderators, including mean sample age, sex composition (proportion female), and publication date, did not significantly explain variability in effect sizes (all $p > .10$). Further details of the above results are provided in Supplementary Materials.

3.5. Meta-analysis – other interoceptive measures

A three-level meta-analysis examined the association between depression and various non-MAIA interoceptive measures, as well as the MAIA Total score (which was not included in the previous multilevel analysis of the MAIA subscales) across 36 samples (38 effect sizes, 33 individual studies). Overall, no significant relationship emerged between these other measures of interoception and depression ($r = -0.07$, 95% CI [−0.19, 0.06], $p = .28$; Fig. 3). Heterogeneity was substantial ($I^2 = 95.56\%$), predominantly attributed to between-study differences (I^2 Level 3 = 79.53%) rather than within-study variability (I^2 Level 2 = 16.03%; Fig. S3). Egger's test showed no significant evidence of bias or small-study effects ($p = .51$); however, funnel plot inspection (see Fig. S4) indicated some asymmetry, potentially reflecting heterogeneity because of methodological variations rather than genuine publication bias.

Despite there being no overall association, interoceptive measure type significantly moderated effect sizes ($F(10, 29) = 13.45$, $p < .001$). Specifically, the Eating Disorder Inventory-Interoceptive Awareness (EDI-IA; $r = -0.61$, $p < .001$) and MAIA Total scores ($r = -0.22$, $p < .001$) showed significant negative associations with depression. Conversely, the Interoceptive Awareness Questionnaire-Expanded (IAQ-E; $r = 0.55$, $p < .001$), Body Perception Questionnaire (BPQ; $r = 0.17$, $p = .004$), Body Responsiveness Questionnaire (BRQ; $r = 0.41$, $p = .012$), and Body Vigilance Scale (BVS; $r = 0.24$, $p = .032$), demonstrated significant positive associations with depression. Depression assessment tools also significantly moderated the effect sizes ($F(9,29) = 2.61$, $p = .024$), with the BDI-II ($r = -0.36$, $p = .022$) and ZSRDS ($r = -0.59$, $p = .28$) showing significant effects. No other moderators significantly predicted variability in effect size, including: study design (within vs. between-subjects), mean sample age, proportion of female participants, and publication date (all $p > .05$; see supplementary Table S3). Full details of these analyses are provided in Supplementary Materials.

3.6. Quality assessment/risk of bias

The Appraisal tool for Cross-Sectional Studies tool was used to assess the quality for the 49 included studies. A random selection of 20% of the included papers were independently assessed by another author (JM).

Table 1
Summary of included study characteristics.

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Anestis et al. [33]	88	Undergraduate psychology students	M = 19.41 SD = 3.82	68F/20M (77.5% female)	USA	EDI-IA	BDI-II	0.70	15.00
Benau [34]	98	Healthy adults	M = 36.21 SD = 10.2	28F/78M (29% female)	USA	IAS, MAIA	DASS-21	IAS = −0.206 MAIA Noticing = −0.191 General[a] = −0.242	17.00
Bohler et al. [35]	293	Medical and psychology students	NR	206F/85M (2 'other')	Australia	BPQ (awareness subscale)	DASS-21	0.41	18.00
Brand et al. [36]	16	Healthy adults	M = 23 SD = NR	12F/4M	New Zealand	MAIA	CES-D	−0.16	15.00
Bullock and Goldbacher [37]	140	Healthy adults (students)	M = 19.75 SD = 1.59	140F/0M	USA	IAQ-E	CES-D	0.55	15.00
Burrows et al. [38]	136	MDD patients on SSRI (n = 47); MDD-unmedicated (n = 48); healthy controls (*n* = 41)	MDD-SSRI M = 35.87 SD = 11.21 MDD-unmed M = 32.31 SD = 11.28 Healthy M = 31.49 SD = 10.54	MDD-SSRI 36F/11 M MDD-unmed 33F/15M Healthy 23F/18M	USA	MAIA	DSM-IV or DSM-5 diagnosis of MDD determined by MINI interview [39]	MDD-SSRI[c] Noticing = 0.055 Not distracting = −0.21 Not worrying = −0.219 Attention Regulation = −0.301 Emotional awareness = 0.042 Self-regulation = −0.433 Body listening = −0.267 Trusting = −0.459 MDD-unmed[c] Noticing = 0.012 Not distracting = −0.208 Not worrying = −0.358 Attention Regulation = −0.321 Emotional awareness = −0.085 Self-regulation = −0.523 Body listening = −0.251 Trusting = −0.531	16.00
Critchley et al. [40]	202	MDD patients (*n* = 59); Anxiety patients (*n* = 29); mixed MDD-Anxiety patients (*n* = 47); healthy controls (*n* = 67)	MDD M = 38.4 SD = 15.3 Anxiety M = 35.1 SD = 16.1 Mixed M = 41.6 SD = 12.7 Healthy M = 35 SD = 13.2	MDD 34F/24M Anxiety 19F/10M (1 non-binary) Mixed 32F/15M Healthy 41F/26M	UK	BPQ (awareness subscale)	Psychiatric diagnosis confirmed by medical records	.037[c]	14.00

(*continued on next page*)

Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Crucianelli et al. [41]	172	Healthy adults	M = 26.30 SD = 5.05	87F/85M	Sweden	BAQ	DASS-21	−0.113	14.00
Datko et al. [42]	28	Patients with moderate/severe MDD (*n* = 13); Individuals with mild/no MDD (*n* = 15)	Moderate/ severe MDD M = 32.8 SD = 8.3 No/mild MDD M = 32.4 SD = 7.6	Moderate/ severe MDD: 7F/6M No/mild MDD: 7F/6M	USA	MAIA	DASS-21	Noticing = −.146[c] Not distracting = .28[c] Not worrying = −.217[c] Attention Regulation = −.14[c] Emotional awareness = −.195[c] Self-regulation = −.255[c] Body listening = −.162[c] Trusting = −.380[c] Total = −.253[c]	17.00
Desdentado et al. [43]	391	Healthy adults	M = 29 SD = 11.4	239F/152M (61% female)	Spain	MAIA-2	BDI	Noticing = 0.11 Not distracting = −0.12 Not worrying = −0.2 Attention Regulation = −0.16 Emotional awareness = 0.1 Self-regulation = −0.23 Body listening = −0.07 Trusting = −0.19	15.00
Desdentado et al. [44]	85	Healthy adults (*n* = 42); Patients with ABI (*n* = 43[b])	Healthy M = 43.74 SD = 13.33	Healthy 18F/24M	Spain	MAIA-2	HADS	Noticing = NR Not distracting = −0.41 Not worrying = −0.08 Attention Regulation = −0.18 Emotional awareness = NR Self-regulation = NR Body listening = NR Trusting = −0.08	15.00
Di Lernia et al. [45]	54	Healthy adults	M = 25.74 SD = 6.38	18.5% M	Italy	MAIA-2	BDI	Noticing = −0.077 Not distracting = −0.237 Not worrying = −0.086 Attention Regulation = −0.015 Emotional awareness = −0.058 Self-regulation = −0.29 Body listening = −0.075 Trusting = −0.05	16.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Dobrushina et al. [46]	258	Healthy adults (*n* = 182 completed self-reported interoception measure)	Total Sample M = NR SD = NR Range = 18–73	Total Sample 203F/55M	Russia	MAIA-2	BDI	MAIA Total = −0.04	15.00
Dunn et al. [47]	54	Community Depressed (*n* = 18); Clinical Depressed (n = 18); Non-depressed controls (n = 18)	Community Depressed M = 40.1 SD = 15.6 Clinical Depressed M = 47.1 SD = 9.9 Healthy M = 44.8 SD = 13	Community Depressed 72.2% F Clinical Depressed 72.2% F Healthy 77.8% F	UK	BCQ-Private	BDI	Community depressed = 0.23[c] Clinical depressed = 0.265[c]	15.00
D'Orsi et al. [48]	57	Healthy adults (COVID-19 hospital outpatients)	M = 55.89 SD = 10.15	15F/42M	Italy	MAIA	ZSDS & BDI-13	ZSDS Noticing = 0.218 Not distracting = −0.066 Not worrying = −0.337 Attention Regulation = −0.24 Emotional awareness = 0.042 Self-regulation = −0.193 Body listening = 0.027 Trusting = −0.33 BDI-13 Noticing = 0.397 Not distracting = −0.19 Not worrying = −0.421 Attention Regulation = −0.143 Emotional awareness = 0.046 Self-regulation = −0.125 Body listening = 0.068 Trusting = −0.224	
Ewing et al. [49]	86	Patients accessing mental health services (*n* = 138) including *n* = 44 with MDD; Healthy controls *n* = 42.	Patients (all; MDD not reported separately) M = 34.21 SD = NR Range = 18–64 Healthy M = 28.2 SD = NR Range = 18–65	Patients (all) 92F/43M (1 other, 2 undisclosed) Healthy 34F/8M	UK	BPQ (awareness subscale)	Clinician diagnosis – ICD or DSM criteria based on medical records	.204[c]	15.00
Fazia et al. [50]	145	Healthy controls (*n* = 55); Patients with an Eating Disorder (*n* = 90[b])	Healthy M = 24.2 SD = 6.5	Healthy 100% F	Italy	MAIA	BDI-II	MAIA Total = −0.51	16.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Fermin et al. [51]	64	Healthy adults (students)	M = 21.95 SD = NR Range = 18.34	32F/32M	Japan	MAIA	BDI-II	MAIA Total = −0.3	14.00
Fissler et al. [52]	99	Patients with MDD (*n* = 74); Healthy controls (*n* = 25)	MDD M = 42 SD = 12.5 Healthy M = 36.4 SD = 12.5	MDD 42 F Healthy 15 F	Germany	MAIA	DSM criteria using Structured Clinical Interview for DSM IV [53]	Noticing = −.186[c] Not distracting = −.094[c] Not worrying = −.369[c] Attention Regulation = −.462[c] Emotional awareness = −.022[c] Self-regulation = −.309[c] Body listening = −.152[c] Trusting = −.567[c]	17.00
Forkmann et al. [54]	95	MDD patients (*n* = 51); healthy controls (n = 44)	MDD M = 34.5 SD = 11.5 Healthy M = 35.2 SD = 11.8	56F/39M (58,9% female)	Germany	MAIA	DESC-I	Noticing = −0.110 [c] Not distracting = −.267[c] Not worrying = −0.239 [c] Attention Regulation = −0.441 [c] Emotional awareness = −0.116 [c] Self-regulation = −0.251 [c] Body listening = −0.481 [c] Trusting = −0.628 [c]	15.00
Frietchen et al. [55]	301	Healthy adults (transgender & gender diverse people)	M = 29.63 SD = 9.09	159F/135M (5 Intersex; 2 not disclosed)	USA	MAIA-2	DASS-21	Noticing = −0.23 Not distracting = −0.36 Not worrying = −0.27 Attention Regulation = −0.32 Emotional awareness = −0.15 Self-regulation = −0.39 Body listening = −0.24 Trusting = −0.58	
Gessner et al. [56]	791	Healthy adults	M = 46.55 SD = 14.35	635F/156M (80,3% female)	Germany	BVS	PHQ-2	BVS (Attention bodily sensations) = 0.16 BVS (Interoceptive sensitivity) = 0.18 BVS (Time spent scanning the body) = 0.21 BVS (Attention anxiety symptoms) = 0.29	15.00
Grossi et al. [57]	14	Healthy adults	M = 38.85 SD = 14.01	9F/5M (64,3% female)	Italy	SAQ	BDI-II	0.77	15.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Ikeda [58]	470	Healthy adults	M = 40.28 SD = 11.73	322F/148M	Japan	BPQ-VSF (Japanese Version) (awareness subscale)	CES-D	0.419	
Kalkışım et al. [59]	289	Healthy adults	M = 19.5 SD = 1.55	189F/100M	Turkey	BAQ	BDI	BAQ Total = −0.105	15.00
Karanassios et al. [60]	52	Healthy adults	M = 40.85 SD = 11.19	30F/22M	Germany	BPQ (awareness subscale)	BDI	0.08	16.00
Li et al. [61]	Sample 1 455 Sample 2 196	Healthy adults	Sample 1 M = 23.68 SD = 5.57 Sample 2 M = 24.99 SD = 6.49	Sample 1 315F/124M Sample 2129F/ 64M	USA	MAIA	BDI-II	Sample 1 Noticing = 0.05 Not distracting = −0.2 Not worrying = −0.24 Attention Regulation = −0.25 Emotional awareness = −0.04 Self-regulation = −0.24 Body listening = −0.13 Trusting = −0.38 Sample 2 Noticing = −0.04 Not distracting = −0.26 Not worrying = −0.32 Attention Regulation = −0.22 Emotional awareness = −0.08 Self-regulation = −0.36 Body listening = −0.21 Trusting = −0.38	
Machorrinho et al. [62]	38	Healthy adults	M = 40 SD = 10.9	38F/0M	Portugal	MAIA	HADS (depression)	Noticing = 0.037 Not distracting = 0.089 Not worrying = −0.089 Attention Regulation = −0.18 Emotional awareness = −0.185 Self-regulation = −0.342 Body Listening = NR Trusting = −0.505	15.00
Marschall et al. [63]	52 (first block) 44 (second block) 40 contributed	Healthy adults	M (first block) = 29.75 SD (first block) = n.a M (second block) = 30.6	29F/23M (first block) 21F/23M (second block)	Netherlands	MAIA	DASS-21	Noticing = 0.15 Not distracting = NR Not worrying = NR Attention Regulation =	17.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
	data to MAIA-DASS-21 correlations		SD (second block) = n.a.					NR Emotional awareness = 0.07 Self-regulation = −0.13 Body listening = −0.06 Trusting = NR	
Moradi and Tebbe [64]	201	Healthy adults	M = 25.9 SD = 8.1	176F/25M	USA	BRQ	CES-D	0.41	18.00
Morales et al. [65]	128	Healthy adults	M = 19.3 SD = 1.95	128F/0M	USA	MAIA	BDI-II	MAIA total = −0.09	15.00
Naraparedddy et al. [66]	48	Healthy adults	M = 31.5 SD = NR IQR = 23.5–49.5	20F/28M (41.66% female)	USA	MAIA-2	PHQ-9	Noticing = 0.31 Not distracting = −0.19 Not worrying = −0.36 Attention Regulation = −0.06 Emotional awareness = 0.12 Self-regulation = −0.22 Body listening = −0.10 Trusting = −0.19	17.00
Ojalehto et al. [67]	438	Healthy adults	M = 30.29 SD = 17.92	75.3% F 24.4% M 0.2% gender nonconform	USA	BVS	DASS-21	0.27	17.00
Peat and Muehlenkamp [68]	214	Healthy adults	M = NR SD = NR. Range = 18–41 Median = 19	214 (all women)	USA	EDI-IA	BDI-II	0.59	15.00
Roca et al. [69]	431	Healthy adults	M = 45.95 SD = 10.16	73.3% women	Spain	MAIA	DASS-21	MAIA total = 0.01	18.00
Ruggiero et al. [70]	88	Healthy adults	M = 23.36 SD = 2.51	58F/30M	Italy	BPQ-SF (awareness subscale)	DASS-21	−0.238	
Shen et al. [71]	226	Depressed patients with alexithymia (A-DEP; *n* = 34) Depressed patients without alexithymia (NA-DEP; *n* = 54) Healthy controls (HC; n = 50)	A-DEP M = 25.86 SD = 6.36 NA-DEP M = 27.15 SD = 8.84 HC M = 26.40 SD = 4.71	A-DEP 27F/7M NA-DEP 40F/14M HC 38F/12M	China	MAIA	Psychiatrist diagnosis using ICD-10	A-DEP vs. HC MAIA total = −0.526 [c] NA-DEP vs. HC MAIA total = −0.069 [c]	
Sim and Zeman [72]	37	Depressive patients (n = 18) Healthy controls (n = 19)	MDD M = 16y,3 m SD = 19 m Healthy Controls M = 16y,8 m SD = 16 m	100% F	USA	EDI-IA	DSM-IV using K-SADS-P [73]	0.6[c]	15.00
Singh Solorzano et al. [74]	229	Pregnant women	M = 31.93 SD = 4.84	100% women	Italy	MAIA	EPDS (Italian version)	Noticing = 0.028 Not distracting = −0.38 Not worrying = −0.214 Attention Regulation = 0.103 Emotional awareness = 0.04	17.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
Sun et al. [75]	396	Healthy adults	M = 19.33 SD = 1.02	353F/44M	China	MAIA-2	PHQ-9	Self-regulation = −0.027 Body listening = −0.023 Trusting = −0.164 Noticing = −0.035 Not distracting = −0.18 Not worrying = −0.181 Attention Regulation = −0.162 Emotional awareness = −0.178 Self-regulation = −0.293 Body listening = −0.221 Trusting = −0.383	
Suzuki et al. [76]	10,672	Healthy adults	M = 46.6 SD = 14.6	48.6% male	Japan	MAIA	PHQ-9	Noticing = 0.13 Not distracting = −0.22 Not worrying = −0.13 Attention Regulation = −0.01 Emotional awareness = 0.13 Self-regulation = −0.12 Body listening = 0.12 Trusting = −0.26	15.00
Tebbe et al. [77]	201	Healthy adults	18 or 19 M = NR SD = NR	100% female	USA	BAQ	CES-D	−0.22	17.00
Tiggemann and Williams [78]	146	Healthy adults	Mean = 20.4 SD = 2.87	100% female	Australia	EDI-IA	ZSRDS	0.59	16.00
Tünte et al. [79]	736	Healthy adults (3 samples): a) Prolific (*n* = 400); b) Students Vienna (*n* = 80); c) Students Potsdam (*n* = 256)	a) Prolific M = 30.96 SD = 10.86 b) Students M = 23.47 SD = 6.45 c) Students M = 24.53 SD = 6.42	a) Prolific 56.5% F b) Students 73.68% F c) Students 81.1% F	Germany	MAIA, BPQ-SF (awareness), IAS	BDI-II	Noticing = −0.263 Not distracting = −0.134 Not worrying = −0.378 Attention Regulation = −0.387 Emotional awareness = −0.069 Self-regulation = −0.426 Body listening = −0.233 Trusting = −0.592 IAS = 0.146 BPQ-awareness = 0.058	14.00
Vivas-Rivas et al. [80]	414	Healthy adults	M = 23.4 SD = NR	252 M/162F	Peru	MAIA-2	PHQ-9	MAIA total = −0.19	
Wang et al. [81]	688	Healthy adults	M = 19.85 SD = 1.87	367 M	China	BPQ-SF (awareness)	SDS-SOM & SDS-PSY	SDS-PSY BPQ-	16.00

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Table 1 (*continued*)

Author	Overall N	Participants	Age	Sex (F/M)	Country	Interoception Measure	Depression Measure(s)	*r*	Study Quality
								awareness = 0.16 SDS-SOM BPQ-awareness = 0.29	
Wiebking et al. [82]	37	MDD patients (n = 20) Healthy controls (*n* = 17)	MDD M = 41.88 SD = 12.1 Healthy controls M = 37.59 SD = 12.84	MDD 11F/6M Healthy controls 11F/6M	Germany	BPQ (awareness subscale)	DSM-IV & BDI	BPQ-Awareness = −.131[c]	16.00
Zhou et al. [83]	98	Subsyndromal depression (*n* = 48) Healthy controls (*n* = 50)	Subsyndromal depression M = 20.87 SD = 2.11 Healthy controls M = 22.57 SD = 2.64	Subsyndromal depression 11 M Healthy controls 11 M	China	BPQ-SF (awareness subscale)	CES-D	0.177[c]	17.00
Zhou et al. [84]	1120	Subclinical MDD (SC-MDD; *n* = 206) MDD patients (*n* = 483) Healthy controls (HC; *n* = 431)	SC-MDD M = 26 SD = 8 MDD M = 27 SD = 10 HC M = 28 SD = 9	SC-MDD 132F/74M MDD 345F/138M HC 262F/169M	China	MAIA-2	DSM-5 diagnosis via Structured Clinical Interview for DSM-5.	SC-MDD vs. HC[c] Noticing = 0.102 Not distracting = −0.119 Not worrying = −0.167 Attention Regulation = 0.035 Emotional awareness =0.071 Self-regulation = −0.097 Body listening = −0.009 Trusting = −0.099 MDD vs. HC[c] Noticing = 0.164 Not distracting = −0.113 Not worrying = −0.30 Attention Regulation = −0.108 Emotional awareness = 0.035 Self-regulation = −0.44 Body listening = −0.174 Trusting = −0.346	

a = MAIA-g, the 'general' factor of the MAIA calculated by taking the average score of each scale except Not Worrying and Not Distracting.
b = details of this group are not included as they were excluded from our analyses based on our inclusion/exclusion criteria.
c = effect size calculated from between-subject comparison.
ABI = Acquired Brain Injury; BAQ = Body Awareness Questionnaire; BCQ-Private = Body-Consciousness Questionnaire Private Subscale; BDI = Beck Depression Inventory; BDI-II = Beck Depression Inventory, Version 2; BPQ = Body Perception Questionnaire; BPQ-BA = Body Perception Questionnaire – Body Awareness Subscale; BPQ-SF/VSF = Body Perception Questionnaire – Short Form/Very Short Form; BRQ = Body Responsiveness Questionnaire; BVS = Body Vigilance Scale; CES-D = Center for Epidemiological Studies - Depression scale; DASS-21 = Depression Anxiety and Stress Scale, 21-Item Version; DESC-I = Rasch-based Depression Screening version 1; DSM = Diagnostic and Statistical Manual; ICD = International Statistical Classification of Diseases and Related Health Problems; EDI-IA = Eating Disorder Inventory – Interoceptive Awareness; EPDS = Edinburgh Postnatal Depression Scale; HADS = Hospital Anxiety and Depression Scale; IAQ-E = Interoception

Awareness Questionnaire – Expanded; IAQ-E = Interoceptive Awareness Questionnaire – Expanded; IAS = Interoceptive Accuracy Scale; K-SADS-P = Schedule for Affective Disorders and Schizophrenia for School-Aged Children – Present Version; MAIA = Multidimensional Assessment of Interoceptive Awareness; MAIA-2 = Multidimensional Assessment of Interoceptive Awareness, Version 2; MDD = Major Depressive Disorder; MINI = Mini International Neuropsychiatric Inventory; NR = not reported; PHQ-9 = Patient Health Questionnaire, 9-Item Version; PHQ-2 = Patient Health Questionnaire, 2-Item Version; SAQ = Self-Awareness Questionnaire; SDS-SOM = Self-rating Depression Scale Somatic Symptoms; SDS-PSY = Self-rating Depression Scale Psychological Symptoms; ZSRDS = Zung Self-Rating Depression Scale.

Higher EDI-IA scores indicate worse interoception and so, scores were reversed for the meta-analyses

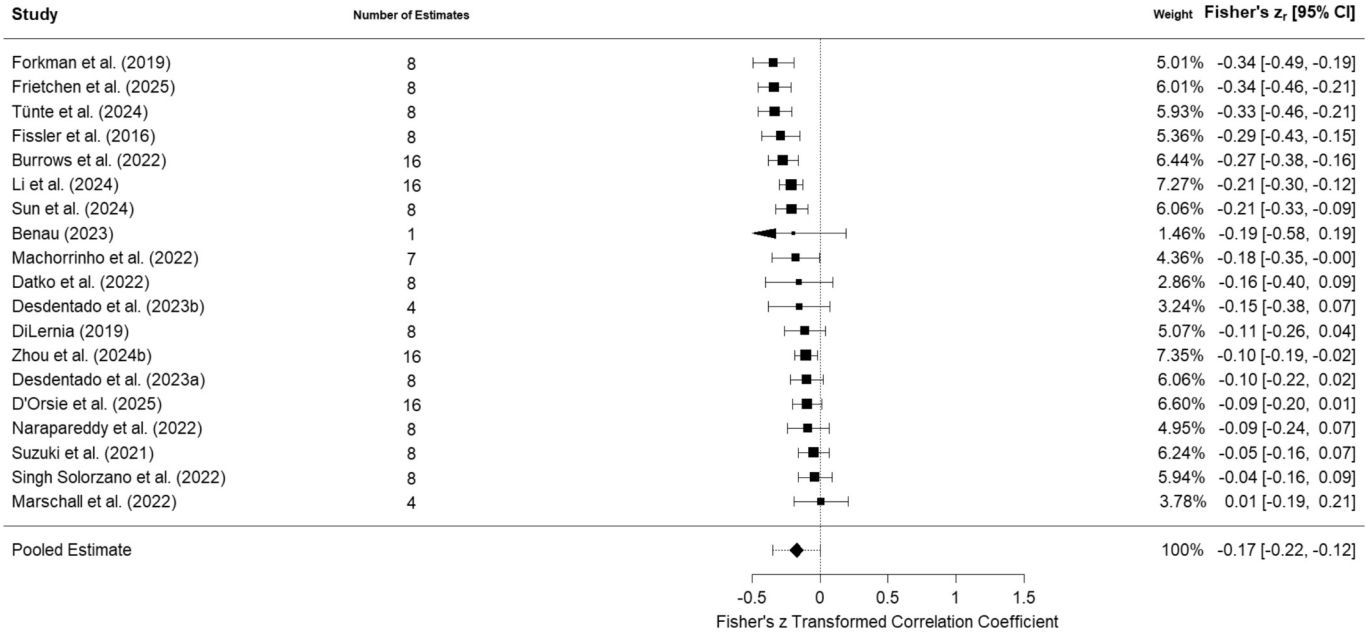

Fig. 2. Forest plot for all depression studies reporting on MAIA interoception outcomes.

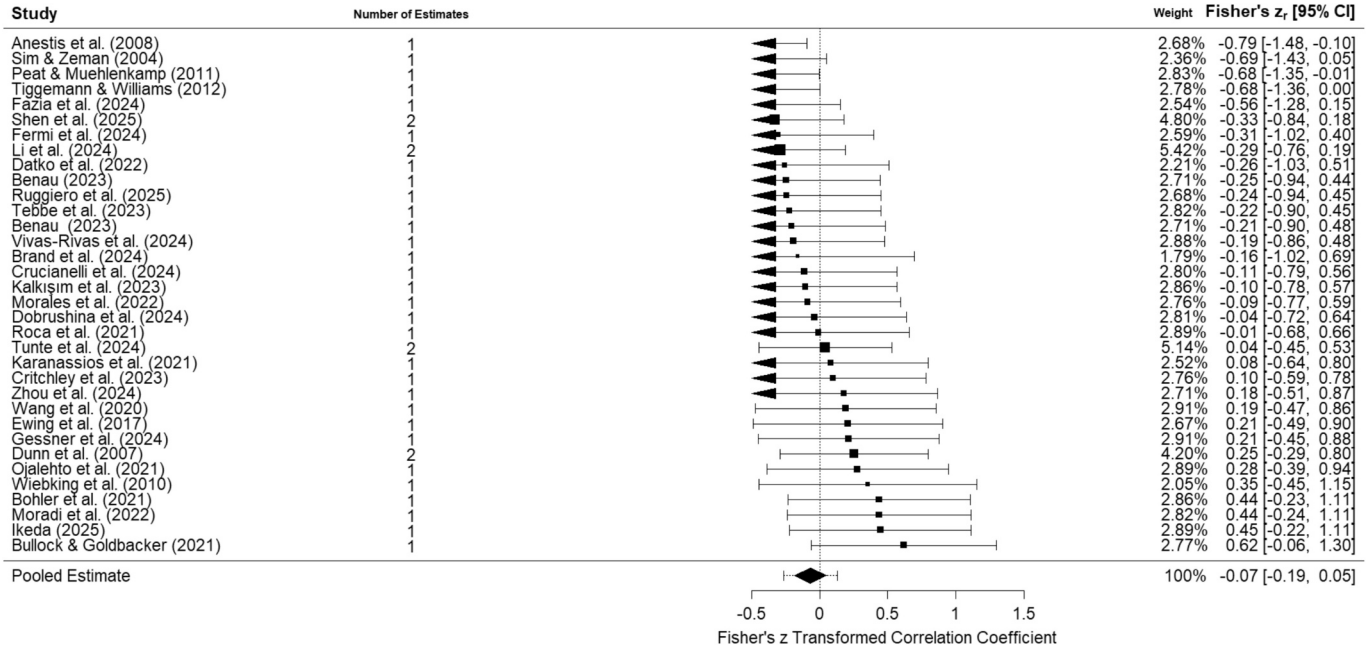

Fig. 3. Forest plot for all depression studies reporting on other (non-MAIA subscale) interoception outcomes.

Inter-rater reliability of AXIS ratings showed near perfect agreement between the two study raters ($k = 0.97$, $p < .001$). All 49 studies were rated as either moderate (29/49: 59.18%) or high quality (20/49: 40.82%). Aggregated sums for studies meeting AXIS criteria can be found in the Supplementary Materials Table S4. The mean quality rating across all 49 studies was 15.98 (SD = 1.38); mean scores for the subscales were: research design (6.82 [SD = 0.53]); study quality (5.37 [SD = 0.60]); and potential bias (3.80 [SD = 0.89]). No significant

relationships were revealed between the year of study publication and AXIS total and subscale scores (all $p > .05$). Full details of the AXIS ratings are provided in Supplementary Materials.

4. Discussion

This systematic review and meta-analysis of 49 studies ($N = 21,755$ participants) provides evidence of a measure-dependent association between self-reported interoception and depression. Interoception was assessed using a range of self-report questionnaires, with the most common being the Multidimensional Assessment of Interoceptive Awareness (MAIA) [20] and its updated version, the MAIA-2 [21]. Depression was significantly associated with six MAIA subscales (attention regulation, body-listening, not-distracting, not-worrying, self-regulation, and trusting), with poorer interoception being related to higher levels of depression. The remaining two subscales (emotional awareness and noticing) were not significantly associated with depression, with smaller (negative) relationships observed. Interestingly, and in contrast to these findings, other measures of interoception did not show an overall significant association with depression; and indeed, the direction of the relationship was negative for some scales (EDI-IA and MAIA Total score) but positive for others (BPQ, BVS, BRQ and IAQ-E). While several of the observed effects are small to medium [28], their magnitude is best interpreted in the context of the heterogeneity of the measures included. Different self-report questionnaires capture distinct facets of interoceptive experience, such as adaptive/regulatory awareness versus hypervigilance or bodily threat, which produce associations with depression in opposite directions. Accordingly, the modest pooled effects reflect the diversity of constructs assessed rather than the absence of meaningful relationships. We discuss these issues and their theoretical and clinical implications in detail below.

The association between depression and MAIA subscales was moderated by study design, with effect sizes being larger in between-group comparisons (i.e., clinical vs. non-clinical samples) than in within-group analyses of non-clinical participants. Individuals with MDD may exhibit broader physiological and allostatic dysregulation (e.g., altered stress reactivity, disrupted bodily time perception). Hence, interoceptive dysfunction would be more pronounced in clinically diagnosed individuals, highlighting its potential as a distinguishing feature of depression, with interoceptive deficits becoming more pronounced beyond a clinical threshold for depression. Within-group (non-clinical) samples are likely to show more restricted variance in depression scores, with most participants showing low levels of symptom severity. Nevertheless, the inclusion of both clinical and non-clinical samples allows the examination of whether interoceptive difficulties vary dimensionally with depressive symptom severity, rather than being restricted to the presence of such physiological dysregulation. Additionally, the specific depression measure employed influenced the magnitude of the association with the MAIA, though the direction of effect remained consistently negative across subscales. The significant moderation by depression measure type indicates that instruments focusing on somatic or vegetative symptoms may share greater conceptual overlap with interoceptive difficulties than those emphasising cognitive or affective symptoms, highlighting that the relationship between interoception and depression is at least partly measure-dependent. These findings underline the importance of measure selection and sample characteristics in interpreting effect sizes within this literature.

Moderator analyses examining demographic variables (age, sex) and publication year revealed no significant effects across any interoceptive measures. The lack of moderation by age or sex indicates that the association between interoception and depression is consistent across demographic subgroups. Sample demographics and the publication date also did not significantly contribute to the variation in effect sizes across studies. Indeed, the test for residual heterogeneity was significant, indicating that these moderators did not explain the substantial heterogeneity (further details are provided in Supplementary Material). Study quality ratings using the AXIS tool indicated that all 49 included studies were of moderate to high quality, suggesting consistent methodological standards over time These findings show that a consistent effect of self-reported interoception on depression occurs across demographic subgroups. Likewise, the absence of a publication year effect indicates a stable relationship across the past two decades, regardless of shifts in diagnostic frameworks, research practices or ways of measuring depression or interoception across time.

Our results address a key gap in the interoception and depression literature, which has traditionally focused on cardiac interoceptive accuracy measured through physiological tasks such as heartbeat detection or discrimination. These tasks predominantly evaluate objective, perceptual accuracy and consistently reveal minimal or no significant associations with depressive symptomatology [25]. In contrast, our meta-analysis establishes significant relationships between depression and multiple dimensions of self-reported interoception as assessed via the MAIA. These dimensions, particularly attention regulation, body-listening, self-regulation, trusting, not distracting and not-worrying, reflect regulatory and evaluative processes that extend beyond basic perceptual accuracy.

Theoretical and clinical implications arise from the contrasting patterns observed between objective physiological measures and subjective self-reports of interoception. Theoretically, our results reinforce contemporary conceptualisations of interoception as a multifaceted construct, comprising distinct yet interrelated processes that include basic perceptual sensitivity, evaluative interpretation, and regulatory control of internal bodily signals [14,89,104]. Clinically, the strong associations with self-reported regulatory and metacognitive dimensions identify these as promising targets for interoception-focused psychological interventions aimed at reducing depressive symptoms [105]. Thus, our findings highlight the relevance of subjective interoceptive appraisal in depression, and support a broader, more integrative approach to understanding how interoceptive mechanisms contribute to mental health disorders.

Emerging evidence linking anxiety with interoceptive dysfunction are consistent with our results in depression, reinforcing the idea that difficulties in interoception may be a shared, transdiagnostic feature of common mental health disorders. Clemente et al. [22] reported significant negative associations between self-reported interoceptive awareness and anxiety symptoms, particularly in dimensions related to regulatory control and metacognitive appraisal of bodily signals. Notably, these patterns, observed across both anxiety and depression, stand in sharp contrast to earlier meta-analytic evidence focused on cardiac interoceptive accuracy (e.g., heartbeat detection and discrimination tasks), which has yielded less consistent associations. Adams et al. [23] demonstrated minimal or no significant relationship between objective cardiac interoceptive measures and anxiety symptoms. A separate team of researchers in the same year [25], also found no evidence of an association between cardiac interoceptive accuracy and anxiety. The parallel lack of associations between cardiac awareness and anxiety or depression indicates that physiological accuracy alone might be insufficient in capturing the clinically relevant dimensions of interoceptive dysfunction. In contrast, meta-analyses of both anxiety and depression underscore the consistent role of subjective *interoceptive evaluations* in these two common mental health disorders. Collectively, these patterns indicate a compelling theoretical distinction within interoception research: subjective, regulatory dimensions of interoception may hold greater clinical relevance than purely perceptual interoceptive abilities. Consistent findings across meta-analyses in anxiety [22] and here for depression strengthens the case for developing targeted interventions that explicitly address the metacognitive and regulatory aspects of interoception, rather than focusing solely on enhancing perceptual sensitivity to bodily signals.

Different interoceptive measures capture distinct processes [18,106], as shown by contrasting associations with depression. Notably, the

significant negative associations we observed between depression and specific MAIA subscales contrast sharply with the positive associations found using alternative interoceptive measures (e.g., IAQ-E, BPQ, BRQ, BVS). Although the latter associations might be inflated or spurious given fewer studies employing these instruments, this divergence nonetheless underscores a critical distinction: the MAIA primarily captures adaptive regulatory and evaluative aspects of interoception, whereas other instruments might reflect heightened vigilance or maladaptive attention towards bodily sensations. Our findings highlight crucial theoretical distinctions within the concept of interoception, aligning closely with discussions by Murphy and colleagues who emphasise the dissociable nature of various interoceptive dimensions [22,89,104]. Murphy and colleagues propose that the measurement of interoceptive processes depends on a 2 × 2 separation of how an assessment is obtained (objective vs. self-report) and what is being assessed (attention vs. accuracy of perception). Thus, even within self-report measures, different aspects of interoception might be captured, each with unique clinical and theoretical implications.

Our findings reinforce and extend the view that subjective, regulatory dimensions captured by the MAIA are consistently associated with fewer depressive symptoms; suggesting that effective management and evaluation of bodily sensations play protective roles. Conversely, other measures potentially indexing maladaptive forms of interoceptive attention, characterised by heightened and negatively biased vigilance, might reflect mechanisms underlying increased vulnerability to depression. Thus, our results concur with the multidimensional view of interoception advocated by Murphy and colleagues, emphasising the importance of carefully distinguishing between adaptive and maladaptive interoceptive processes when investigating their clinical relevance and when designing targeted therapeutic interventions.

The current meta-analysis provides empirical support for the Allostatic Self-Efficacy (ASE) theory [107,108], which proposes that depression arises from a metacognitive perception of reduced control over bodily states. Specifically, the ASE framework proposes that fatigue reflects a subjective response to sustained uncertainty or failure in interoceptive regulation, marked by heightened interoceptive surprise. Depression, in turn, is thought to arise when these low self-efficacy beliefs generalise beyond bodily states, contributing to broader feelings of helplessness and diminished control. Our findings empirically support key elements of this refined ASE model. Specifically, significant negative associations between depression and MAIA regulatory subscales, might represent interoceptive mechanisms underlying the metacognitive judgments central to ASE theory. Indeed, previous studies [107] have specifically operationalised metacognition of allostatic control through two MAIA subscales (“not worrying” and “trusting”), both of which emerged as strongly negatively associated with depression in our analysis. This provides empirical support for the notion that reduced confidence or precision in bodily signals, and the consequent impaired metacognitive judgments about allostatic control, contribute critically to depressive symptoms.

Recent refinements to ASE theory offer further explanatory power for our observed interoceptive-depression associations. Indeed, Hess et al. [107] also propose refinements to the original ASE causal structure, suggesting potential direct relationships between interoceptive metacognition (allostatic control) and general self-efficacy beliefs. Such a refinement aligns well with our observations that some MAIA subscales, particularly regulatory dimensions capture broader self-efficacy judgments, not limited exclusively to bodily control. Future research, using both longitudinal and experimental designs, is required to further explore the specificity of interoceptive dimensions implicated in depression and to clarify their causal roles.

4.1. Strengths, limitations and future research

The current multi-level meta-analysis (MLMA) offers several advantages over a standard meta-analysis, particularly when dealing with complex or nested data structures including subscale scoring for the MAIA and the use of multiple outcome measures of depression. Our results enabled us to incorporate multiple effect sizes per study, and a clear advantage of MLMA is that it avoids the potential inflation of Type I errors, which occurs when dependencies are ignored. The separation of between-study and within-study variance also enables a clearer understanding of heterogeneity sources and permits more nuanced moderator analyses at different levels.

Nevertheless, some limitations should be acknowledged when interpreting the current findings. First, the potential presence of publication bias, as indicated by funnel plot asymmetry in some analyses, warrants cautious interpretation of results, particularly those derived from measures with fewer studies. Second, the reliability and generalisability of outcomes involving non-MAIA interoceptive measures are limited owing to fewer studies employing these instruments. These limitations highlight that the most robust and consistent results identified in this meta-analysis pertain particularly to the MAIA/MAIA-2 subscales. Our findings should be interpreted in light of the conceptual heterogeneity among self-report interoception questionnaires. The MAIA emphasises various positive facets of body awareness (adaptive, mindful, and regulatory), and thus tends to show negative associations with depression, whereas scales such as the BPQ or EDI-IA focus more on bodily distress or hypervigilance and are often positively related to depressive symptoms. These divergent emphases likely reflect overlapping but distinct facets of *interoceptive sensibility* [18] and may account for inconsistencies across studies.

Furthermore, despite the presence of various significant moderators, residual heterogeneity remains, implying that using the examined variables and moderators in this study we are unable to account for such heterogeneity (further details provided in Supplementary Materials). Future research could strengthen the evidence base by expanding the number of studies using alternative interoceptive measures.

4.2. Conclusions

This meta-analysis provides evidence of a measure-dependent association between self-reported interoception and depression. The strongest effects are observed in interoceptive domains related to regulatory control and metacognitive evaluation - particularly attention regulation, self-regulation, body-listening, not-worrying, and trusting. These findings extend previous work by demonstrating that subjective interoceptive dysfunction, rather than perceptual accuracy alone, is a meaningful correlate of depressive symptomatology. Moreover, the significantly larger effect sizes in clinical versus non-clinical samples suggests that interoceptive deficits may become more pronounced beyond a diagnostic threshold and could serve as a distinguishing feature of clinical depression.

Importantly, this work strengthens the view of interoception as a multidimensional construct and supports emerging models such as the Allostatic Self-Efficacy framework, which highlight how metacognitive beliefs about bodily control contribute to the development of depression. Clinically, our findings support the use of interoceptive-based interventions and suggest that enhancing an individual's confidence in and regulation of bodily signals provides a promising therapeutic avenue. Future research should prioritise both longitudinal and experimental designs to establish causal pathways, explore the specificity of interoceptive deficits across psychiatric conditions, and further clarify the translational utility of interoceptive constructs in mental health care.

CRediT authorship contribution statement

Paul M. Jenkinson: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Rodolfo Leuzzi:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Charlotte E. Dean:** Writing – review & editing, Methodology, Formal analysis. **Aaron T. Clarke:** Writing – review &

editing, Formal analysis, Data curation. **Joanna Mash:** Writing – review & editing, Formal analysis, Data curation. **Keith R. Laws:** Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT to summarise key results. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Declaration of competing interest

None declared.

Appendix A. Supplementary data

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