Meta-analysis of the Interoceptive Accuracy Scale (IAS) Structure and its Subjective Correlates

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Abstract

Blabla the abstract blabla.

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Interoception is referred to the process of sensing, interpreting and integrating information pertaining to internal organs, such as the heart, the lungs or the gut (Khalsa et al., 2018). While recent research emphasizes a key role of interoception in a variety of processes (e.g., emotion regulation, decision making) and of outcomes (physical and psychological well being), the field remains clouded by concerns about how interoception is assessed.

[**TO DO**: add - previous work suggests the importance of physiological contexts (Vlemincx et al., 2021)] **I would rather put that in the discussion in the suggestions for better scales**

Various measures of interoception have been developed (see **Figure 1**), forming a combination of "objective" and "subjective" assessments (i.e., physiological tasks such as the heart beat counting or tracking vs. questionnaires and subjective scales involving a metacognitive reflection), "explicit" and "implicit" paradigms (i.e., directing participants' awareness and attention to interoceptive processes *vs.* measuring interoception unbeknownst to them), various interoceptive modalities (e.g., cardioception, respiroception, gastroception) and theoretical dimensions (e.g., accuracy, sensitivity, awareness). While there is no consensus as to which particular approach provides the most accurate and "pure" measure of interoception and interoceptive abilities (assuming it is a unidimensional construct), it is instead plausible that each measure has strengths and limitations, and a utility dependent on the context and goal at hand (Jahedi & Méndez, 2014).

For instance, while the use of subjective self-reports questionnaires to measure deeply embodied functions might seem paradoxical, recent redefinitions of interoception, emphasizing the role of high-level and metacognitive elaboration of interoceptive information, has provided the theoretical grounding to support the idea that some facets of interoception (including participants' metacognitive beliefs) can be assessed subjectively, providing useful and interesting measures (Lin et al., 2023; Murphy et al., 2019). **TODO: that's a long sentence consider splitting** The notion that self-reports might not reflect the same processes as other interoception measures is important to contextualize the apparent lack of convergence between measures in the field (Desmedt et al., 2022). **(TODO: I would talk here a bit more about the relationship and lack thereof with intero tasks rather than later)** A better understanding of what is being measured with different questionnaires and dimensions, as well as their potential overlaps with other constructs (e.g., alexithymia, body awareness), is thus needed to clarify the role of self-reports in the assessment of interoception.

A recently developed scale with a rapidly growing popularity is the Interoceptive Accuracy Scale (IAS, Murphy et al., 2019). The IAS consists of 21 Likert-scale items that query how accurately one can perceive different bodily signals, with one item per physiological modality such as respiration (*"I can always accurately perceive when I am breathing fast"*), heart (e.g *"I can always accurately perceive when my heart is beating fast"*), skin (e.g *"I can always accurately perceive when something is going to be ticklish"*), arousal or bodily functions like coughing (e.g *"I can always accurately perceive when I am going to cough"*) or urinating (e.g. *"I can always accurately perceive when I need to urinate"*). Interestingly, the IAS' statements are about specific interoceptive behaviours, which is a notable difference with other popular interoception questionnaires, such as the Multidimensional Assessment of Interoceptive Awareness scale (MAIA, Mehling et al., 2012; MAIA-2, Mehling et al., 2018), which contains more general and metacognitive items (e.g., *"I trust my body sensations"*, *"I can notice an unpleasant body sensation without worrying about it"*).

Although the original validation study suggested a two-factor structure for the IAS (**TODO: what are they?**), the authors underline its acceptable but imperfect fit [Murphy et al. (2019); p. 127], calling on further investigation of the scale's factor structure. Notably, the only other validation study to report a 2-factor solution was conducted by Koike and Nomura (2023), who performed an Exploratory Factor Analysis (EFA) assuming 2 factors to align with the findings from the original validation paper. **TODO: this above is not really a validation study showing 2 factors is good if they prespecified two to match the original?** Other follow-up studies using confirmatory factor analysis (CFA) and structural modeling (Morin et al., 2015) have identified different optimal solutions. Some studies, like Brand et al. (2023), reported a 1-factor solution, while Lin et al. (2023) and Campos et al. (2021) found bifactor solutions - one general factor and a set of lower-level factors (Rodriguez et al., 2016) - to be the best fit. **TODO: what does morin2016 found? I would cite it after saying what they found rather than here**

Discussions have also been focused on specific items. For instance, Murphy et al. (2019) notes that some items might measure direct interoceptive signals such as cardioception, while others might capture phenomena not perceivable through interoceptive signals alone (e.g., “bruising”; p. 119). Lin et al. (2023) also highlights their correlation analysis, showing five locally dependent pairs and three items (touch, blood sugar, bruise) with exceptionally high difficulty and low discrimination. Additionally, Campos et al. (2021) suggests that the “tickle” item represents a more specific *(separate?)* factor. Interestingly, Lin et al. (2023) reported that all items of the IAS grouped together using a new approach, Exploratory Graph Analysis [EGA; Golino and Epskamp (2017)], to assess convergent and discriminant validity, providing further evidence for unidimensionality.

The IAS has naturally been compared to other interoception-related scales, and shows a positive correlations with most facets of the MAIA **(TODO: MAIA should be introduced before)**, except for the Non-Distracting and Not-Worrying subscales (Brand et al., 2023). Interestingly, findings on the correlation between the IAS and the body awareness dimension of the Body Perception Questionnaire (BPQ-A, Porges, 1993) have been mixed: some studies report small positive correlations (Brand et al., 2023; Campos et al., 2021; Koike & Nomura, 2023), while others find small negative correlations (Lin et al., 2023) or no correlation at all (Murphy et al., 2019). Small positive correlations have also been observed with the “observation” and “description” subscales of the Five Facet Mindfulness Questionnaire (FFMQ, Baer et al., 2006; Brand et al., 2023; Koike & Nomura, 2023), as well as with the “non-reactivity” and “acting with awareness” subscales (Koike & Nomura, 2023). Additionally, the IAS has shown a positive correlation with the interoceptive awareness subscale of the Eating Disorder Inventory (Lin et al.,

2023) and a negative correlation with the Interoceptive Confusion Questionnaire (Brand et al., 2023; ICQ, Brewer et al., 2016; Murphy et al., 2019). Lastly, small positive correlations have also been reported with the Interoceptive Attention Scale (IATS, Gabriele et al., 2022), though studies have also found no correlation between these measures (Gabriele et al., 2022) **(TODO: why same reference for two contradictory claims?)**.

While assessing the validity of an interoception scale can be conceived as theoretically challenging, several measures have been used to assess convergent validity for the the IAS, including expected negative associations with alexithymia Murphy et al. (2019), somatic symptoms Lin et al. (2023), depressive symptoms (Brand et al., 2023; Koike & Nomura, 2023; Lin et al., 2023), anxiety (Brand et al., 2023), neuroticism (Brand et al., 2023) and self-esteem (Murphy et al., 2019).

Few studies have examined the correlation between objective interoceptive measures, such as the Heartbeat Counting Task (HCT; Schandry, 1981) and the Heartbeat Detection Task (HDT; Kleckner et al., 2015). Existing findings report weak correlations for the HCT (Murphy et al., 2019), no correlations except for the sensitivity variable of the HCT (Brand et al., 2023), and small correlations for the HDT (Brand et al., 2023). These results suggest that the IAS, a subjective measure, does not strongly align with objective interoceptive assessments.

The current study aims at 1) clarifying the structure of the IAS with a meta-analytic approach that leverages existing data and contrast the traditional CFA/SEM factor-based analyses with network-based ones such as EGA. 2) The second part will provide an overview of the dispositional correlates of the IAS, providing an overview of the pattern of associations that is key to better understand the nature, place and role of interoception questionnaires within a larger context.

Study 1

The goal of study 1 is to re-analyse and assess the factor structure of the IAS by taking advantage of the large number of open-access datasets (Arslanova et al., 2022; Brand et al., 2022; Brand et al., 2023; Campos et al., 2021; Gaggero et al., 2021; Lin et al., 2023; Murphy et al., 2019; Todd et al., 2022; Von Mohr et al., 2023). While combining these studies might provide a more robust and generalizable understanding of the IAS' factor structure, we also additionally provide an individual analysis (i.e., on all samples separately) to add nuance to the general picture, as all studies differ in their sample sizes, demographics, language, and procedure.

Methods

Datasets. Our search focused on studies citing the original IAS validation paper (Murphy et al., 2019), identifying 136 papers (as of 01/05/2024). To qualify for inclusion, papers needed to (1) provide accessible data in open-access, (2) employ the IAS as a measure, and (3) report individual IAS items scores. A total of 10 studies was included (see **Table 1**). We also included the data of two unpublished (but already open-access) studies from the authors and one from another author. The total N participants was 32,214 participants (*Mean* = 48.6 years, *SD* = 13.1, 71.6% Female).

Sample	Subsample	Language	N	Difference	Age (Mean ± SD)	Range	Female %	Availability
Murphy et al., (2020)								osf.io/3m5nh
	Sample 1	English	451		25.8 ± 8.4	18-69	69.4%	
	Sample 2	English	375		35.3 ± 16.9	18-91	70.1%	
Gaggero et al., (2021)		English and Italian	814		24.9 ± 5.3	18-58	60.3%	osf.io/5x9sg
Campos et al., (2022)		Portuguese	515		30.7 ± 10.5	18-72	59.6%	osf.io/j6ef3
Todd et al., (2022)		English	802		48.6.6 ± 14.1*	18-92*	50%*	osf.io/ms354
Arslanova et al., (2022)		English	143		28.5 ± 7.6	18-73	46.8%	osf.io/mp3cy
Brand et al., (2022)		German	619		43.9 ± 14.5	18-78	78.7%	osf.io/xwz6g
Brand et al., (2023)								osf.io/3f2h6
	Sample 1	German	522		23.4 ± 6.7	18-79	79.5%	
	Sample 2	German	1993		32.0 ± 12.6	16-81	77.7%	
	Sample 3	German	802		27.3 ± 9.3	18-72	68.9%	
Lin et al., (2023)								osf.io/3eztd
	Sample 1	Chinese	1166	Collapsed "Itch" and "Tingling"	32.5 ± 8.4	16-60	57.0%	
	Sample 2	Chinese	500	Collapsed "Itch" and "Tingling"	37.4 ± 7.4	20-60	56.2%	
VonMohr et al., (2023)		English	21843		56.5 ± 14.4	18-93	73.2%	osf.io/7p9u5
Makowski et al., (2023a)		English	485	Analog scales	30.1 ± 10.1	18-73	50.3%	github.com/RealityBending/IllusionGameReliability
Makowski et al., (2023b)		English	836	Analog scales	25.1 ± 11.3	17-76	53.0%	github.com/DominiqueMakowski/PHQ4R
Makowski et al., (2023c)		English	104	Analog scales	21.6 ± 5.0	18-50	76%	github.com/RealityBending/InteroceptionPrimals
Poreiro et al., (2024)		English	107		26.8 ± 9.2	18-57	74.8%	osf.io/49wbv
Poreiro et al., unpublished		English	131		30.9 ± 12.0	18-60	75.9%	
Total			32214		48.6 ± 13.1	17-93	71.6%	

* Information taken from the sample description of relevant paper rather than recomputed.

Statistical Analysis. To examine the factor structure of the IAS, a two-step approach was employed. First, Exploratory Graph Analysis (EGA), was used to estimate the dimensions via network estimation and community detection, alongside assessing the stability of dimensions and items using the bootstrapping techniques (Golino & Epskamp, 2017). The selection of EGA was motivated by its capability to handle complex, multidimensional data and provide robust dimension estimates. A novel network psychometrics - Unique variable analysis [UVA; Christensen et al. (2023)] - approach based on the weighted topological overlap will be computed to evaluate which items have substantial local dependence (> 0.25). Subsequently, exploratory factor analysis (EFA) was employed followed by confirmatory factor analysis (CFA).

Arslanova, I., Galvez-Pol, A., Kilner, J., Finotti, G., & Tsakiris, M. (2022). Seeing through each other's hearts: Inferring others' heart rate as a function of own heart rate perception and perceived social intelligence. *Affective Science*, *3*(4), 862–877.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, *13*(1), 27–45.

Brand, S., Meis, A. C., Tünte, M. R., Murphy, J., Woller, J. P., Jungmann, S. M., Witthöft, M., Hoehl, S., Weymar, M., Hermann, C., & Ventura-Bort, C. (2023). A multi-site German validation of the Interoceptive Accuracy Scale and its relation to psychopathological symptom burden. *Communications Psychology*, *1*(1). https://doi.org/10.1038/s44271-023-00016-x

Brand, S., Petzke, T. M., & Witthöft, M. (2022). The differential relationship between self-reported interoceptive accuracy and attention with psychopathology. *Zeitschrift für Klinische Psychologie Und Psychotherapie*.

Brewer, R., Cook, R., & Bird, G. (2016). Alexithymia: A general deficit of interoception. *Royal Society Open Science*, *3*(10), 150664.

Campos, C., Rocha, N. B., & Barbosa, F. (2021). *Untangling self-reported interoceptive attention and accuracy: Evidence from the european portuguese validation of the body perception questionnaire and the interoceptive accuracy scale*. http://dx.doi.org/10.31234/osf.io/a7wdj

Christensen, A. P., Garrido, L. E., & Golino, H. (2023). Unique variable analysis: A network psychometrics method to detect local dependence. *Multivariate Behavioral Research*, *58*(6), 1165–1182.

Desmedt, O., Heeren, A., Corneille, O., & Luminet, O. (2022). What do measures of self-report interoception measure? Insights from a systematic review, latent factor analysis, and network approach. *Biological Psychology*, *169*, 108289.

Gabriele, E., Spooner, R., Brewer, R., & Murphy, J. (2022). Dissociations between self-reported interoceptive accuracy and attention: Evidence from the interoceptive attention scale. *Biological Psychology*, *168*, 108243.

Gaggero, G., Bizzego, A., Dellantonio, S., Pastore, L., Lim, M., & Esposito, G. (2021). Clarifying the relationship between alexithymia and subjective interoception. *PLoS One*, *16*(12), e0261126.

Golino, H. F., & Epskamp, S. (2017). Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. *PloS One*, *12*(6), e0174035.

Jahedi, S., & Méndez, F. (2014). On the advantages and disadvantages of subjective measures. *Journal of Economic Behavior & Organization*, *98*, 97–114. https://doi.org/10.1016/j.jebo.2013.12.016

Khalsa, S. S., Adolphs, R., Cameron, O. G., Critchley, H. D., Davenport, P. W., Feinstein, J. S., Feusner, J. D., Garfinkel, S. N., Lane, R. D., Mehling, W. E., Meuret, A. E., Nemeroff, C. B., Oppenheimer, S., Petzschner, F. H., Pollatos, O., Rhudy, J. L., Schramm, L. P., Simmons, W. K., Stein, M. B., … Zucker, N. (2018). Interoception and Mental Health: A Roadmap. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *3*(6), 501–513. https://doi.org/10.1016/j.bpsc.2017.12.004

Koike, H., & Nomura, M. (2023). Development and validation of japanese versions of the interoceptive accuracy scale and interoceptive attention scale. *SAGE Open*, *13*(4), 21582440231214639.

Lin, X.-X., Shen, H.-R., Lin, J.-X., Zhang, Y.-H., Murphy, J., Wang, Y.-Z., Sun, Y.-B., Wang, N., Wang, J.-Y., Wei, G.-X., & Luo, F. (2023). Psychometric validation and refinement of the

Chinese Interoceptive Accuracy Scale (IAS) in general population and patients with chronic pain. *Journal of Psychosomatic Research*, *175*, 111541. https://doi.org/10.1016/j.jpsychores.2023.111541

Mehling, W. E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The multidimensional assessment of interoceptive awareness, version 2 (MAIA-2). *PloS One*, *13*(12), e0208034.

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. https://doi.org/10.1371/journal.pone.0048230

Morin, A. J. S., Arens, A. K., & Marsh, H. W. (2015). A bifactor exploratory structural equation modeling framework for the identification of distinct sources of construct-relevant psychometric multidimensionality. *Structural Equation Modeling: A Multidisciplinary Journal*, *23*(1), 116–139. https://doi.org/10.1080/10705511.2014.961800

Murphy, J., Brewer, R., Plans, D., Khalsa, S. S., Catmur, C., & Bird, G. (2019). Testing the independence of self-reported interoceptive accuracy and attention. *Quarterly Journal of Experimental Psychology*, *73*(1), 115–133. https://doi.org/10.1177/1747021819879826

Porges, S. (1993). Body perception questionnaire. *Laboratory of Developmental Assessment, University of Maryland*, *10*, s15327752jpa5304_1.

Rodriguez, A., Reise, S. P., & Haviland, M. G. (2016). Evaluating bifactor models: Calculating and interpreting statistical indices. *Psychological Methods*, *21*(2), 137.

Todd, J., Swami, V., Aspell, J. E., Furnham, A., Horne, G., & Stieger, S. (2022). Are some interoceptive sensibility components more central than others? Using item pool visualisation to understand the psychometric representation of interoception. *Plos One*, *17*(12), e0277894.

Von Mohr, M., Silva, P. C., Vagnoni, E., Bracher, A., Bertoni, T., Serino, A., Banissy, M. J., Jenkinson, P. M., & Fotopoulou, A. (2023). My social comfort zone: Attachment anxiety shapes peripersonal and interpersonal space. *Iscience*, *26*(2).

Figure 1

Different ways in which interoception can be measured.