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# The Differential Relationship Between Self-Reported Interoceptive Accuracy and Attention With Psychopathology

## A Latent Variable Approach

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**Abstract:** *Background:* Only recently has interoception been discussed as a common risk factor for psychopathology. Recent approaches distinguish between the ability to accurately perceive (*interoceptive accuracy*) and the propensity to attend (*interoceptive attention*) to internal signals. *Objective:* To examine the latent structure of self-reported interoceptive accuracy and attention and their relationships to psychopathology. *Methods:* We used a confirmatory factor analysis to clarify the latent structure of interoceptive accuracy and attention. Structural equation modeling was utilized to determine relationships between both abilities with internalizing and somatoform symptomatology according to the HiTOP model (Kotov et al., 2017). Data from $N$ = 619 persons from the German general population were analyzed. *Results:* Interoceptive attention showed significant positive relationships with all psychopathological traits ($r$ = .221 to $r$ = .377), whereas interoceptive accuracy was negatively associated with internalizing symptomatology ($r$ = -.106). *Conclusion:* The present findings indicate that personal beliefs about interoceptive abilities have different influences on psychopathological developments.

**Keywords:** interoception, interoceptive accuracy, interoceptive attention, psychopathology, structural equation modeling

**Der unterschiedliche Zusammenhang zwischen selbstberichteter interozeptiver Genauigkeit und Aufmerksamkeit mit Psychopathologie. Ein latentes Variablenmodell**

**Zusammenfassung:** *Theoretischer Hintergrund:* Erst kürzlich wurde Interozeption als ein häufiger Risikofaktor für Psychopathologie diskutiert. Neuere Ansätze unterscheiden zwischen der Fähigkeit zur genauen Wahrnehmung (*interozeptive Genauigkeit*) und der Neigung, auf interne Signale zu achten (*interozeptive Aufmerksamkeit*). *Fragestellung:* Untersuchung der latenten Struktur selbstberichteter interozeptiver Genauigkeit und Aufmerksamkeit und deren Beziehungen zu Psychopathologie. *Methode:* Zur Klärung der latenten Struktur interozeptiver Genauigkeit und Aufmerksamkeit und ihrer Beziehungen zu internalisierender und somatoformer Symptomatik entstprechend dem HiTOP Modell (Kotov et al., 2017) wurden konfirmatorische Faktorananalysen und Strukturgleichungsmodelle verwendet. Daten von $N$ = 619 Personen aus der deutschen Allgemeinbevölkerung wurden analysiert. *Ergebnisse:* Interozeptive Aufmerksamkeit zeigte signifikante positive latente Zusammenhänge mit allen psychopathologischen Merkmalen ($r$ = .221 bis $r$ = .377), während interozeptive Genauigkeit negativ mit internalisierender Symptomatik assoziiert war ($r$ = -.106). *Schlussfolgerung:* Die vorliegenden Ergebnisse deuten darauf hin, dass die persönliche Einschätzung interozeptiver Fähigkeiten unterschiedliche Einflüsse auf psychopathologische Entwicklungen haben.

**Schlüsselwörter:** Interozeption, interozeptive Genauigkeit, interozeptive Aufmerksamkeit, Psychopathologie, Strukturgleichungsmodelle

Interoception, the ability to perceive internal body signals (e.g., gastrointestinal sensations; Khalsa et al., 2018), has recently been discussed as "a common risk factor for psychopathology" (Brewer et al., 2021, p. 1). Murphy et al. (2019) also introduced a 2 x 2 factorial model to define how interoceptive processes could be categorized and measured. The authors described interoceptive abilities as a two-dimensional construct that can be divided into features of interoceptive accuracy (i.e., the ability to correctly perceive one's internal states) and interoceptive attention (i.e., the tendency to focus one's attention on interoceptive information). The authors state that both di-

mensions can be measured, either via self-assessment of personal beliefs (e.g., questionnaires like Mehling et al., 2012; Porges, 1993, for interoceptive attention; or Murphy et al., 2020, for interoceptive accuracy) or via performance ratings (e.g., heartbeat counting tasks such as Pohl et al., 2021; Schandry, 1981, for interoceptive accuracy; or experience sampling methods for interoceptive attention, Csikszentmihalyi & Larson, 2014). The latter represents a novel approach to the construct of interoception; in previous considerations, the assessment method often determined which interoceptive ability was supposed to be measured (e.g., Garfinkel & Critchley, 2013; Khalsa et al., 2018, for an overview). Thus, further important possibilities for operationalizing interoception arise, since each of the mentioned interoceptive domains appears to be critically involved in everyday functions (such as emotional processing or decision-making; e.g., Bevins & Besheer, 2014; Herbert et al., 2011) or even psychopathological symptomology[1].

Because the linearity between interoceptive sensations and their cognitive representations are questioned, for example, in patients with asthma, where the perceived severity of asthma symptoms has been shown to vary from patient to patient and to be strongly influenced by contextual information (Janssens et al., 2009), altered interoceptive accuracy could lead to distorted expectations (so-called *prediction errors*) regarding internal signals and thus play a key role in the development of false representations of the body, subsequently contributing to the development, severity, or maintenance of mental or, as some authors suggest, physical illness (Barrett & Simmons, 2015; Edwards et al., 2012; Van den Bergh et al., 2017; Van den Bergh et al., 2021). However, evidence on the relationship between interoceptive accuracy and psychopathology is rather inconsistent, as most studies find reduced interoceptive accuracy (typically measured by performance ratings, especially heartbeat-counting tasks) in most clinical disorders (e.g., depression, eating disorders, autism spectrum disorders, and functional somatic syndromes), whereas in anxiety and obsessive-compulsive disorders, the relationship often points in the opposite direction (see Brewer et al., 2021; Wolters et al., 2022, for an overview). In particular, the relationship between anxiety symptoms and interoceptive accuracy measured by heartbeat perception tasks seems nonexistent (Adams et al., 2022). On the other hand, for interoceptive attention, Palser et al. (2018) showed that high self-reported interoceptive attention appeared to be the best predictor of anxiety symptoms in children with autism spectrum disorder. Since interoceptive attention was recently operationalized through different questionnaires (e.g., Porges's Body Perception Questionnaire, 1993, in Palser et al., 2018), it is difficult to observe a general trend in its relation to psychopathology. Analyses have indicated that there may be variance in the construct being measured in self-reports of interoception, which complicates communication about interoceptive attention (Desmedt et al., 2022).

Altered interoceptive abilities have often been discussed as a *p-factor*, an underlying factor predicting various clinical symptoms of psychopathology (Brewer et al., 2016). Brewer et al. (2021) pointed out that, although there is no agreement on interoception as an underlying p-factor, its potential role in diagnoses and symptoms is difficult to deny. The authors argue that there could be different patterns of altered interoception (e.g., increased or decreased interoceptive accuracy or attention) in specific domains (e.g., gastrointestinal sensations) leading to distinct conditions. This fact becomes particularly relevant when considering recent innovative approaches to the taxonomy of psychopathology, specifically the HiTOP model (Hierarchical Taxonomy of Psychopathology; Kotov et al., 2017), which is a dimensional and strictly empirical nosological approach, assembling components into syndromes and grouping them into psychopathology spectra. Within the model, interoceptive abilities could be conceptualized as higher-order dimensions. Current versions of the HiTOP model assume that certain spectra (i.e., somatoform and internalizing) represent distinct spectra under a common superspectrum of emotional dysfunction (Watson et al., 2022). This assumption warrants further investigation of common risk factors of such superspectra, for instance, interoception (see also Brewer et al., 2021, for an overview of the relationship between interoception and emotion regulation).

The development of the 2 x 2 factorial model of interoception caused two newly created questionnaires to be published: the Interoceptive Accuracy Scale (IAS; Murphy et al., 2020) and the Interoceptive Attention Scale (IATS; Gabriele et al., 2022), which have already shown good psychometric properties in English-speaking countries. Both self-assessment procedures assess the ability to either accurately perceive or attend to internal body states based on the same 21 bodily signals (e.g., heartbeat, pain, need to urinate). Because a German-speaking workgroup from Mainz, Potsdam, Vienna, and Giessen is currently

[1] In the present paper findings from adult and child samples are reported to provide a general overview. However, research has already shown that profound differences in interoceptive abilities exist between children and adults (e.g., Murphy et al., 2017; Opdensteinen et al., 2021; Schaan et al., 2019).

working on German validations of both questionnaires (Brand et al., 2022; Tünte et al., 2022), a good basis exists to further investigate the dissociation between self-reported interoceptive accuracy and attention and its relation to psychopathology according to the 2 x 2 factorial model. Despite the promising psychometric properties and the already existing trend to make the questionnaires available in many countries, some uncertainties remain regarding the underlying factor structure of self-reported interoceptive accuracy and attention. For example, the initial authors found a two-component structure for the IAS and a three-component structure for the IATS (Gabriele et al., 2022; Murphy et al., 2020). In contrast, the German working group found support for a single-factor structure for both questionnaires (Brand et al., 2022; Tünte et al., 2022), whereas the Portuguese version of the IAS assumes a bifactorial structure (Campos et al., 2021). This leads to the question of the latent structure of self-reported interoceptive accuracy and attention: Based on the fact that highly correlated factors were found in the multifactorial solutions of the constructs, it is hypothesized that an overarching dimension probably represents personal beliefs about interoceptive accuracy and attention, but further empirical evidence is needed to support this hypothesis.

Therefore, the present study uses the 2 x 2 factorial model of interoceptive abilities with the IAS and IATS questionnaires to operationalize interoceptive abilities as self-reported interoceptive accuracy and attention. We replicate the latent factor structure of both according to recent findings on single-factor structure in the German versions of the IAS and IATS (Brand et al., 2022; Tünte et al., 2022) as well as the initially theoretically assumed single-factor structure in the original English versions (Gabriele et al., 2021; Murphy et al., 2020). Subsequently, we use dimensional scores on individual depressive, anxious, and somatic symptom burdens resulting from three questionnaires to model latent factors related to two spectra (i.e., somatoform and internalizing) within the HiTOP model (Kotov et al., 2017). Somatic symptom burden accordingly represents a somatoform factor, whereas depressiveness and anxiousness represent an internalizing factor. Finally, we want to explore the latent relationships between those factors with interoceptive accuracy and attention.

# Method

The present study was part of a larger longitudinal research project at the Department of Clinical Psychology, Psychotherapy, and Experimental Psychopathology at the University of Mainz. Data collection was conducted using SoSci Survey (Leiner, 2019).

## Participants and Sample Analysis

Participants were recruited through newspaper articles, social media, and university press releases. Inclusion criteria were at least 18 years of age and a fully completed survey, so 8 participants had to be excluded retrospectively. As compensation, participants were given a chance to win one of five shopping vouchers or earn research credits. Overall, $N$ = 619 participants took part in the survey. Thereof, 78.7% reported their gender as female, 20.2% as male, and 1.1% as nonbinary. The mean age of the participants was $M$ = 43.88 years ($SD$ = 14.53, range 18–78). Of all participants, 85.6% reported having some form of university entrance qualification, while 13.8% reported having some form of lower education diploma (0.6% could not be categorized due to uncertainties regarding the German educational equivalent).

## Materials

Based on current recommendations (e.g., Hayes & Coutts, 2020), we used the McDonald's ω coefficient (McDonald, 2013) to determine the internal consistency of the standardized procedures applied in the present study. The evaluation follows common rules of thumb for internal consistency (e.g., George & Mallery, 2016). The descriptive statistics of the calculated sum scores and the relationships between the individual measurements are shown in Table 1.

### Patient Health Questionnaire – 2 (PHQ-2)

The PHQ-2 (Löwe et al., 2005) is a very short questionnaire that asks about the severity of the two leading symptoms of a major depressive episode. The two items are: *Having little interest or pleasure in doing things* and *Feeling down, depressed, or hopeless*. For each of the two items, participants indicate *how often* they *have been bothered over the last 2 weeks* on a scale from *not at all* to *nearly every day*. In the present study, the PHQ-2 had a good internal consistency of ω = .828.

### Generalized Anxiety Disorder Scale – 2 (GAD-2)

The GAD-2 (Kroenke et al., 2007) is a brief version of a well-established screening tool to identify anxiety disorders (Spitzer et al., 2006). The two items of the questionnaire are: *Over the last two weeks, how often have you been bothered by the following problems,* (a) *feeling nervous, anxious, or on edge,* and (b) *not being able to stop or control*

**Table 1.** Pearson correlations between questionnaires of interoceptive abilities and psychopathology

| Questionnaire | *M* (*SD*) | 1 [95% *CI*] | 2 [95% *CI*] | 3 [95% *CI*] | 4 [95% *CI*] |
|---|---|---|---|---|---|
| 1. PHQ-2 (*N* = 619) | 3.87 (1.58) | 1 | – | – | – |
| 2. GAD-2 (*N* = 619) | 3.81 (1.60) | .703*** [.661 – .741] | 1 | – | – |
| 3. SSS-8 (*N* = 619) | 15.98 (5.45) | .557*** [.501 – .609] | .560*** [.504 – .612] | 1 | |
| 4. IAS (*N* = 619) | 80.26 (11.91) | -.073 [-.151 – .005] | -.087* [-.164 – -.008] | -.038 [-.117 – .040] | 1 |
| 5. IATS (*N* = 619) | 41.69 (15.08) | .163*** [.086 – .239] | .192*** [.115 – .267] | .318*** [.246 – .387] | .080* [.001 – .158] |

*Note.* ***$p < .001$, **$p < .01$, *$p < .05$. PHQ-2 = Patient Health Questionnaire – 2, GAD-2 = Generalized Anxiety Disorder Scale – 2, SSS-8 = Somatic Symptom Scale – 8, IAS = Interoceptive Accuracy Scale, IATS = Interoceptive Attention Scale.

*worrying*. The questions are answered on a 4-point Likert scale from *not at all* to *nearly every day*. The GAD-2 showed an acceptable internal consistency of ω = .790 in the present study.

### Somatic Symptom Scale – 8 (SSS-8)

The Somatic Symptom Scale – 8 (Gierk et al., 2014) was designed to measure individual somatic symptom burden. On a 5-point Likert scale (*not at all* to *very much*), participants are asked whether they have been bothered by a somatic problem (e.g., *back pain* or *headaches*) during the past 7 days. In the present study, the SSS-8 had a good internal consistency of ω = .802.

### Interoceptive Accuracy Scale (IAS)

The Interoceptive Accuracy Scale (Murphy et al., 2020) is a self-report questionnaire that assesses how accurately participants can perceive internal signals. The German version of the IAS used in the present study corresponds to the version proposed by a German-language working group (Brand et al., 2022), which was translated according to current guidelines (Schmitt & Eid, 2007) by independent scientists and then backtranslated by a native speaker. Participants answer items such as *I can always accurately perceive when my heart is beating fast* on a scale from *disagree strongly* to *strongly agree*. In the present study, the IAS had an excellent internal consistency of ω = .916.

### Interoceptive Attention Scale (IATS)

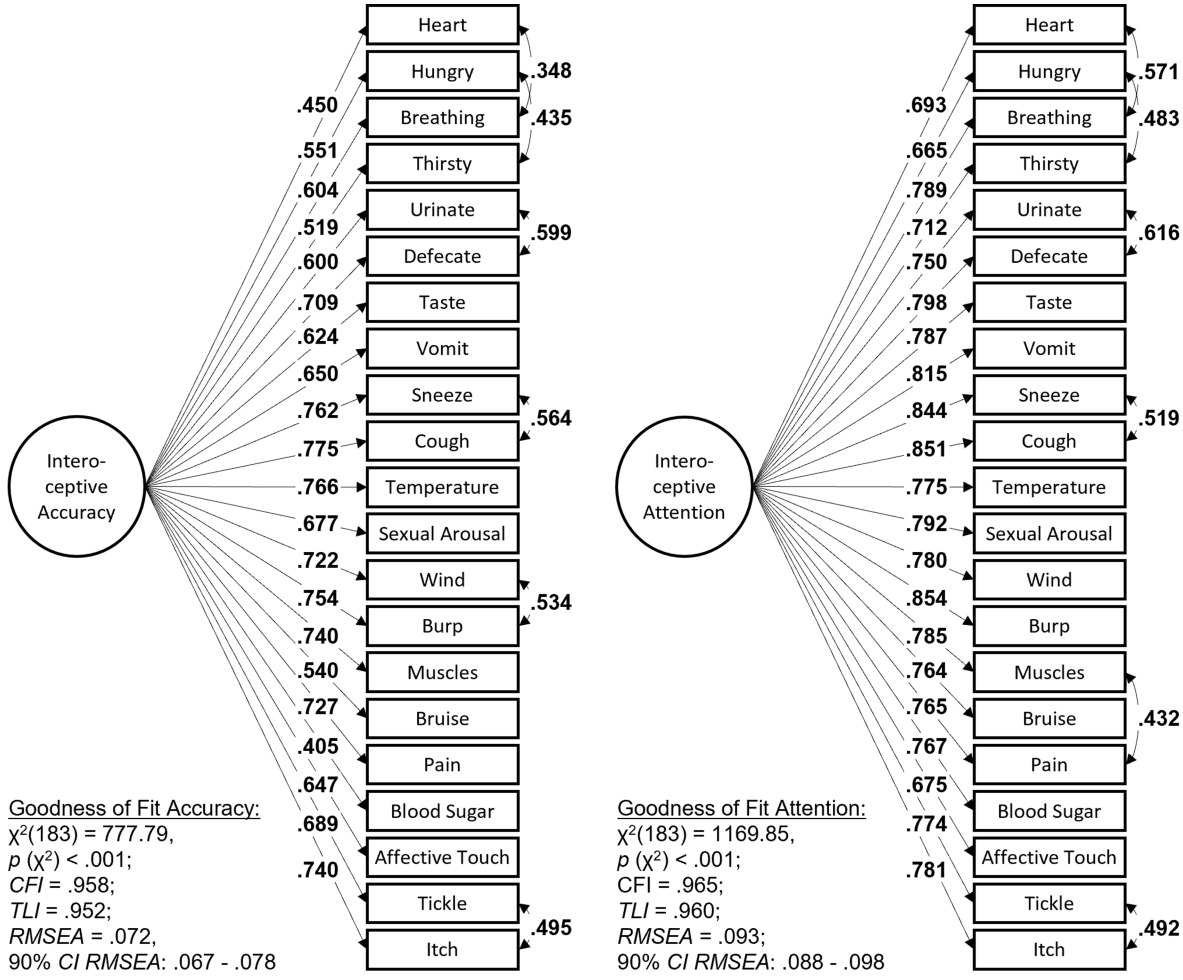
The Interoceptive Attention Scale (Gabriele et al., 2022) is a questionnaire that assesses participants' tendency to focus on interoceptive information regardless of the accuracy in processing this information. The version of the IATS used also originates from a German-language working group (Tünte et al., 2022). The translation process was the same as for the IAS. On a scale from *disagree strongly* to *strongly agree*, participants indicate whether they *most of the time focus their attention* on *their heart beating fast*, for example. The internal consistency of the questionnaire was excellent in the present study, with ω = .954.

## Data Analysis

We used IBM SPSS Statistics (IBM Corporation, 2020) for data preparation, JASP (JASP Team, 2022) for general analysis, and MPLUS (L. K. Muthén & Muthén, 1998–2017) for confirmatory factor analysis (CFA) and structural equation modeling (SEM).

The CFAs and SEMs were conducted using the robust mean and variance-adjusted weighted least squares (WLSMV) procedure (B. O. Muthén, 1984). To examine model fit, we report root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) in addition to the $\chi^2$-statistic, which proved to be sensitive to the sample size and complexity of a model (Bentler & Bonett, 1980). The goodness of fit was evaluated according to Schermelleh-Engel et al. (2003).

To replicate recent findings on one-factor solutions of self-reported interoceptive accuracy and attention within the German versions of the IAS and IATS (Brand et al., 2022; Tünte et al., 2022), we applied CFAs. We employed a stepwise, data-driven approach using modification indices (Sörbom, 1989; Whittaker, 2012) to restrict the model in terms of corresponding residuals to modify the hypothesized model posthoc until at least either RMSEA or CFI / TLI values indicated an acceptable model fit for the one-factor solution. Subsequently, SEM was applied to determine relationships between interoceptive accuracy and attention with internalizing and somatoform symp-




*Note.* Circles represent latent variables, squares refer to manifest variables, single-headed arrows represent factor loadings, and double-headed arrows between manifest variables represent standardized residual correlation paths; all factor loadings and correlation coefficients are significant at $p < .05$; error terms of manifest variables are not shown. CFI = comparative fit index, TLI = Tucker-Lewis index, RMSEA = root mean square error of approximation, CI = confidence interval.

**Figure 1.** One-factor model of interoceptive accuracy in the IAS left and interoceptive attention in the IATS right with standardized factor loadings.

tomatology. We calculated both psychopathology factors (i. e., spectra) according to the HiTOP model (Kotov et al., 2017) using the items of the PHQ-2 and GAD-2 as manifest variables contributing to the latent variable *internalizing* and the items of the SSS-8 as manifest variables contributing to the latent variable *somatoform* within the SEM. To ensure that the items of the two depressiveness and anxiety questionnaires can be considered an internalizing factor in the sense of the HiTOP model, we report the corresponding calculations again with two separate latent variables (depressiveness and anxiety) in the Electronic Supplementary Material (ESM 1). We address potential discrepancies. Relevant coefficients were calculated (i. e., factor loadings, latent regression, and correlation coefficients) and reported as standardized values.

# Results

## The Latent Structure of Interoceptive Accuracy and Interoceptive Attention

For both constructs (interoceptive accuracy and attention), one-factor models showed an acceptable fit to the data. The goodness of fit statistics for each construct as well as the correlated residuals and factor loadings are depicted in Figure 1.

### Associations Between Interoception, Internalizing Psychopathology, and Somatic Symptom Burden

To test the strength of associations between interoception and psychopathology, we calculated a SEM consisting of the single-factor models of interoceptive accuracy and attention, a single-factor model of internalizing symptomatology (i.e., depressiveness and anxiousness), and a hierarchical model of the SSS-8 including one higher-order factor (somatoform symptoms) and several lower-order factors (*gastrointestinal symptoms*, *pain symptoms*, *cardiopulmonary symptoms,* and *fatigue symptoms*). The corresponding model, where internalizing psychopathology was split into depression and anxiety factors, is listed in ESM 1; no association differences were observed.

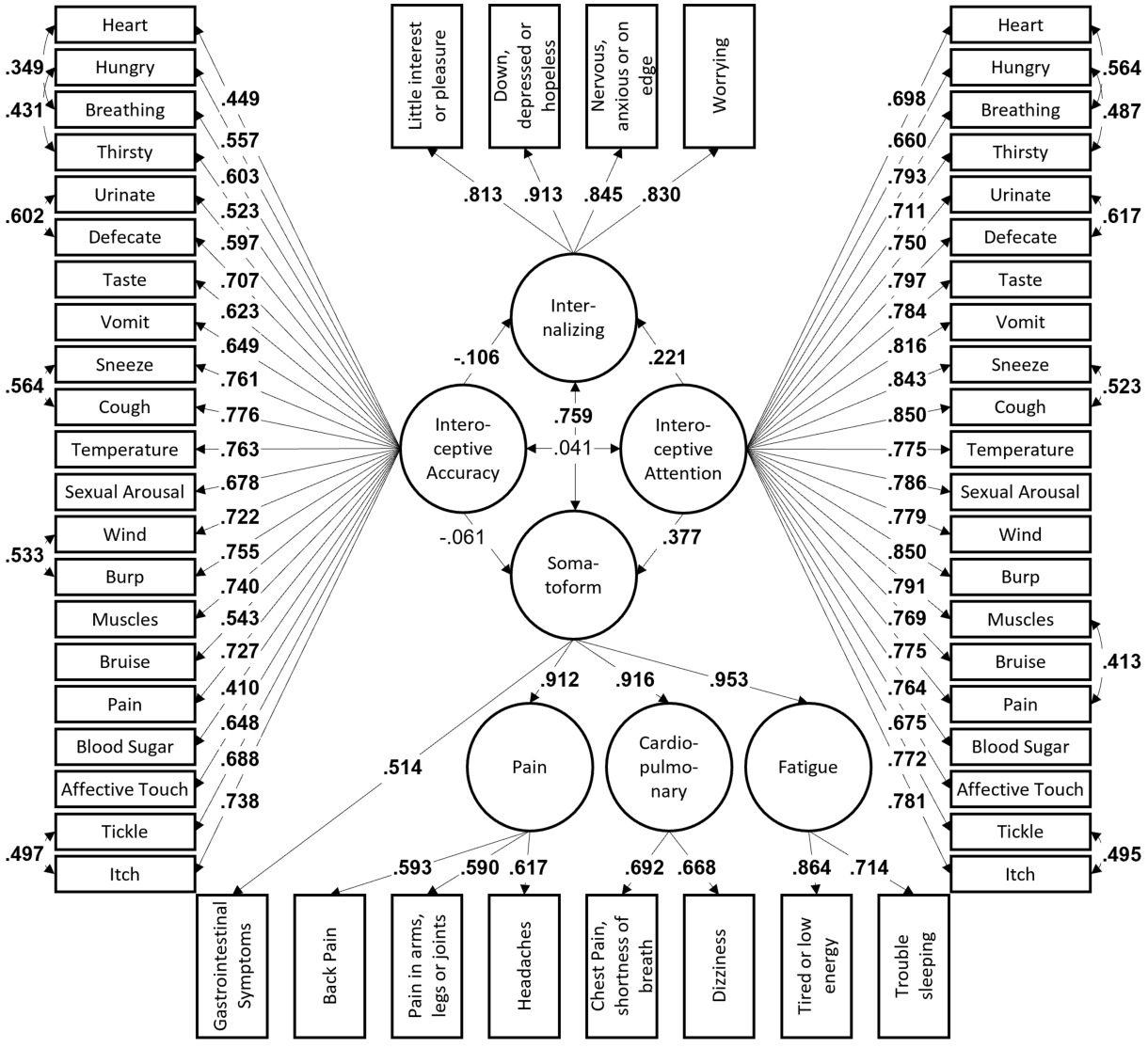
The overall model (Figure 2) showed a good fit. The interoceptive accuracy and attention factors did not correlate significantly with each other ($r$ = .041, $p$ = .311, $SE$ = 040), whereas the internalizing factor showed a strong association with the somatoform factor ($r$ = .759, $p$ < .001, $SE$ = .030). Regressing internalizing and somatoform symptomatology on interoceptive attention yielded small to moderate significant positive latent regression coefficients (Internalizing on interoceptive attention: β = .221, $p$ < .001, $SE$ = .042; somatoform on interoceptive attention: β = .377, $p$ < .001, $SE$ = .040). Regressing internalizing psychopathology on interoceptive accuracy resulted in a small significant negative latent regression coefficient (β = -.106, $p$ = .013, $SE$ = .042), while the prediction of somatoform symptomatology showed no significant value (β = -.061, $p$ = .147, $SE$ = .042).

## Discussion

Given the importance of interoceptive information processing both for cognition and emotion in general as well as for psychopathology in particular, the present study aimed to further investigate the latent structure of two core facets of interoception, namely, interoceptive accuracy and interoceptive attention, and to test their relationship with central dimension of psychopathology. Therefore, we used the recently postulated 2 x 2 factorial model of interoceptive abilities (Murphy et al., 2019) to operationalize interoceptive abilities as self-reported interoceptive accuracy and attention. Based on a hierarchical perspective of psychopathology, namely, the HiTOP model (Kotov et al., 2017), we examined the latent relationships of interoceptive abilities, a presumed higher-order dimension, with somatoform and internalizing symptomatology.

A one-factor measurement model restricted to multiple correlated residuals showed an acceptable model fit for both facets of interoception. Restricting a model for residual correlations was largely data-driven and less theoretically based. For both, interoceptive accuracy and interoceptive attention, we observed a pattern of associations between the perception of *heartbeat* and *breathing*, *hunger* and *thirst*, the *need to urinate* or *defecate*, the *need to sneeze* or *cough*, and the sensation of *tickling* and *itching.* In addition, for interoceptive accuracy, there were associations between the *need to pass wind* or *burp.* For interoceptive attention, associations were found between the perception of *muscle soreness* and *pain.* Although theoretical considerations support a unidimensional explanation for self-reported interoceptive accuracy and attention, psychometric evidence for an underlying single-factor solution for both constructs was initially lacking (Gabriele et al., 2022; Murphy et al., 2020). Factor solutions for the IAS found sensation clusters related to sensations that are either socially unacceptable (e.g., *need to defecate* or *urinate*) or difficult to perceive when interoceptive information alone is used for perception (e.g., *low blood sugar*; Campos et al., 2021; Murphy et al., 2020). The sensation clusters found for IATS on the other hand were categorized as *general physiological sensations*, *food signals*, and *skin-related signals* (Gabriele et al., 2022). Although recent results from two multicenter studies on the German version of the IAS and IATS also support the assumption of unidimensionality of interoceptive accuracy and attention (Brand et al., 2022; Tünte et al., 2022), additional information on the latent structure of personal beliefs about interoceptive abilities may still be needed. Questionnaires on interoceptive abilities could perhaps be refined by grouping different sensations under one umbrella term, as human perceptual performance may not be highly discriminative for these (e.g., *I can always accurately perceive sensations on my skin*) or leave sensations out that seem too difficult to perceive, and therefore might show little correlation with general knowledge about one's interoceptive ability (e.g., accurate perception of *levels of blood sugar* within the IAS and IATS; Gabriele et al., 2022; Murphy et al., 2020). Future research may examine the contribution of questions regarding specific sensations and their relationship to personal beliefs about one's interoceptive abilities.

The latent regression model for the prediction of internalizing and somatoform symptomatology on self-reported interoceptive accuracy and attention showed a highly significant positive relationship between internalizing and somatoform symptomatology. This result is consistent with previous observations on the relationships between the SSS-8, PHQ-2, and GAD-2 (Gierk et al., 2014). Moreover, the current version of the HiTOP model assumes




Goodness of Fit statistics:

$\chi^2(1356) = 2891.77$, $p(\chi^2) < .001$; *CFI* = .964; *TLI* = .962; *RMSEA* = .043, 90% *CI RMSEA*: .041 - .045

*Note.* Circles represent latent variables, squares refer to manifest variables, single-headed arrows between manifest and latent variables represent factor loadings, single and double-headed arrows between latent variables represent standardized latent regression and correlation paths, respectively. All factor loadings, latent regression, and latent correlation coefficients printed in **bold** are significant at $p < .05$; error terms of manifest variables are not shown. CFI = comparative fit index, TLI = Tucker-Lewis index, RMSEA = root mean square error of approximation, CI = confidence interval.

**Figure 2.** Latent regression model for the regression of internalizing and somatoform symptomatology on interoceptive accuracy and attention.

that these two constructs are distinct spectra beneath a unified superspectrum of emotional dysfunction, highlighting common risk factors such as negative affect or neuroticism (Watson et al., 2022). The latent relationships between personal beliefs about one's interoceptive abilities with internalizing and somatoform symptomatology add further information to the still heterogeneous knowledge about relationships between interoception and psychopathology (see Brewer et al., 2021, for an overview): On the side of interoceptive accuracy, the present results indicate a negative relationship with internalizing symptomatology, which is consistent with previous findings from operationalizing interoceptive accuracy as the accuracy of heartbeat perception, suggesting a negative association between interoceptive accuracy and depressive symptoms (e.g., Furman et al., 2013; Pollatos et al., 2009) but not consistent with previous findings on the relationship of cardiac interoceptive accuracy with anxiety symptoms (e.g., Adams et al., 2022; Domschke et al., 2010). The typically found pattern of positive or nonexistent re-

lationships between cardiac interoceptive accuracy and anxiety could not be replicated at a construct level of personal beliefs about one's ability to accurately perceive internal signals; rather, stable negative relationships were found (also when internalizing symptomatology was split into depression and anxiety constructs, see ESM 1).

The inconsistency of the findings might be explained by the fact that the subjective facet of interoceptive accuracy measured in the present study might be a different construct from accuracy in performance ratings. Although at least one previous study that initially validated the IAS found a correlation between the two ("$r(52) = .271$, $p = .047$"; Murphy et al., 2020, p. 124), the findings of the present study indicate that further research should be pursued regarding performance measurements of interoceptive accuracy and their correlation to subjective measures. Another possible explanation arises from previous findings showing that specific symptom groups may be differentially associated with interoceptive accuracy (e.g., problems with sleep; Ewing et al., 2017). Both the PHQ-2 and GAD-2 ask only about leading symptoms of depression or anxiety disorder. In addition, differential associations between individuals reporting mild and severe symptoms could explain this pattern. In the past, low expression of interoceptive accuracy has been reported primarily in individuals with low symptom expression (e.g., Dunn et al., 2007; Eggart et al., 2019), which were also primarily found in the present sample consisting of predominantly healthy individuals. These thoughts should also be considered when looking at the prediction of somatoform symptomatology on interoceptive accuracy. Previously, it was assumed that somatic symptoms might be caused by misinterpretation (poor interoceptive accuracy; Barrett & Simmons, 2015; Edwards et al., 2012) or distorted expectations (*prediction errors*), of physical changes (Van den Bergh et al., 2017, 2021; Witthöft et al., 2020). However, our results showed no relationship between self-reported interoceptive accuracy as a potential contributor to false predictions and somatoform symptomatology, which appears to be incongruent with previous findings on the relationship of somatoform symptoms with cardiac interoceptive accuracy (e.g., Witthöft et al., 2020).

On the side of relationships with self-reported interoceptive attention, the present results are consistent with previous work suggesting positive associations between self-reported interoceptive attention and anxiety (e.g., Palser et al., 2018), depression (Limmer et al., 2015), or somatoform disorders (Barsky, 1992). Note that these results are from different operationalizations of self-reported interoceptive attention, for example, data obtained with the Body Perception Questionnaire (Porges, 1993) or other self-assessment measures, where we do not know whether they measure the same latent construct (Desmedt et al., 2022). Future research should therefore focus on better understanding the latent construct of interoceptive attention and defining what widely used questionnaires (for a review, see Desmedt et al., 2022) measure to thus gather reliable information about relations to psychopathology.

Some limitations of the present study should be acknowledged. Although we examined a sample from the German general population, we observed mostly well-educated female participants, which limits generalizability. In addition, the self-assessment measures used are associated with typically expected biases, such as extreme response bias or conformity bias. The present study comprised no experimental measures or manipulations. Although behavioral measures are generally considered to be more objective and less prone to bias (Brewer et al., 2021), the present study did not use them. Established procedures, such as Heartbeat Perception or Detection Tasks (Pohl et al., 2021; Schandry, 1981) or the Water Load Test (van Dyck et al., 2016), would have been an alternative to the self-report procedures used in the study. However, the limitations already described (e.g., unidimensionality of the physical sensations recorded) also limit the use of behavioral measures alone. Future research should therefore conduct more investigations using multidimensional measurement methods.

## Conclusion

Overall, the present results support the recently discussed distinction between self-reported interoceptive accuracy and attention and the possibility of measuring both using questionnaires, as provided by the 2 x 2 factor model of interoception. We showed that both factors are associated in different ways with two psychopathological spectra, namely, internalizing and somatoform, according to the HiTOP model. Further research should focus on refining measures assessing self-reported interoceptive abilities and further exploring the differential relationships between these abilities (as well as their interactions) with psychopathology to provide more information on whether and how altered interoception can be considered a higher order dimension in the HiTOP model.

## Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at https://doi.org/10.1026/1616-3443/a000678

**ESM 1.** The figure shows the SEM with the internalizing factor split into a depression factor and an anxiety factor. The model fit was nearly the same. The depression factor showed a strong association with the somatoform symptomatology factor ($r = .732$, $p < .001$, $SE = .034$), as did the anxiety factor ($r = .730$, $p < .001$, $SE = .035$). Depression and anxiety itself were similar strong associated ($r = .873$, $p < .001$, $SE = .021$). Regressing depression and anxiety on interoceptive attention yielded small, yet significant positive latent regression coefficients (depression on interoceptive attention: $\beta = .194$, $p < .001$, $SE = .044$; anxiety on interoceptive attention: $\beta = .235$, $p < .001$, $SE = .044$). On the other hand, regressing depression and anxiety on interoceptive accuracy resulted in significant negative latent regression coefficients (depression on interoceptive accuracy: $\beta = -.106$, $p = .013$, $SE = .042$; anxiety on interoceptive accuracy: $\beta = -.106$, $p = .013$, $SE = .042$). The remaining coefficients stayed unchanged.

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We have no further conflicts of interest to disclose.

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**Authorship**
Sebastian Brand: conceptualization, methodology, formal analysis, writing – original draft preparation, visualization; Tara M. Petzke: writing – review & editing; Michael Witthöft: conceptualization, writing – review & editing, supervision.

**Open Data**
The dataset for the study is available at Open Science Framework. The DOI for this website is: https://doi.org/10.17605/OSF.IO/XWZ6G. The permanent URL pointing to this raw data is: https://osf.io/xwz6g/

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