Self-reported body awareness: validation of the Postural Awareness Scale and the Multidimensional Assessment of Interoceptive Awareness (version 2) in a non-clinical adult French-speaking sample

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Abstract

Body awareness refers to the individual ability to process signals originating from within the body, which provide a mapping of the body's internal landscape (interoception) and its relation with space and movement (proprioception). The current study evaluates psychometric properties and validate in French two self-report measures of body awareness: the Postural Awareness Scale (PAS), and the last version of the Multidimensional Assessment of Interoceptive Awareness questionnaire (version 2, MAIA-2). We collected data in a non-clinical, adult sample (N=308) using online survey, and a subset of the original sample (n=122) also completed the retest control. Factor analyses of the PAS supported the same two-factor structure as previously published versions (in other languages). For the MAIA-2, factor analyses suggested that a six-factor structure, excluding Not-Worrying and Not-Distracting factors, could successfully account for a common general factor of self-reported interoception. We found satisfactory internal consistency, construct validity, and reliability over time for both the PAS and the MAIA-2. Altogether, our findings suggest that the French version of the PAS and the MAIA-2 are reliable self-report tools to assess both components of body awareness (proprioception and interoception dimension, respectively).

Keywords

Body awareness; proprioception; interoception; PAS; MAIA-2

Introduction

The investigation of how the brain perceives the body has increased considerably in the past decade, particularly in clinical neuroscience. Indeed, disrupted body awareness is prominently featured in the diagnosis of a wide range of diseases encompassing physical (e.g., chronic pain; Van Der Maas et al., 2016) and mental disorders (e.g., anxiety, eating disorders, etc.; Khalsa et al., 2018). In parallel, body-centered practices (e.g., mindfulness-based programs, meditation, etc.) are increasingly investigated with a mechanistic focus on how they might improve mental health and well-being, in particular through enhanced awareness of bodily signals (Farb et al., 2015; Treves et al., 2019).

Body awareness has been defined (and operationalized) as a psycho-cognitive construct that refers to the individual ability to feel engaged by information coming from the body and noticing subtle changes (Mehling et al., 2009). From a neural perspective, bodily signals continuously provide the brain with a mapping of the body's internal physiological state (interoception), and with information about the relation the body has with space and movement (proprioception). Interoception entails the integrative interpretation of a variety of stimuli (e.g., signals from the heart, humoral receptors, and free nerve endings) – in a cognitive/emotional context – to derive an overall physiological representation of the state of the body, including conscious and nonconscious aspects (Berntson & Khalsa, 2021; Craig, 2002). On the other hand, proprioception is made up of signals from various peripheral receptors (e.g., somatosensory and vestibular receptors) that are integrated at the central level to provide representation of the body's orientation relative to gravity (Tuthill & Azim, 2018), which in turn contributes to postural control (Forbes et al., 2018). Of note, postural control relies on cerebral processes that mostly operate unconsciously, but individuals may be partially aware of action of postural balance and can volitionally control it when desired (Amboni et al., 2013; Forbes et al., 2018).

For some authors, the construct of body awareness may be considered as a trait-like characteristic since "the view one has regarding one's body and bodily processes are likely to influence the way persons experience themselves" (Ferentzi et al., 2020, page 2; Fisher & Cleveland, 1958; Rani & Rao, 1994). In that respect, it has been suggested that body awareness could be associated with major dimensions of personality, as measured with the Big Five Inventory (Goldberg, 1993; John et al., 1991). In line with this theoretical suggestion, some studies reported significant association between interoception and personality dimensions of Openness and Conscientiousness (Ferentzi et al., 2017; Ferentzi et al., 2020; Trapnell & Campbell, 1999). Yet, it should be noted that relationship between interoception and personality has not been reported systematically (Sze et al., 2010), and did not encompass all personality dimensions, *e.g.* body awareness was reported to be independent of the dimension of Neuroticism (Ferentzi et al., 2017; Ferentzi et al., 2020;

Shields et al., 1989). To the best of our knowledge, no previous study has investigated the potential relation between personality dimensions and proprioception in non-clinical adult population.

Interoception is recognized as playing a major role in emotion regulation. Indeed, emotional feeling states arise from physiological changes that occur within internal organs, and emotions themselves track and steer the redirection of physiological resources to adapt behaviour (Critchley & Garfinkel, 2017). Alexithymia is a personality trait characterized by difficulty in describing feelings and struggle to tell apart emotions from bodily sensations (Sifneos, 1991; Taylor, 1984). It has been shown that alexithymia involves deficiencies in emotion regulation (Swart et al., 2009) and is associated with deficit in interoception (as assessed with heartbeat perception tasks into which participants are instructed to report either the number or the timing of their heartbeats; Herbert et al., 2011; J. Murphy et al., 2018).

Paralleling findings from clinical science, recent contemplative research suggests that body awareness is fundamental for adaptive behaviour and is intimately connected to self-regulation and homeostasis (Farb et al., 2015). Contemplative practice, such as mindfulness meditation, relies on training the mind to pay sustained attention to the current body experience, primarily the breath, and deliberately returning attention to it whenever distracted (Lutz et al., 2015). Indeed, it can be argued that the more fully an individual is apprised of what is occurring within one's body, the more adaptive and value consistent the individual's behavior is likely to be. Previous studies have shown that trait mindfulness, i.e. individual differences in the ability to be mindful in daily life that are supposed to be relatively stable over time (Brown & Ryan, 2003), is associated with enhanced interoception (Hanley et al., 2017; Mehling et al., 2012; Verdonk et al., 2021) and proprioception (Cramer et al., 2018; Topino et al., 2020).

Although self-report instruments raise some long-standing methodological concerns (social-desirability biases, vulnerability to limitations of introspection, etc.; Baumeister et al., 2007), they remain widely used in the field of neuroscience because they are particularly attractive, especially, but not exclusively, for efficient field research. To our knowledge, there is currently no psychometric tool validated in French that enables assessment of the proprioceptive dimension of body awareness. Interestingly, Cramer *et al* (2018) have developed the Postural Awareness Scale (PAS) (Cramer et al., 2018), which was recently validated in Italian (Topino et al., 2020) and in English (Colgan et al., 2021). Furthermore, regarding the interoceptive dimension of body awareness, only the first version of the Multidimensional Assessment of Interoceptive Awareness questionnaire (MAIA-1; Mehling et al., 2012) has been very recently validated in a French-speaking sample (Willem et al., 2021). The PAS and the MAIA have the theoretical advantage to specifically assess one of the two main dimensions of body awareness, namely either interoception or proprioception, thus probably contributing to make them more robust than previously developed self-report measures that assess body awareness in a more global fashion (Mehling et al., 2009).

In the present study, we aimed to validate in French the PAS and the last version of the MAIA (version 2, MAIA-2) in a non-clinical adult sample. Construct validity was assessed with self-reporting measurements of mindfulness with the Freiburg Mindfulness Inventory (FMI; Trousselard et al., 2010; Walach et al., 2006), personality with the Big Five Inventory (BFI; John et al., 1991; Plaisant et al., 2010) and alexithymia with the Toronto Alexithymia Scale (TAS-20; Bagby, Parker, et al., 1994; Loas et al., 1995). We hypothesized good psychometric properties for the PAS and the MAIA-2, including good internal consistency and satisfactory reliability over time. We also expected positive intercorrelation between each other, and positive correlation with the FMI, whereas negative correlation with the TAS-20 and the dimension Neuroticism of the BFI. Finally, we assumed to find a significant effect of several non-psychological factors, such as gender, sport activity and body-centered practices on the scores of the PAS and the MAIA-2.

Method

Translation procedure

For the first step of the validation, we followed the international guidelines of cross-cultural adaptation of self-administered questionnaires (Beaton et al., 2000). With the agreement of the original authors (Mehling W.E. and Cramer H.), the questionnaires were translated by native French-speakers (one psychologist (CB), one researcher in the field of neuroscience (AD), and one medical doctor (CV)). Then, a concertation meeting (with the initial translators CB, AD, and CV) and one additional medical doctor (MT) was conducted in order to harmonize the French translations. Subsequently, the translated questionnaires were back translated by three English speakers totally blind to the original version (one American student in neuroscience (BR), one professional translator (ES), and one naive French speaker with fluency in English (CGV)). A final harmonization meeting involving translators of the two steps procedure (CB, AD, CV, ES, and CGV) as well as a student in clinical psychology (LDCS), was held in order to come to satisfactory formulations and validate the translation process. Of note, we completed the translation process of the MAIA-2 a few months ahead of the publication of the French version of the MAIA-1 (Willem et al., 2021). As a consequence, common items between MAIA-1 and MAIA-2 questionnaires may show slightly different formulations in their French version.

A “field test” was performed with a group of 20 participants to determine whether the translated items of the PAS and MAIA-2 retained the same meaning as the original items. In this pilot testing, each participant completed the two self-questionnaires and was interviewed to probe about what he or she thought was meant by each questionnaire item and the chosen response. The French translation of the PAS and the MAIA-2 has been validated when investigators were sure that there was no linguistic confusion. This process revealed a good understanding of the French translation and no revision was needed to the final translated version of the questionnaires.

Participants and data collection

Our study was conducted online following standards for Internet-based experimenting (Reips, 2002). Participants were recruited through announcements that were posted on different websites and social media. To be eligible for inclusion in the study, a subject had to *(i)* report no history of neuropsychiatric disease and chronic pain, *(ii)* be over 18 years and under the age of 65, and *(iii)* be able to read and understand French. At the beginning of the survey the participants were informed of the aim of the study and consented to participate by clicking the “next” button on the online survey. They also received, via email, the study information letter. No compensation was offered for the participation in the study. They were guaranteed privacy and anonymity. The data were collected online via the LimeSurvey tool (https://www.limesurvey.org, LimeSurvey Project Team / Carsten Schmitz, 2012).

Measures

The socio-demographic data included age, gender, weight, height, educational level, sport practice (frequency, average duration of sport, body-oriented practice), history of injury which changed body perception and history of chronic pain.

Questionnaires

Postural Awareness Scale

The 12-item Postural Awareness Scale measures two facets of postural body awareness: 1) *Ease/familiarity with postural awareness* (PAS-EwPA): effortless awareness of the body posture; 2) *Need for attention regulation with postural awareness* (PAS-NfA): awareness of the posture requires efforts to balance conscious cognitive processes and bodily needs. The two facets can be interpreted as two opposite ends of a continuum effort necessary to becoming aware of one's posture (Cramer et al., 2018). The questionnaire is scored using a seven-point scale, with responses ranging from 1 (not like me at all) to 7 (completely like me). For each of the two subscales, the score was counted by adding the rating for all items; items related to the subscale *Need for attention regulation with postural awareness* (items 1, 2, 3, 4, 5 and 12) were reversed beforehand.

Multidimensional Assessment of Interoceptive Awareness (version 2)

The 37-item Multidimensional Assessment of Interoceptive Awareness (MAIA-2) questionnaire, developed by Mehling et al. (2018), measures eight facets of interoceptive body awareness: 1) *Noticing* (MAIA-2-N): awareness of uncomfortable, comfortable, and neutral body sensations; 2) *Not-distracting* (MAIA-2-ND): tendency not to be distracted by oneself from sensations of pain or discomfort; 3) *Not-worrying* (MAIA-2-NW): tendency not to worry with sensations of pain or discomfort; 4) *Attention regulation* (MAIA-2-AR): ability to sustain and control attention to body sensation; 5) *Emotional Awareness* (MAIA-2-EA): awareness of the connection between body sensations and emotional states; 6) *Self-regulation* (MAIA-2-SR): ability to regulate psychological distress by attention to body sensations; 7) *Body listening* (MAIA-2-BL): actively listens to the body for insight; and 8) *Trusting* (MAIA-2-T): experiences one own's body as safe and trustworthy. The questionnaire is scored using a six-point scale, with responses ranging from 0 (never) to 5 (always). For each of the eight subscales, the score was counted by averaging the scores of items belonging to the subscale (items 5, 6, 7, 8 and 9 were reversed). Of note, the MAIA-2 includes 5 additional items with regard to the Version 1 of the MAIA (MAIA-1) (Mehling et al., 2012; Willem et al., 2021) that have been added to improve internal consistency and reliability of the MAIA (Mehling et al., 2018).

Freiburg Mindfulness Inventory

The 14-item Freiburg Mindfulness Inventory (FMI), developed by Walach et al. (2006) measures dispositional trait mindfulness by indexing facets of Presence (*i.e.* being aware of all experiences in the present moment) and Non-judgmental acceptance (*i.e.* understanding that things are not necessarily how one wishes them to be). This questionnaire is semantically independent from a meditation context and it is applicable to all population groups, in particular to those with no practice of mindfulness meditation (Trousselard et al., 2010; Walach et al., 2006). The questionnaire is scored using a four-point scale, with responses ranging from 1 (rarely) to 4 (almost always). In the French version, a total mindfulness score was computed by adding the rating for all items, except for the 13th item which was reversely scored (Trousselard et al., 2010).

Big Five Inventory

The 44-item Big Five Inventory (BFI-FR) was used to describe the five main personality traits : 1) E: Extraversion, Energy, and Enthusiasm; 2) A: Agreeableness, Altruism, and Affection; 3) C: Conscientiousness, Constraint, and Control of impulse; 4) N: Neuroticism, Negative affectivity, and Nervousness; and 5) O: Openness, Originality, and Open-mindedness. Each item is rated on a 5-point likert scale from 1 (disagree a lot) to 5 (agree a lot) (Plaisant et al., 2010; Plaisant et al., 2005).

Toronto Alexithymia Scale

The 20-item Toronto Alexithymia Scale (TAS-20) assesses the level of alexithymia (Bagby, Parker, et al., 1994; Bagby, Taylor, et al., 1994). It is scored on a 1- to 5-point Likert scale. The questionnaire measures three main dimensions of alexithymia: 1) difficulty in identifying feelings and distinguishing between feelings and bodily sensations in emotional activation (DIF), 2) difficulty in the verbal expression of emotions (DVE), and 3) externally oriented thinking (EOT) (Loas et al., 1995; Zimmermann et al., 2007).

Statistical and data analysis

Data analyses were performed using R (version 3.5.3; R core Team, 2013) and JASP (version 0.11.1, https://jasp-stats.org/).

Factor structure

We tested whether the factor structure originally proposed for the PAS (Cramer et al., 2018) and for the MAIA-2 (Mehling et al., 2018) would replicate in the French version. For this purpose, we conducted Exploratory Factor Analysis (EFA) on a subset of the original sample including 50% of the available data (154 subjects). Horn's parallel analysis (HPA) was performed to determine the optimal number of factors to extract using principal axis factoring and promax rotation (Horn, 1965). Subsequently, Confirmatory Factor Analysis (CFA) were conducted on the remaining 50% of the available data (154 subjects). We tested a higher-order model in which a second-order factor (e.g. the factor *Interoceptive awareness* for the MAIA-2) causes individual differences in several first-order factors (e.g. the subscales *Noticing* and *Trusting* for the MAIA-2), which in turn directly influence the observed item responses (see Figure 2 for the MAIA-2), in using the diagonally weighted least square (DWLS) estimation method. Of note, the DWLS is specifically designed for ordinal data, as this is the case for the PAS and the MAIA-2, and is less biased and more accurate than alternative methods (e.g. the maximum likelihood) in estimating the factor loadings (Li, 2016). For the PAS, we fixed the variance of the second-order factor to one, and made the loadings of the two first-order factors equal. Absolute model fit was evaluated with the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI) based on common standards (good fit: RMSEA ≤ 0.05, SRMR ≤ 0.08, and CFI ≥ 0.95; Hu & Bentler, 1999; Marsh et al., 2004).

Reliability

Internal consistency. Reliability of the PAS and the MAIA-2 was assessed using the coefficient omega in considering a higher-order model (ω_{HO}) for the two questionnaires. The rationale for using the coefficient omega, rather than the commonly used Cronbach alpha, is that the latter assumes an essential tau-equivalence model[1] that appeared to be inappropriate for the PAS and the MAIA-2. As a consequence, the Cronbach alpha can provide misleading reliability estimates (Flora, 2020). In the present paper, values of Cronbach alpha were also reported to provide a comparison with original validation works of the PAS (Cramer et al., 2018) and the MAIA-2 (Mehling et al., 2018).

Test-retest. To ensure that measurement variation reported in our sample is due to replicable differences between participants regardless of time, we performed test-retest reliability analyses. To this end, a subset of participants (N=122) were recalled to complete the PAS and the MAIA-2 questionnaire in a second online testing session (mean (sd) of test-retest interval = 44 (11) days). Test-retest reliability was quantified by computing the Intraclass Correlation Coefficient (ICC) using the *psych* R package. Briefly, ICC quantifies the extent to which repeated measurements for each individual (within-individual) are statistically similar enough to discriminate between individuals (Aldridge et al., 2017). We used a two-way random effects model for absolute agreement, which corresponds to ICC (2,1) in the Shrout and Fleiss (1979) nomenclature (Shrout & Fleiss, 1979). ICC values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliability, respectively (Koo & Li, 2016).

Construct validity

We assessed the PAS and the MAIA-2 for convergent and discriminant validity by performing Pearson's correlations between the two questionnaires and the other three psychological measures (the FMI, the TAS-20, and the BFI-FR). Regarding the convergent validity, we reasoned that if both the PAS and the MAIA-2 measure the construct of body awareness, then individuals felt engaged by information coming from their body should exhibit PAS and MAIA-2 scores that are positively correlated. Since mindfulness has been characterized by enhanced body awareness (Treves et al., 2019), we also expected a positive correlation between PAS and MAIA-2 scores and FMI score. For the discriminant validity, because of the theoretical distinction we make between body awareness and personality, we expected that PAS and MAIA-2 scores do not correlate with BFI-FR subscores. Moreover, given perception of bodily signals plays an important role in emotional experience (Critchley & Garfinkel, 2017), alexithymia that characterized individuals having difficulties in identifying their emotions should negatively correlate with postural and interoceptive body awareness.

Effect of non-psychological factors on self-report measures

We assessed the potential effect on self-reported postural awareness of several 'non-psychological' factors, including practice of sport, body-centered practice (e.g., yoga, mindfulness meditation), age, gender, and body mass index (BMI) to replicate and extend findings that have been recently published with the Italian version of the PAS (Topino et al., 2020). For this purpose, we used both standard statistical tests and Bayesian equivalents to guide interpretation of significance (p values), according to how likely the alternative hypothesis is versus the null (Rouder et al., 2009; Wagenmakers et al., 2018). To confirm whether the potential non-significant results reported represent support for the null hypothesis, we calculated the log scale of the Bayes factor (noted $\log(BF_{10})$) that can be easily interpreted such that a negative value indicates support for the null hypothesis, whereas a positive value indicates evidence in favor of the alternative hypothesis (see Table S1 in the Supplementary for an interpretation scale of $\log(BF_{10})$; Jeffreys, 1961). Standard tests included Mann-Whitney (for the factors practice of sport, body-centered practice, and gender) and Kruskal-Wallis (for the factors age and BMI that were recoded to categorical variables with more than two classes, see Table S2 in the Supplementary) nonparametric tests. If a significant difference was observed, we computed the effect size (to evaluate the magnitude of the difference) using a measure suited to nonparametric analyses: 95% confidence interval of the rank biserial correlation (Glass, 1966). For the Bayesian analyses, we used the default JASP priors that assume a medium effect size on a Cauchy distribution of 0.707 for independent t-tests, and a r scale prior width of 0.5).

Results

Socio-demographic characteristics

A total of 434 respondents completed the study. Of these, 113 (26%) had incomplete data, and 13 (3%) reported aberrant values for two non-psychological factors of interest (weight < 30kg or > 200kg, height < 100cm or > 230cm). Thus, these 126 respondents were excluded from the final study sample. The 308 remaining subjects (mean age: 35.22 ± 11.75 years; 189 females – 61.40%) were included in the final analyses. This sample was used to compute socio-demographic statistics (Table S2 of the Supplementary), to assess reliability, convergent and discriminant validity of the PAS and the MAIA-2 measures, and to investigate potential effects of non-psychological factors. Subsequently, this sample was randomly split into two subsamples. The first subsample was used for EFA and consisted of 154 subjects (mean age: 36 ± 12 years; 96 females – 62%). The second subsample was used for CFA consisted of the remaining 154 subjects (mean age: 35 ± 12 years; 93 females – 60%)

Reliability

Internal consistency

PAS. Overall, internal consistency was satisfactory : for total PAS, the coefficient omega based on a higher-order model (ω_{ho}, see Method section for detailed explanation) was 0.70; for the subscales PAS-EwPA and PAS-NfA, Cronbach alphas were 0.82 and 0.77, respectively (Table 1).

MAIA-2. For total MAIA-2, internal consistency was satisfactory : ω_{ho}= 0.79. Cronbach alphas for the eight subscales ranged from 0.71 (MAIA-2-ND) to 0.89 (MAIA-2-AR) (Table 1).

Table 1. Descriptive statistics for the Postural Awareness Scale (PAS) and the Multidimensional Assessment of Interoceptive Awareness (MAIA-2) questionnaire in the total sample (N=308).

	M	SD	[Min - Max]	α	ω_{ho}	Range of item-scale correlations[#]
PAS						
Total score	45.08 41.2∓	12.60 10.90∓	[12 - 84]	0.85 0.80∓	0.70	-
Subscale *Familiarity with postural awareness*	22.59 22.20∓	7.30 6.80∓	[6 - 42]	0.82 0.81∓	0.82	[0.39 - 0.77]
Subscale *Need for attention regulation with postural awareness*	22.49 19.10∓	7.15 6.80∓	[6 - 42]	0.77 0.77∓	0.77	[0.44 - 0.69]
MAIA-2						
Total score	23.80	5.11	[9.58 - 35.93]	0.90 0.74§	0.79	-
Subscale *Noticing*	3.44 3.34§	1 0.90§	[0 - 5]	0.77 0.64§	0.76	[0.64 - 0.75]
Subscale *Not-distracting*	2.38 2.06§	0.84 0.80§	[0 - 4.67]	0.71 0.74§	0.57	[0.18 - 0.39]
Subscale *Not-worrying*	3.10 2.52§	0.98 0.85§	[0 - 5]	0.84 0.67§	0.84	[-0.08 - 0.03]
Subscale *Attention regulation*	2.88 2.84§	1.04 0.86§	[0 - 5]	0.89 0.83§	0.89	[0.75 - 0.83]
Subscale *Emotional awareness*	3.51 3.44§	1.09 0.96§	[0 - 5]	0.85 0.79§	0.86	[0.66 - 0.77]
Subscale *Self-regulation*	2.84 2.78§	1.15 1.01§	[0 - 5]	0.85 0.79§	0.85	[0.72 - 0.81]

	M	SD	[Min - Max]	α	ω_{ho}	Range of item-scale correlations#
MAIA-2						
Subscale *Body listening*	2.34 2.20§	1.18 1.17§	[0 - 5]	0.77 0.80§	0.77	[0.72 - 0.81]
Subscale *Trusting*	3.30 3.37§	1.20 1.11§	[0 - 5]	0.84 0.83§	0.83	[0.53 - 0.67]

PAS: Postural Awareness Scale; MAIA-2: Multidimensional Assessment of Interoceptive Awareness (version 2); M: mean; SD: standard deviation; Min: minimum value; Max: maximum value; α: Cronbach alpha; ω_{ho}: coefficient omega based on a higher-order model; #Correlations are intended to be descriptive and are not corrected for multiple comparisons; ∓Reference values extracted from the original version of the PAS (Cramer, 2018); §Reference values extracted from the original version of the MAIA-2 (Mehling, 2018)

Test - retest

PAS. We found evidence that the PAS total score has good reliability over time (ICC = 0.76). The two subscales of the PAS showed moderate reliability with ICCs equal to 0.69 and 0.71 for the subscales PAS-EwPA and PAS-NfA, respectively (Table 2).

MAIA-2. We found evidence that the MAIA-2 total score has good reliability over time (ICC = 0.81). Such a good reliability was also observed for the dimension Trusting (ICC = 0.82). Other subscales of the MAIA-2 showed moderate reliability over time, including ICCs that ranged from 0.63 (MAIA-2-AR) to 0.74 (MAIA-2-EA and MAIA-2-SR) (Table 2).

Table 2. Intraclass Correlation Coefficients that inform about reliability over time at the individual level for the Postural Awareness Scale (PAS) and the Multidimensional Assessment of Interoceptive Awareness (MAIA-2).

	ICC	95% CI
PAS		
Total score	0.76	0.69 - 0.82
Subscale *Familiarity with postural awareness*	0.69	0.61 - 0.76
Subscale *Need for attention regulation with postural awareness*	0.71	0.63 - 0.78
MAIA-2		
Total score	0.81	0.75 - 0.85
Subscale *Noticing*	0.69	0.60 - 0.76
Subscale *Not-distracting*	0.66	0.56 - 0.73
Subscale *Not-worrying*	0.72	0.64 - 0.78
Subscale *Attention regulation*	0.63	0.53 - 0.71
Subscale *Emotional awareness*	0.74	0.67 - 0.80
Subscale *Self-regulation*	0.74	0.67 - 0.80
Subscale *Body listening*	0.73	0.65 - 0.79
Subscale *Trusting*	0.82	0.77 - 0.87

PAS: Postural Awareness Scale; MAIA-2: Multidimensional Assessment of Interoceptive Awareness (version 2); ICC: Intraclass Correlation Coefficient; 95% CI: 95% confident interval for the Intraclass Correlation Coefficient

Factor structure

PAS

EFA. A two-factor structure was suggested with the Horn's Parallel Analysis (Figure S1A of the Supplementary), explaining 42% of the total variance. The first factor (EwPA) consisted of six items (items 6, 7, 8, 9, 10 and 11) that accounted for 26% of the total variance. The second factor (NfA) was made up of six items (items 1, 2, 3, 4, 5 and 12) that accounted for 16% of the total variance.

CFA. The higher-order model yielded a good model fit: RMSEA = 0.043 (90% CI: [0 - 0.070]), SRMR = 0.062, CFI = 0.996. First-order factor loadings range from 0.35 (item 7) to 0.88 (item 8) for the factor *Ease/familiarity with postural awareness*, and from 0.53 (item 4) to 0.85 (item 2) for the factor *Need for attention regulation with postural awareness* (Figure 1). To provide a comparison with the previously published Italian validation of the PAS (Topino et al., 2020), we also report values fit indexes when using Maximum Likelihood (ML) estimation method: RMSEA = 0.055 (90% CI: [X - X]), SRMR = 0.057 CFI = 0.960.

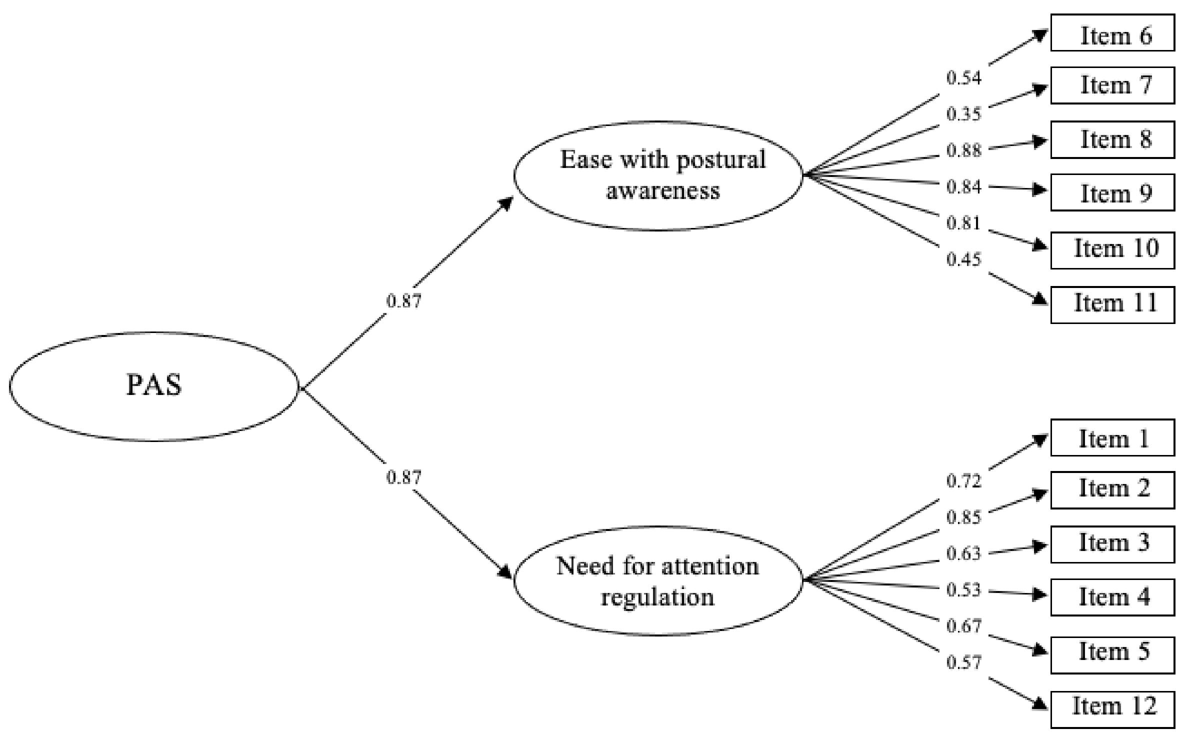

Figure 1. Simplified illustration of the PAS factor model. Values presented represent the standardized regression coefficients.

MAIA-2

EFA. Horn's Parallel Analysis suggested that a six-factor model would be optimal given available data (Figure S1B of the Supplementary), explaining 55% of the total variance. The six first-order factors accounted for from 6% to 13% of the total variance. It should be noted that an eight-factor model, which is the factor structure originally proposed for the MAIA-2 (Mehling et al., 2018), increased to 60% the proportion of total variance that is explained.

CFA. The higher-order model including a second-order factor on top of six first-order factors, as results of EFA suggested, showed mixed evidence for an acceptable model fit: RMSEA = 0.111 (90% CI: [0.105 - 0.117]), SRMR = 0.104, CFI = 0.950. When considering the eight-factor model that was originally proposed for the MAIA-2 (Mehling et al., 2018), the model fit increased slightly: RMSEA = 0.106 (90% CI: [0.100 - 0.112]), SRMR = 0.102, CFI = 0.955. Of note, we also computed values fit indexes when using Maximum Likelihood (ML) estimation method to provide a direct comparison with original validation work of the MAIA-2 (Mehling et al., 2018): RMSEA = 0.075 (90% CI: [0.064 - 0.078]), SRMR = 0.102, CFI = 0.813. Finally, because it was recently suggested that the first-order factors *Not-distracting* and *Not-worrying* could be independent from the second-order factor *Interoceptive awareness* (Ferentzi et al., 2020), we tested a third higher-order model (Figure 2) in which the first-order factors *Not-distracting* and *Not-worrying* were excluded, and we removed responses to items related to these two factors from the dataset. This latter model yielded the best model fit: RMSEA = 0.079 (90% CI: [0.069 - 0.088]), SRMR = 0.076, CFI = 0.986. According to this model, first-order factor loadings range from 0.65 (factor *Noticing*, item 1) to 0.97 (factor *Trusting*, item 37) (Figure 2).

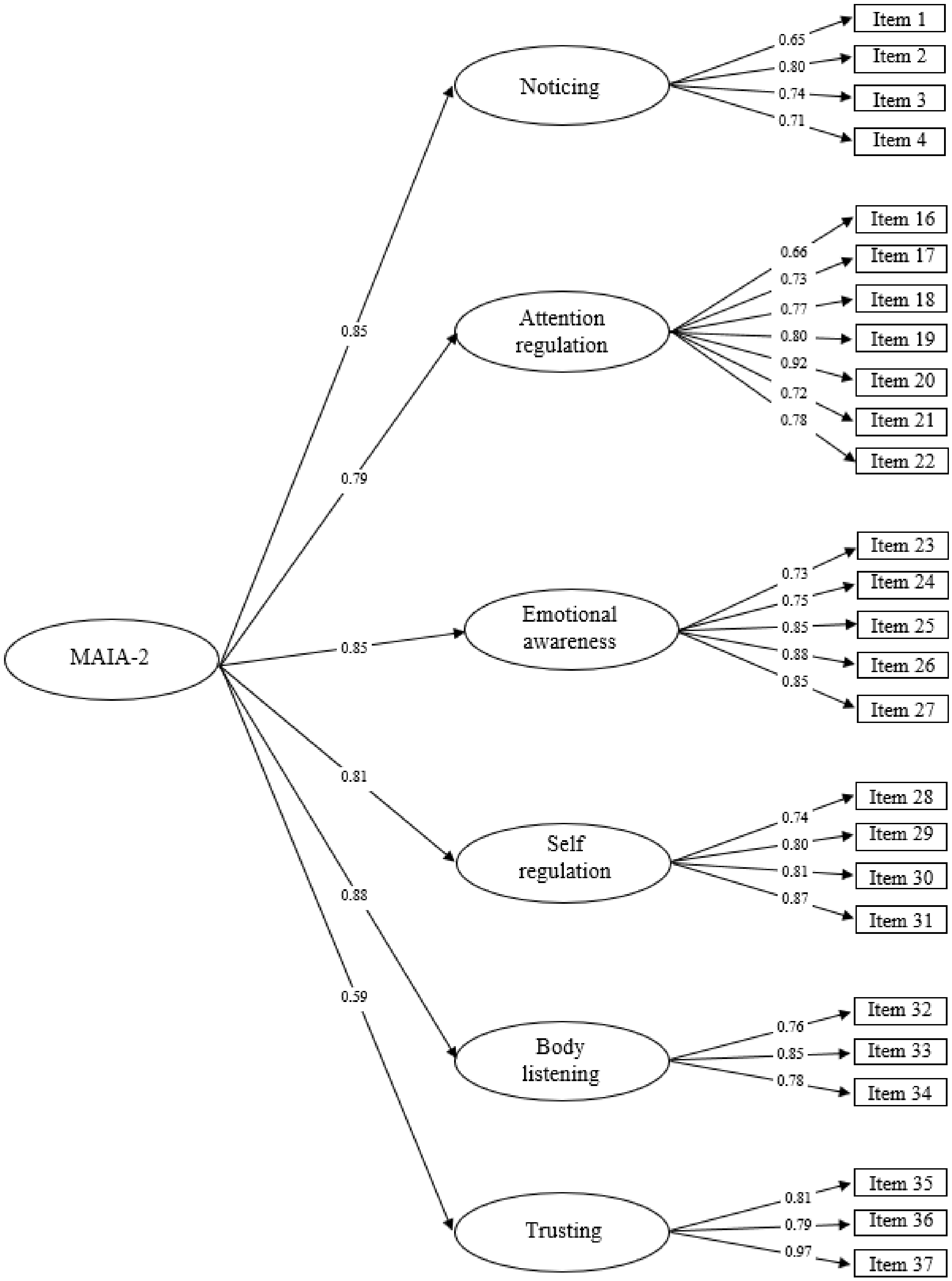
MAIA-2
Noticing
Attention regulation
Emotional awareness
Self regulation
Body listening
Trusting
0.85
0.79
0.85
0.81
0.88
0.59
Item 1
Item 2
Item 3
Item 4
0.65
0.80
0.74
0.71
Item 16
Item 17
Item 18
Item 19
Item 20
Item 21
Item 22
0.66
0.73
0.77
0.80
0.92
0.72
0.78
Item 23
Item 24
Item 25
Item 26
Item 27
0.73
0.75
0.85
0.88
0.85
Item 28
Item 29
Item 30
Item 31
0.74
0.80
0.81
0.87
Item 32
Item 33
Item 34
0.76
0.85
0.78
Item 35
Item 36
Item 37
0.81
0.79
0.97

Figure 2. Simplified illustration of the MAIA-2 factor model showing the best model fit based on our data. Specifically, this model excludes the factors Not-distracting and Not-worrying and responses to items related to these two factors have been removed from the dataset. Values presented represent the standardized regression coefficients.

Construct validity

Correlation matrix showed significant correlations with different measures used for the analysis of construct validity of the PAS and the MAIA-2 (Table S3 of the Supplementary). Descriptive statistics of these measures, including the BFI-FR, the FMI and the TAS-20 questionnaires in the total sample (N=308) are summarized in the Table S4 of the Supplementary.

PAS

Both subscales scores were positively, strongly and significantly correlated with the total score (PAS-EwPA, r = 0.88, p < 0.001 and PAS-NfA r = , 0.87, p < 0.001). The two subscales scores were also significantly intercorrelated (r = 0.52, p < 0.001).

Convergent validity.Ov erall, the pattern of correlations (direction and significance) with the different measures was similar for the PAS total score and its two subscales. Of note, the measure of MAIA-2-NW was an exception in that it only correlated with the PAS-EwPA subscale (r = - 0.14, p < 0.05). Specifically, we observed strong positive correlation between the PAS and the MAIA-2 total scores (r = 0.60, p < 0.001). Positive correlations were found between the PAS total score and the MAIA-2's subscales, ranging from r = 0.21, p < 0.001 (MAIA-2-ND) to r = 0.54, p < 0.05 (MAIA-2-AR) (see Table S3 in the Supplementary). We also observed positive correlations between all PAS scores (total and subscales) and the FMI total score (r = 0.47, p < 0.001 for PAS-EwFA and PAS-NfA; r = 0.54, p < 0.001 for PAS total score). Similar positive correlations were found with the two FMI subscales (see Table S3 in the Supplementary). All PAS scores were moderately and positively correlated with the BFI-E, the BFI- A, the BFI-C, and the BFI-O (ranging from r = 0.14, p < 0.05 to r = 0.26, p < 0.001) (see Table S3 in the Supplementary).

Discriminant validity. Negative correlations were found with all TAS scores, ranging from r = - 0.16, p < 0.001 (PAS-EwPA and TAS-DIF and TAS-DVE) to r = - 0.40, p < 0.001 (PAS-NfA and TAS-DIF). PAS total and subscales were also negatively, but moderately, correlated with the BFI-N (the weakest correlation: r = - 0.14, p < 0.05 for PAS-EwFA) (Table S3 of the Supplementary).

MAIA-2

Convergent validity. All MAIA-2 scores (total and subscales) showed positive correlation with the FMI total score (r = 0.64, $p < 0.001$ for the MAIA-2 total score, and from r = 0.16, $p < 0.001$ (MAIA-2-ND) to r = 0.58, $p < 0.001$ (MAIA-2-SR) for MAIA-2 subscales; see Table S3 in the Supplementary).

Discriminant validity. Negative correlation has been found between the MAIA-2 total score and the total score of the TAS-20 (r = - 0.50, $p < 0.001$), as well as the dimension Neuroticism of the BFI-FR (r = - 0.28, $p < 0.001$). Almost all subscale scores of the MAIA-2 (except one: Not-worrying) were significantly negatively correlated with the TAS total score, ranging from r = - 0.27, $p < 0.001$ (MAIA-2-NW) to r = - 0.42, $p < 0.001$ (MAIA-2-T). Regarding the dimension Neuroticism of the BFI-FR, it was negatively correlated with four MAIA-2 subscales, ranging from r = - 0.24, $p < 0.001$ (MAIA-2-NW) to r = - 0.44, $p < 0.001$ (MAIA-2-T).

Effect of non-psychological factors on self-report measures

Table S5 in the Supplementary summarizes statistics that inform the effects of categorical non-psychological factors (sport practice, body-centered activity, and gender) on the self-report measure of interoceptive (MAIA-2) and postural (PAS) body awareness.

Practice of sport

Individuals who reported practice of sport showed significantly higher score for the dimensions PAS-NfA, MAIA-2-AR and MAIA-2-T, compared to individuals who did not. For the dimension PAS-EwPA, individuals who reported practice of sport tend to have a higher score than those who did not. There was no significant effect of sport practice on other subscales of the MAIA-2.

Body-centered activity

Figure 3 describes the body-centered activities that were reported in our sample. Individuals who reported practice of a regular body-centered activity showed significantly higher scores for all the dimensions of the PAS and the MAIA-2, except for the dimensions MAIA-2-ND and MAIA-2-NW, compared to individuals who did not.

Figure 3. Word cloud of body-centered activities that were reported in our sample based on their relative frequency. The bigger the word, the greater the frequency influences. The figure is a representation of words that have been entered at least more than twice (minimum frequency = 2).

Gender

We did not find any effect of the gender on self-reported postural body awareness. By contrast, regarding the interoceptive body awareness, we found that scores for the dimensions MAIA-2-N, MAIA-2-EA, and MAIA-2-BL were significantly higher in females than in males. Furthermore, the score for the dimension MAIA-2-T was significantly higher in males than in females.

Age

None of the dimensions of the PAS and the MAIA-2 did correlate with age of participants, with $\log(BF_{10})$ ranging from -1.30 (MAIA-2-N) to -2.63 (MAIA-2-BL) suggesting extreme evidence for the null hypothesis. To provide a direct comparison with results from Topino *et al* (2020), we also tested the effect of age when transforming as a categorical variable in using Topino's criteria (Topino et al., 2020) on the PAS subscales. We did not find any effect of age classes on the two dimensions of the PAS-EwPA: $\log(BF_{10}) = -2.51$, suggesting extreme evidence for the null hypothesis; PAS-NfA: $\log(BF_{10}) = -3.92$, suggesting extreme evidence for the null hypothesis.

Body Mass Index

All the dimensions of the PAS and most of the dimensions of the MAIA-2 (except the dimension MAIA-2-T) did not correlate with BMI of participants, with $\log(BF_{10})$ ranging from -1.12 (MAIA-2-BL) to -2.63 (PAS-EwPA), suggesting strong to extreme evidence for the null hypothesis. The dimension MAIA-2-T showed significant negative correlation with the BMI of participants (r = -0.21, $p < 0.001$). To provide a direct comparison with results from Topino *et al* (2020), we also tested the effect of BMI when transforming as a categorical variable in using Topino's criteria (Topino et al., 2020) on the PAS subscales. We did not find any effect of BMI classes on the two dimensions of the PAS-EWPA: $\log(BF_{10}) = -1.59$, suggesting very strong evidence for the null hypothesis; PAS-NfA: $\log(BF_{10}) = -2.78$, suggesting extreme evidence for the null hypothesis).

Discussion

General discussion

The aim of this study was to evaluate psychometric properties and validate in French the PAS, a recently developed questionnaire to assess postural body awareness (Cramer et al., 2018), and the MAIA-2, which is the latest version of a popular questionnaire assessing interoception (the interoceptive component of body awareness) (Mehling et al., 2018). Our data, collected in a non-clinical adult sample, showed that the French version of the PAS and the MAIA-2 have both good construct validity and good internal consistency, as well as a good reliability over time. First, regarding the construct validity of the two questionnaires, significant positive correlations were found with the dispositional trait mindfulness, which is characterized by enhanced body awareness (Treves et al., 2019). Our finding is consistent with previously published applications of the MAIA (Bornemann et al., 2015; Hanley et al., 2017; Mehling et al., 2012; Verdonk et al., 2021) and the PAS (Cramer et al., 2018; Topino et al., 2020). On the other hand, scores of the PAS and the MAIA-2 showed negative correlation with alexithymia (inability to identify and describe emotions in the self), which is a psychological construct that is theoretically and empirically in opposition to body awareness (Herbert et al., 2011; J. Murphy et al., 2018; Jennifer Murphy et al., 2018; Topino et al., 2020; Zamariola et al., 2018). This result supports the idea that individuals with alexithymia have a disrupted processing of bodily signals, which could ultimately lead to impairments in emotional awareness since the ability to feel bodily sensations is thought to be a central antecedent of the conscious experience of emotions (Zamariola et al., 2018). Regarding the dimension *Neuroticism* of the BFI-FR, our analyses showed significantly negative correlation with the interoceptive dimensions of *Attention Regulation, Self-regulation, Trusting, and Not-worrying*. This finding is in line with the work from Pearson et al. (2020) but contrasts with results from Ferentzi et al. (2020) (Ferentzi et al., 2020; Pearson & Pfeifer, 2020). Neuroticism is considered as an individual's tendency to worry and be anxious, as well as to overreact to negative affect (Costa Jr & McCrae, 1992). Previous studies have reported that higher neuroticism individuals have a diminished ability to regulate emotion regulation, specifically a diminished capacity to downregulate negative emotions (Harenski et al., 2009; Yang et al., 2020). Our finding suggests that difficulty experienced by individuals with high neuroticism in regulating their emotion could partly result from inability to actively pay attention to their body sensations, which are proposed to shape emotional experience (Critchley & Garfinkel, 2017; Critchley & Nagai, 2012). Taken together, our results suggest that the psychological construct of body awareness, *i.e.* the ability to feel engaged by information coming from the body, might potentially play a mediator role in the relationship between personality traits, such as neuroticism and alexithymia, and emotion dysregulation (Harenski et al., 2009; Preece et al., 2021; Yang et al., 2020). This hypothesis needs to be tested in further studies by using mediation analyses to reveal potential role of body awareness in the transmission of (causal) effect of personality traits to emotion dysregulation (Agler & De Boeck, 2017; Baron & Kenny, 1986). Regarding other personality dimensions assessed with the BFI-FR, we reported a moderate positive correlation between scores of the PAS and the MAIA-2 and the dimensions of *Conscientiousness, Extraversion and Openness*. These results are consistent with the findings from Ferentzi *et al.* (2020, 2017). Finally, we observed that self-reported postural and interoceptive body awareness strongly and positively correlate to each other, thus suggesting that proprioception and interoception refer to two components of a homogeneous, unified psychological construct of body awareness. Interestingly, recent neuroimaging studies also accounted for this hypothesis by highlighting that some of the brain areas involved in the processing of interoceptive and proprioceptive signals, notably the parietal cortex, could overlap (García-Cordero et al., 2017; Salvato et al., 2020). It has also been shown that redundancy and complementarity characterize signals originating from within the body, and such features appear to be functionally relevant for cardiac interoception (Khalsa et al., 2009), as well as for postural response in stressful situations (Volchan et al., 2017).

Factor analyses showed that the French version of the PAS has the same underlying two-factor structure as previously published versions (Cramer et al., 2018; Topino et al., 2020). The first factor regards the ability to have a high postural awareness in a natural and effortless way (Ease/familiarity with postural awareness), and the second refers to the need for high efforts to be aware of their own posture (Need for attention regulation with postural awareness). Regarding the French version of the MAIA-2, results from EFA suggested a model in which the optimal number of factors is limited to six. This model differs from the eight-factor model that has been proposed with the first version of the MAIA (MAIA-1; Mehling et al., 2012). Of note, the recent development of a modified version of the MAIA (MAIA-2) aimed to improve its psychometrics by adding new items to the *Not-worrying* and *Not-distracting* subscales, which have been reported to be of limited internal consistency reliability in numerous applications (Mehling et al., 2018). We observed that *Not-worrying* and *Not-distracting* scores are only weakly correlated with MAIA-2 total score, in line with the recent work from Ferentzi et al. (2020). They suggested that *Not-worrying* and *Not-distracting* subscales could be unrelated to the common general factor of interoceptive body awareness. Based on this hypothesis, we performed additional CFA on a subset of the original dataset, in which responses to items related to *Not-worrying* and *Not-distracting* factors were removed, and we found the best model fit with a six-factor model including factors of *Noticing, Attention regulation, Emotional Awareness, Self-regulation, Body listening*, and *Trusting*. Our findings, which need to be confirmed in a larger French-speaking sample, contribute to the call for a reconsideration of the MAIA structure, in particular the relevance of keeping items that are related to *Not-worrying* and *Not-distracting* factors. Nonetheless, the reader should bear in mind that differences in model fit between the six-factor and the eight-factor models remain relatively small, thus supporting the 37-item MAIA-2 as an appropriate instrument for interoception research to assess subjective body awareness.

In our work, we also investigated the effect of 'non-psychological' factors on the PAS and the MAIA-2 scores. In line with findings of the Italian version of the PAS (Topino et al., 2020), we found that practices of sport and body-centered activity are associated with higher self-reported postural awareness. Contrary to results from Topino *et al* (2020), we did not observe any significant relationship between BMI and PAS score. For the MAIA-2 questionnaire, we also found that practices of sport and body-centered activity are associated with higher self-reported interoceptive body awareness. Furthermore, we observed a significant effect of gender on the dimensions *Noticing, Emotional Awareness, Body listening*, and *Trusting*, which is consistent with findings from interoception literature (Grabauskaitė et al., 2017).

Limitations, constraints on generality, and perspectives

This study has some limitations that might need to be addressed in future research. First, a relatively small number of self-report measures were collected to test construct validity of the PAS and the MAIA-2. This results from the limited collection of questionnaires used in interoception research that are currently validated in the French-speaking population. Secondly, our sample included a relatively large proportion of participants with an education level higher than 2 years of university courses (n=244 – 79.22%), and hence differs from the French general population in which the proportion of individuals reporting more than two years of university courses is between 28.6 and 36.1%. There are also some limitations inherent in the self-report psychological scales, among which social desirability and response bias, but in the field of body awareness they seem to be one of the most relevant tools. Indeed, like patient reported outcome - PRO - used in chronic pathologies (such as chronic arthritis or irritable bowel syndrome) to assess how well patients respond to treatment from the patients' perspective, assessment of body awareness has to be patient/subject centered. Yet, one could argue that self-report questionnaires are only one of the well-established methods of capturing individual differences in psychology. Objective measures, in particular physiological signals, are also of particular interest to investigate inter-subject variability in the process of sensing signals coming from the body. It should be noted that many behavioural tests enable objective measure of body awareness (e.g., heartbeat perception task for cardiac interoception; Brener & Ring, 2016), but their features that make them robust in an experimental sense make behavioural tests unreliable in a psychometric sense (Hedge et al., 2018). For the interoceptive component of body awareness, the Heartbeat Evoked Potential (HEP), which refers to evoked changes in brain activity (measured using magnetoencephalography, electroencephalography, or intracranial neural recordings) that occurs after a heartbeat, has been proposed as a neurophysiological marker of interoception (Coll et al., 2021). However, in a recent study, Verdonk et al (2021) have shown that the HEP amplitude is not associated with the self-reported interoceptive awareness, as measured with the MAIA-1. Regarding the postural component of body awareness, we suggest that the postural signal could be a candidate physiological biomarker to assess construct validity of the PAS. Future studies are encouraged to investigate the relationship the self-reported postural body awareness, as measured with the PAS, could have with the postural signal recorded during standing posture.

Endnotes.

[1] A tau-equivalence model includes a single factor (*i.e.* the model is unidimensional) that shows equal factor loadings across all items (Flora, 2020).

Author Notes. The opinions or assertions expressed herein are the private views of the authors and are not to be considered as official or as reflecting the views of the French Military Health Service.

Preregistration. This study was not preregistered.

Author Contributions. LDCS, AMD, and CV equally contributed to the work, including conceptualization of the research question, design of the methodology, and execution of the study, data analysis and writing of the paper. CB, BR, ES, CV and GA actively took part in the process of cross-cultural translation of the two questionnaires. All authors approved the final version of the manuscript for submission**.**

Ethics Statement. The study has been approved by the H.I.A. Saint Anne ethics committee (0011873-2021-02) and was conducted in accordance with ethical standards of the 1964 Helsinki declaration and its later amendments.

Informed Consent. Electronic-based written informed consent was obtained from all individual participants included in the study.

Disclosure statement. The authors declare that they have no conflict of interest.

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Data accessibility. The data and materials are currently private for peer review.

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Supplementary

Table S1 - A descriptive and approximate classification scheme for the interpretation of the log scale of Bayes factor BF_{10} (adapted from Jeffreys, 1961)

Log (BF_{10})	Interpretation	Symbol
> 2	extreme evidence for H_1	H_1^{****}
[1.48 ; 2]	very strong evidence for H_1	H_1^{***}
[1 ; 1.48]	strong evidence for H_1	H_1^{**}
[0.48 ; 1]	moderate evidence for H_1	H_1^{*}
[0 ; 0.48]	anecdotal evidence for H_1	ns
0	no evidence	ns
[-0.48 ; 0]	anecdotal evidence for H_0	ns
[-1 ; -0.48]	moderate evidence for H_0	H_0^{*}
[-1.48 ; -1]	strong evidence for H_0	H_0^{**}
[-2 ; -1.48]	very strong evidence for H_0	H_0^{***}
< -2	extreme evidence for H_0	H_0^{****}

Growing evidence in favor of H_1

Growing evidence in favor of H_0

log(BF_{10}): log scale of Bayes factor BF_{10}; H_1: alternative hypothesis; ns: non-significant; H_0: null hypothesis

Table S2 - Summary of socio-demographic data

	N	%
Gender		
Male	119	61.4
Female	189	38.6
Body Mass Index (M ± SD : 23.93 ± 4.18)		
Obesity (class 2 & 3) : BMI ≥ 35	7	2.3
Obseity (class 1) : BMI [30 – 35[	13	4.2
Overweight : BMI [25 – 30[	76	24.7
Normal weight : BMI [18.5 – 25[	203	65.9
Underweight : BMI < 18.5	9	2.9
Study degree		
Middle school diploma	21	6.8
High school diploma	31	10.1
Higher national diploma	33	10.7
University degree	16	5.2
Bachelor degree	90	29.2
Doctoral degree	105	34.1
Other	12	3.9
Sport practice		
Yes	208	67.5
No	100	32.5

	N	%
Sport		
Gym	2	0.6
Water sports	8	2.6
Football	5	1.6
Cycling and running	84	27.3
Walking and trekking	18	5.8
Bodyweight exercises, yoga, fitness	50	16.2
Dance and skating	3	1.0
Volley	4	1.3
Basket and rugby	2	0.6
Martial arts and combat sports	11	3.6
Other	21	6.8
Practice of a body-centered activity		
Yes	146	46.4
No	162	52.6

N: number of participants; %: proportion of participants; M: mean; SD: standard deviation; BMI: Body Mass Index

Table S3 - Pearson's correlations of the measures used to assess construct validity

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1- PAS	1	.87**	.88**	.60**	.45**	.21**	-.06	.54*	.39**	.43**	.45**	.40**	.54**	.53**	.47**	-.35**	-.31**	-.22**	-31**	.20**	.23**	.26**	-.29**	.21**
2 - PAS-EwPA		1	.52**	.56**	.46**	.14*	-.14*	.48**	.44**	.43**	.49**	.30**	.47**	.50**	.39**	-.26**	-.16**	-.16**	-.31**	.19**	.17*	.19**	-.14*	.22**
3 - PAS-NfA			1	.48**	.32**	.23**	.04	.46**	.23**	.33**	.28**	.39**	.47**	.44**	.43**	-.36**	-.40**	-.23**	-.23**	.16**	.22**	.26**	-.37**	.14*
4 - MAIA-2				1	.70**	.29**	.03	.80**	.72**	.77**	.77**	.61**	.64**	.62**	.56**	-.50**	-.38**	-.32**	-.51**	.19*	.22**	.28**	-.28**	.25**
5 - MAIA-2-N					1	.20**	-.22**	.56**	.58**	.42**	.51**	.27**	.38**	.43**	.28**	-.30**	-16**	-.21**	-.37**	.14*	.08	.20**	-.03	.21**
6 - MAIA-2-ND						1	-.21**	.13**	.04	.05	.22**	.13*	.16**	.16*	.14*	-.27**	-.17**	-.23**	-.26**	-.03	.06	-.04	.04	.14*
7 - MAIA-2-NW							1	.04	-.17**	-.10	-.26**	.11	-.07	-.16*	.02	0.2	-.18**	.11	.13*	-.01	.09	.04	-.24**	-.
8 - MAIA-2-AR								1	.52**	.56**	.52**	.41**	.54**	.52**	.47**	-.37**	-.30**	-.21**	-.37**	.13*	.14*	.24**	-.26**	.24**
9 - MAIA-2-EA									1	.54**	.64**	.20**	.35**	.42**	.24**	-.30**	-.12*	-.21**	-.41**	.14*	.14*	.26**	.03	.14*
10 - MAIA-2-SR										1	.64**	.41**	.58**	.55**	.52**	-.37**	-.27**	-.23**	-.39**	.07	.18**	.22**	-.30**	.12**
11 - MAIA-2-BL											1	.28**	.48**	.49**	.40**	-.33**	-.12*	-.25**	-.45**	.16*	.17**	.22**	-.07	.27**
12 - MAIA-2-TR												1	.53**	.44**	.52**	-.42**	-.45**	-.29**	-.26**	.24**	.18**	.17**	.-.44**	-.15**
13 - FMI													1	0.90**	.93**	-.47**	-.39**	-.31**	-.37**	.22**	.34**	.26**	-.58**	.21**
14 - FMI-P														1	.68**	-.40**	-.33**	-.28**	-.37**	.21**	.26**	.31**	-.43**	.18**
15 - FMI-A															1	-.44**	-.40**	-.31**	-.37**	.20**	.34**	.18**	-.61**	.20**
16 - TAS-20																1	.83**	.85**	.73**	-.25**	-.25**	-.24**	-.31**	-.24**
17 - TAS-DIF																	1	.60**	.35**	-.13*	-.19**	-.24**	.46**	-.07
18 - TAS- DVE																		1	0.45**	-.29**	-.20**	-.19**	.22**	-.16**
19 - TAS-EOT																			1	-.17**	-.23**	-.14*	.05	-.37**
20 - BFI-E																				1	.04	.23**	-.15*	.25**
21 - BFI-A																					1	.22**	-.34**	.06
22 - BFI-C																						1	-.24**	.05
23 - BFI-N																							1	-.02
24 - BFI-O																								1

*Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.001 level; PAS: Postural Awareness Scale; PAS EwPA: “Ease/familiarity with postural awareness”; PAS NfA: “Need for attention regulation with postural awareness”; FMI: Freiburg Mindfulness Inventory; FMI-P: “Presence”; FMI-A: “Acceptation”; MAIA-2: Multidimensional Assessment of Interoceptive Awareness (version 2); MAIA-2-N: “Noticing”; MAIA-2-ND: “Not-Distracting”; MAIA-2-NW: “Not-Worrying”; MAIA-2-AR: “Attention Regulation”; MAIA-2-EA: “Emotional Awareness”; MAIA-2-SR: “Self-Regulation”; MAIA-2-BL: “Body Listening”; MAIA-2-TR: “Trusting”. TAS20: 20-item Toronto Alexithymia Scale; TAS-DIF: “Difficulty identifying feelings and distinguishing between feelings and bodily sensations in emotional activation”; TAS-DVE: “Difficulty in the verbal expression of emotions”; TAS-EOT: “Externally oriented thinking”. BFI-E: “Extraversion”; BFI-A: “Agreeableness”; BFI-C: “Conscientiousness”, BFI-N: “Neuroticism”; BFI-O: “Openness to experience”.

Table S4 - Descriptive statistics for the BFI-FR, the FMI and the TAS-20 questionnaires on the total sample (N=308)

	M	SD	[Min - Max]	α	ω	Range of item-scale correlations[#]
BFI-FR						
BFI-O	36.84	6.30	[22 - 50]	0.77	-	-
BFI-C	33.19	5.95	[14 - 44]	0.82	-	-
BFI-E	25.83	6.82	[9 - 40]	0.86	-	-
BFI-A	39.18	5.80	[21 - 49]	0.78	-	-
BFI-N	23.14	7.21	[8 - 40]	0.88	-	-
FMI						
Presence	16.71	3.59	[6 – 25]	0.80	$\omega_{u\text{-}cat} = 0.81$	[0.57 – 0.73]
Acceptation	20.23	4.46	[8 – 32]	0.75	$\omega_{u\text{-}cat} = 0.78$	[0.33 – 0.67]
Total score	36.94	7.39	[15 – 56]	0.86	$\omega_{u\text{-}cat} = 0.89$	-
TAS-20						
Difficulty identifying feelings	16.44	5.44	[7 – 31]	0.77	$\omega_{ho} = 0.80$	[0.11 – 0.72]
Difficulty in the verbal expression of emotions	14.69	5.11	[5 – 25]	0.81	$\omega_{ho} = 0.80$	[0.55 – 0.79]
Externally oriented thinking	17.84	4.72	[8 – 31]	0.59	$\omega_{ho} = 0.61$	[0.17 – 0.54]
Total score	48.97	12.28	[20 – 86]	0.84	$\omega_{ho} = 0.75$	-

BFI-FR: French version of the Big Five Inventory; FMI : Freiburg Mindfulness Inventory; TAS-20 : Toronto Alexithymia Scale; M: mean; SD: standard deviation; Min: minimum value; Max: maximum value; α: Cronbach alpha; ω_{ho}: coefficient omega based on a higher-order model; ω_{u-cat}: categorical omega; [#]Correlations are intended to be descriptive and are not corrected for multiple comparisons

Table S5 - Effects of categorical non-psychological factors (sport practice, body-centered activity, and gender). Standard statistics and Bayesian equivalents inform the effects of factors on psychometric scores.

	Practice of sport				**Body-centered activity**				**Gender**			
	Stat	*p*	*BF*	*Int.*	*Stat*	*p*	*BF*	*Int.*	*Stat*	*p*	*BF*	*Int.*
PAS												
Total score	8097	<0.01	-	✓ > ✗	8213	<0.001	-	✓ > ✗	10187	0.164	-1.29	-
Subscale *Familiarity with postural awareness*	9016	0.06	-	✓ > ✗	8468	<0.001	-	✓ > ✗	10982	0.73	-1.86	-
Subscale *Need for attention regulation with postural awareness*	7747	<0.001	-	✓ > ✗	9144	<0.001	-	✓ > ✗	9731	0.06	- 0.74	-
MAIA-2												
Total score	8641	<0.05	-	✓ > ✗	8784	<0.001	-	✓ > ✗	11941	0.36	-1.53	-
Subscale *Noticing*	9388	0.17	-1.34	-	9815	<0.05	-	✓ > ✗	13485	<0.01	-	♀ > ♂
Subscale *Not-distracting*	11118	0.33	-1.65	-	10661	0.14	-1.19	-	10820	0.58	-1.85	-
Subscale *Not-worrying*	9429	0.18	-1.42	-	12221	0.61	-2.00	-	11011	0.76	-2.06	-
Subscale *Attention regulation*	8225	<0.01	-	✓ > ✗	9397	<0.01	-	✓ > ✗	12029	0.30	-1.68	-

	Practice of sport				**Body-centered activity**				**Gender**			
	Stat	*p*	*BF*	*Int.*	*Stat*	*p*	*BF*	*Int.*	*Stat*	*p*	*BF*	*Int.*
Subscale *Emotional awareness*	9786	0.40	-1.92	-	9873	<0.05	-	✓ > ✗	13331	<0.01	-	♀ > ♂
Subscale *Self-regulation*	9245	0.11	-0.91	-	8924	<0.001	-	✓ > ✗	11065	0.81	-2.03	-
Subscale *Body listening*	10057	0.64	-1.91	-	9650	<0.01	-	✓ > ✗	13002	<0.05	-	♀ > ♂
Subscale *Trusting*	7482	<0.001	-	✓ > ✗	9610	<0.01	-	✓ > ✗	9156	<0.01	-	♀ < ♂

PAS: Postural Awareness Scale; MAIA-2: Multidimensional Assessment of Interoceptive Awareness (version 2); *Stat* : statistic ; *p* : p-value ; *BF* : log scale of Bayes factor BF_{10} ; *Int.* : interpretation of betwen-modality comparisons; ✓ : practice of sport or body-centered activity ; ✗ : no sport practice or body-centered activity ; ♀ : female gender ; ♂ : male gender

Figures

Figure S1

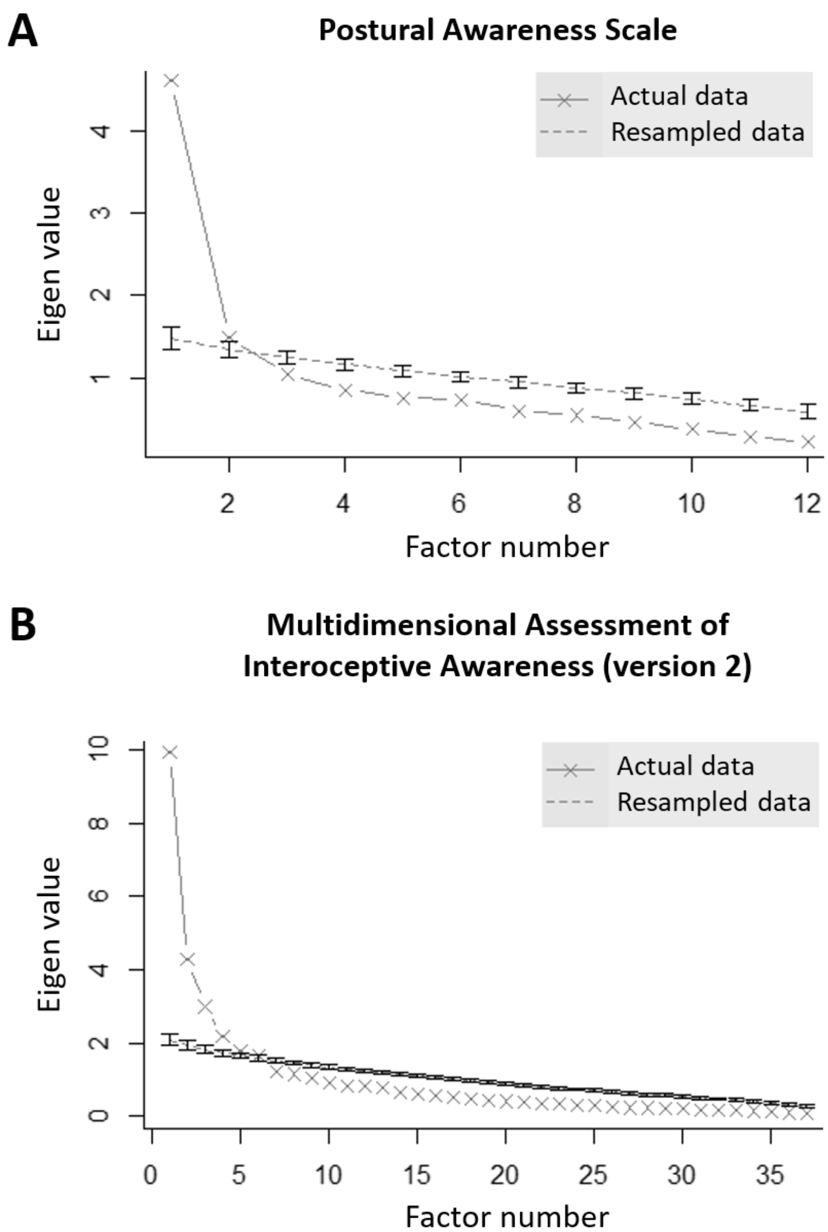

Figure S1 - Scree plot for **(A)** the Postural Awareness Scale and **(B)** the Multidimensional Assessment of Interoceptive Awareness (version 2). The figure includes the 95% confidence interval of eigenvalues obtained after bootstrapping using 1000 replications.

Supplementary Reference

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Postural Awareness Scale

Version française

Consigne Parmi les questions suivantes, merci d'indiquer pour chacune d'elle la réponse qui vous correspond le mieux.

Modalités de réponse
1 = Ne me correspond pas du tout
2 = Me correspond très peu
3 = Me correspond peu
4 = Me correspond moyennement
5 = Me correspond assez
6 = Me correspond beaucoup
7 = Me correspond fortement

Questions	**Réponse**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1. J'ai besoin d'être très concentré(e) pour prendre conscience de ma posture corporelle	□	□	□	□	□	□	□
2. Quand je me tiens dans une mauvaise posture corporelle, souvent je ne la remarque pas avant qu'elle devienne douloureuse	□	□	□	□	□	□	□
3. Quand je suis assis(e), j'ai souvent tendance à m'avachir	□	□	□	□	□	□	□
4. Quand je me concentre sur une activité spécifique, je prends souvent une posture corporelle particulière sans m'en rendre compte	□	□	□	□	□	□	□
5. Il m'est difficile de prendre consciemment une posture corporelle particulière	□	□	□	□	□	□	□
6. Lorsque je travaille, je vérifie régulièrement ma posture corporelle	□	□	□	□	□	□	□
7. Au travers de ma posture corporelle, je peux intentionnellement modifier l'impression que je donne aux autres	□	□	□	□	□	□	□
8. Tout au long de la journée, je suis en permanence conscient(e) de la façon dont je suis assis(e) ou debout	□	□	□	□	□	□	□
9. Je suis souvent conscient(e) / me rends souvent compte de ma posture corporelle, que je sois assis(e) ou debout	□	□	□	□	□	□	□
10. Même si je suis focalisé(e) sur quelque chose, je suis en permanence conscient(e) de ma posture corporelle	□	□	□	□	□	□	□
11. Au travers de ma posture corporelle, je peux contrôler consciemment mon humeur	□	□	□	□	□	□	□
12. Je remarque si ma posture corporelle est bonne pour moi, ou non, seulement quand je me concentre dessus	□	□	□	□	□	□	□

Calcul des scores

- Dimension *Besoin de réguler son attention pour prendre conscience de sa posture corporelle* : addition après inversion des scores obtenus pour les items 1, 2, 3, 4, 5, 12
- Dimension *Aisance/familiarité avec la conscience de sa posture corporelle* : addition des scores obtenus pour les items 6, 7, 8, 9, 10, 11

Multidimensional Assessment of Interoceptive Awareness Version 2 (MAIA-2)

Version française

Consigne Parmi les questions suivantes, merci d'indiquer pour chacune d'elle la réponse qui vous correspond le mieux.

Questions	Réponse					
	0 Jamais	1	2	3	4	5 Toujours
1. Lorsque je suis tendu(e), je perçois où la tension se situe dans mon corps	☐	☐	☐	☐	☐	☐
2. Lorsque je me sens mal dans mon corps, je le remarque	☐	☐	☐	☐	☐	☐
3. Je perçois dans quelle partie de mon corps je me sens à l'aise	☐	☐	☐	☐	☐	☐
4. Je perçois les changements de ma respiration, par exemple lorsqu'elle ralentit ou s'accélère	☐	☐	☐	☐	☐	☐
5. Je ne perçois pas ou j'ignore les tensions physiques ou l'inconfort jusqu'à ce qu'ils deviennent importants	☐	☐	☐	☐	☐	☐
6. Je me détache des sensations d'inconfort	☐	☐	☐	☐	☐	☐
7. Quand je ressens une douleur ou un inconfort, je mobilise toutes mes forces pour la(le) surmonter	☐	☐	☐	☐	☐	☐
8. J'essaie de ne pas tenir compte de la douleur	☐	☐	☐	☐	☐	☐
9. J'éloigne de moi les sensations d'inconfort en me concentrant sur autre chose	☐	☐	☐	☐	☐	☐
10. Quand je ressens des sensations corporelles désagréables, je fais autre chose de façon à ne pas avoir à les ressentir	☐	☐	☐	☐	☐	☐
11. Lorsque je ressens une douleur physique, cela m'inquiète	☐	☐	☐	☐	☐	☐
12. Je commence à m'inquiéter dès que je ressens de l'inconfort	☐	☐	☐	☐	☐	☐
13. Je peux percevoir une sensation corporelle déplaisante sans m'en inquiéter	☐	☐	☐	☐	☐	☐
14. Je peux rester calme et ne pas m'inquiéter quand je ressens des sensations d'inconfort ou de la douleur	☐	☐	☐	☐	☐	☐
15. Quand j'ai une sensation d'inconfort ou de douleur, je n'arrive pas à penser à autre chose	☐	☐	☐	☐	☐	☐
16. Je peux prêter attention à ma respiration sans être distrait(e)par ce qu'il se passe autour de moi	☐	☐	☐	☐	☐	☐
17. Je peux rester conscient(e) de mes sensations corporelles internes même lorsqu'il se passe beaucoup de choses autour de moi	☐	☐	☐	☐	☐	☐
18. Lorsque je parle avec quelqu'un, je peux porter attention à ma posture	☐	☐	☐	☐	☐	☐

Questions (suite)	**Réponse**					
	0 Jamais	**1**	**2**	**3**	**4**	**5 Toujours**
19. Je peux rediriger mon attention sur mon corps si je suis distrait(e)	☐	☐	☐	☐	☐	☐
20. Je peux rediriger mon attention depuis mes pensées vers mon corps (vers mes sensations corporelles)	☐	☐	☐	☐	☐	☐
21. Je peux maintenir l'attention sur l'ensemble de mon corps même lorsque j'ai une douleur ou un inconfort dans une partie de mon corps	☐	☐	☐	☐	☐	☐
22. Je suis capable de me concentrer sur mon corps dans sa globalité	☐	☐	☐	☐	☐	☐
23. Lorsque je suis en colère, je perçois des changements dans mon corps	☐	☐	☐	☐	☐	☐
24. Quand quelque chose ne va pas dans ma vie, je peux le ressentir dans mon corps	☐	☐	☐	☐	☐	☐
25. Après un moment apaisant, je remarque des changements dans mon corps	☐	☐	☐	☐	☐	☐
26. Quand je me sens bien, je remarque que ma respiration devient facile et fluide	☐	☐	☐	☐	☐	☐
27. Quand je me sens heureux(se)ou joyeux(se), je perçois des changements dans mon corps	☐	☐	☐	☐	☐	☐
28. Lorsque je me sens bouleversé(e), je peux retrouver le calme en moi	☐	☐	☐	☐	☐	☐
29. Lorsque je focalise mon attention sur mon corps, je ressens de l'apaisement	☐	☐	☐	☐	☐	☐
30. Je peux utiliser ma respiration pour réduire mon stress	☐	☐	☐	☐	☐	☐
31. Lorsque je suis pris(e) dans mes pensées, j'arrive à m'apaiser en me concentrant sur mon corps ou sur ma respiration	☐	☐	☐	☐	☐	☐
32. Mes sensations corporelles me renseignent sur mon état émotionnel	☐	☐	☐	☐	☐	☐
33. Lorsque je suis préoccupé(e), je prends le temps d'explorer mes sensations corporelles	☐	☐	☐	☐	☐	☐
34. Mes sensations corporelles m'aident à savoir ce que je dois faire	☐	☐	☐	☐	☐	☐
35. Je me sens à l'aise dans mon corps	☐	☐	☐	☐	☐	☐
36. Je me sens en sécurité dans mon corps	☐	☐	☐	☐	☐	☐
37. J'ai confiance en mes sensations corporelles	☐	☐	☐	☐	☐	☐

Calcul des scores : voir https://osher.ucsf.edu/research/maia