Importance of considering interoceptive abilities in alexithymia assessment

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Background. Recent studies have shown that high alexithymia scorers have deficits in their interoceptive abilities, which can lead to psychological and physical disorders. Early assessment of alexithymia trait included the evaluation of these abilities (the 26-item Toronto Alexithymia Scale; TAS-26). However, the revised version of alexithymia scale, the TAS-20, contains three factors solution that do not involve interoceptive abilities. Yet, items permitting to evaluate these abilities were not suppressed at the time of the revision. In this context, we expect that the remaining items assessing interoceptive abilities in the TAS-20 should constitute an independent factor. In addition to exploring the internal structure of the TAS-20, we examined its external validity by assessing the relationships between the new factors and indicators of psychological and physical health.

Methods. Two online studies (N=253 and N=287) were performed. The participants completed the TAS-20 and a set of psychological questionnaires (e.g., anxiety, depression) and health questions (e.g., “Do you suffer from a somatic disorder?”). The structure of the TAS-20 was examined using exploratory factor analyses (EFA), followed by an investigation of the relationships between the resulting new factors and other psychological and health data using regressions. In both studies, EFA revealed a new structure of the questionnaire comprising four dimensions: *(1)* difficulty in the awareness of feelings, *(2)* externally oriented thinking, *(3)* difficulty in interoceptive abilities, and *(4)* poor affective sharing. The first factor was positively associated with all psychological issues while the third factor was associated more with somatic disorders and medication intake.

Results. Our results suggest the presence of a new latent factor in the assessment of alexithymia that reflects interoceptive abilities specifically related to health outcomes. Consequently, it seems important to develop a conceptual justification for the assessment of interoceptive abilities when considering the evaluation of alexithymia. The next step would be to develop a valid measure of these abilities.

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Abstract

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Methods. Two online studies (N=253 and N=287) were performed. The participants completed the TAS-20 and a set of psychological questionnaires (e.g., anxiety, depression) and health questions (e.g., “Do you suffer from a somatic disorder?”). The structure of the TAS-20 was examined using exploratory factor analyses (EFA), followed by an investigation of the relationships between the resulting new factors and other psychological and health data using regressions.

In both studies, EFA revealed a new structure of the questionnaire comprising four dimensions: *(1)* difficulty in the awareness of feelings, *(2)* externally oriented thinking, *(3)* difficulty in interoceptive abilities, and *(4)* poor affective sharing. The first factor was positively associated with all psychological issues while the third factor was associated more with somatic disorders and medication intake.
Results. Our results suggest the presence of a new latent factor in the assessment of alexithymia that reflects interoceptive abilities specifically related to health outcomes. Consequently, it seems important to develop a conceptual justification for the assessment of interoceptive abilities when considering the evaluation of alexithymia. The next step would be to develop a valid measure of these abilities.

Introduction

The alexithymia construct, meaning "lacking words to express feelings", is derived from clinical observations of patients suffering from psychosomatic disorders (MacLean, 1949; Marty & De M'Uzan, 1963; Ruesch, 1948). Based on these observations, the alexithymia construct was defined as three main features: *i)* difficulty identifying and describing one's own feelings, *ii)* limited imaginative processes, and *iii)* an externally-oriented cognitive style (Apfel & Sifneos, 1979; Nemiah & Sifneos, 1970). Later, following a review of the literature on alexithymia, the *difficulty in distinguishing between feelings and bodily sensations* and *social conformity* features were added (Taylor et al., 1985).
Alexithymia is associated with many psychological and physical disorders, such as anxiety (Karukivi, Tolvanen, Karlsson, & Karlsson, 2015), depression (Li, Zhang, Guo, & Zhang, 2015), somatization (Brandt, Pintzinger, & Tran, 2015), somatic complaints (Tominaga, Choi, Nagoshi, Wada, & Fukui, 2014), eating disorders (Jenkinson, Taylor, & Laws, 2018), myocardial infarction (Silva, Freitas, Moreira, Santos, & Almeida, 2016), carotid atherosclerosis (Grabe et al., 2010), and higher mortality rates (Tolmunen, Lehto, Heliste, Kurl, & Kauhanen, 2010). For this reason, alexithymia is a construct of interest in many theoretical models of health psychology (Lumley, Neely, & Burger, 2007). It is, therefore, necessary to correctly assess this construct using reliable and valid measures. Different scales were developed to evaluate the alexithymia construct, but they had inadequate psychometric qualities (Taylor et al., 1985). Consequently, the 26-item Toronto Alexithymia Scale (TAS-26) was developed. This scale assessed four dimensions: *i)* difficulty identifying and distinguishing between feelings and bodily sensations (DIDF), *ii)* difficulty describing feelings (DDF), *iii)* reduced daydreaming, and *iv*) externally oriented thinking (EOT) (Taylor et al., 1985). Due to the problems with the compositional structure of the TAS, the revision of this scale led to the development of the 23-item TAS (TAS-R), which assessed two dimensions: *i)* ability to distinguish between feelings and bodily sensations associated with emotional arousal and the ability to describe feelings to others; *ii)* EOT (Taylor, Bagby, & Parker, 1992). During this review, the *reduced daydreaming* dimension was suppressed due to low corrected item-total correlations with the full TAS and a negative correlation with the factor DIDF. In addition, DIDF and DDF dimensions were merged

into one dimension, and one item was replaced by a new one. Two EOT items were removed and five new items were added. Subsequently, due to social desirability response bias and lack of inter-correlations between factors, the TAS was reviewed one more time, resulting in the 20-item TAS (TAS-20) (Bagby et al., 1994; Taylor, Bagby, & Parker, 2003). The DDF dimension was reintroduced as a fully-fledged dimension. The label *difficulty distinguishing between feelings and bodily sensations* was dropped along with two items, leading to the creation of the DIF dimension; however, the two items which were removed did not refer to the body, and two other items related to interoception were retained. In addition, one item from the EOT was suppressed. The TAS-20 is the most widely used scale in empirical research (Lane, Weihs, Herring, Hishaw, & Smith, 2015; Sekely, Bagby, & Porcelli, 2018). This scale assesses three dimensions: *i)* difficulty identifying feelings (DIF), *ii)* DDF, and *iii)* EOT. The TAS-20 has good reliability and factorial validity in different languages and cultures (Taylor et al., 2003), and the three-dimensional model is considered as the best fit (Bagby et al., 1994; Loas, Parker, Otmani, Verrier, & Fremaux, 1997; Parker, Bagby, Taylor, Endler, & Schmitz, 1993). However, several studies have reported that the factor structure of this scale is not always consistent (e.g., Haviland & Reise, 1996; Kooiman, Spinhoven, & Trijsburg, 2002; Müller, Bühner, & Ellgring, 2003) for different reasons. First, the EOT dimension might reflect more the social norms that guide emotional behaviors rather than a cognitive style of thinking (Dere et al., 2013). This probably leads to the lack of internal consistency of this dimension (Bressi et al., 1996; Taylor et al., 2003; Zhu et al., 2007) and limited usage of this measure, especially in children (Rieffe, Oosterveld, & Terwogt, 2006). Second, the verbalization and the differentiation of feelings seem theoretically interconnected (Lane & Schwartz, 1987), which explains why some studies found a unique factor that combines the DIF and DDF dimensions (Erni, Lötscher, & Modestin, 1997; Kooiman et al., 2002; Loas, Otmani, Verrier, Fremaux, & Marchand, 1996). Third, the lack of consistency could be due to the analysis performed (Loas et al., 2001). Indeed, most studies that have reported others solutions than the three-factor solution used only exploratory factorial analyses (EFA), accounting more for the existence of alternative models (Loas et al., 2001), whereas the appropriate tool to confirm the three-factor solution seems to be the confirmatory factorial analyses (CFA). Fourth, we assume that this could be due to the suppression of the *difficulty distinguishing between feelings and bodily sensations* label without suppressing items referring to bodily sensations. This rearrangement could lead to the existence of a latent factor in the TAS-20, which could reflect the old structure of the TAS-26 and TAS-R.

Overview

Along this line of research, the aim of this paper was to examine the structure of the TAS-20 using EFA. Contrary to the opinion of Loas and collaborators (2001), we decided to use EFA and not CFA. In fact, the aim of this paper was not to validate or confirm the factor structure of this scale but to explore whether the TAS-20 contains a latent factor assessing interoceptive abilities. The use of CFA would have involved making choices based on theoretical data, which could influence the results of our exploratory studies. Two different versions of the TAS-20 are

available in French: the first comprises items rated on a 4-point Likert scale (Bruchon-Schweitzer, 2002) and the second contains items rated on a 5-point Likert scale (Loas et al., 1996). In this context, we conducted two studies. In the first study, the participants completed the 4-point Likert scale and in the second study, the participants completed the 5-point Likert scale. In addition to exploring the internal structure of the TAS-20, we examined its external validity by assessing the relationships between the new alexithymia factors resulting from the EFA and indicators of psychological and physical health. Difficulties in interoceptive abilities can be associated with psychological and physical troubles (Murphy et al., 2017). For these reasons, we assumed that if there is a latent factor in TAS-20 that assesses interoceptive abilities, it should be associated with the presence of physical and psychological health problems. We point out that the purpose of this work is not to criticize the factorial structure of the TAS-20, but rather to highlight possible existence of a latent factor that could assess difficulties in interoceptive abilities, as stated in the earlier versions of the questionnaire (TAS-26 and TAS-R). Furthermore, the results of both studies support the importance of considering the presence of this latent factor.

Materials & Methods

Participants and Ethics Statement

Overall, 540 participants (Study 1: N=253; Study 2: N=287) were enrolled. We recruited 395 undergraduate psychology students (Study 1: 16 men, 92 women; mean age: 19.44±1.28; Study 2: 35 men, 252 women; mean age: 19.56±1.58) from Clermont Auvergne University (formerly Blaise Pascal University, Clermont-Ferrand, France). The remaining of participants were recruited on a voluntary basis from the general population through social networks (61 men, 84 women; mean age: 37.26±14.03). Table 1 provides an overview of the descriptive statistics of the samples and measures used in each study. The Ethics Committee of Clermont-Ferrand approved the study protocol (CPP SUD-EST 6, IRB00008526, 2015-CE23). The nature and potential risks of the study were fully explained to the participants. Written informed consent was obtained from each participant. The experimental data is available at https://osf.io/8kncz.

Measures

Alexithymia was assessed using the 20-item Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994). The 20 items of this scale evaluate three dimensions of alexithymia: *(a)* difficulty identifying feelings (DIF) (items 1,3,6,7,9,13,14) (Study 1: α=.81; Study 2: α=.84), *(b)* difficulty describing feelings (DDF) (items 2,4,11,12,17) (Study 1: α=.80; Study 2: α=.79), and *(c)* externally oriented thinking (EOT) (items 5,8,10,15,16,18,19,20) (Study 1: α=.65; Study 2: α=.59). Items 4, 5, 10, 18, and 19 are reverse coded. Two versions of the TAS-20 exist in French. In Study 1, we used the French version with items rated on a 4-point scale ranging from 1 (*rarely*) to 4 (*very often*) (Bruchon-Schweitzer, 2002). The total score varies from 20 to 80, with a high score indicating a high level of alexithymia (α=.83). In Study 2, we used the French version with items measured on a 5-point Likert scale (Loas et al., 1996) ranging from 1

(*strongly disagree*) to 5 (*strongly agree*). The total score varies from 20 to 100, with a high score indicating a high level of alexithymia (α=.84).

Trait anxiety was assessed using the Trait subscale of the State-Trait Anxiety Inventory (STAI) (Bruchon-Schweitzer & Paulhan, 1993; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) consisting of 20 items measured on a scale ranging from 1 (*almost never*) to 4 (*almost always*). Items 1, 3, 6, 7, 10, 13, 14, 16, and 19 are reverse coded. The overall score varies from 20 to 80, with higher scores indicating a high level of anxiety (Study 1: α=.91; Study 2: α=.91).

In Study 1, *depressive symptomatology* was assessed using the Depression subscale of the Hospital Anxiety and Depression Scale (HADS-D) (Lépine, Godchau, & Brun, 1985; Zigmond & Snaith, 1983). The 7 items of this scale measure the symptoms or behaviors that are often associated with depression on a 4-point scale (from 0 to 3). The total score varies from 0 to 21, with a high score indicating a high level of depressive symptomatology. The HADS-D evaluates moderate depressive states; thus, it does not mention suicidal ideation (Hansson, Chotai, Nordstöm, & Bodlund, 2009) (α=.73). However, in Study 2, we assessed the depressive symptomatology using the Beck Depression Inventory-13 (BDI-13) (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Collet & Cottraux, 1986). The 13 items of this scale measure the depression symptomatology on a 4-point scale from 0 to 3. The total score varies from 0 to 39, with a high score indicating a high level of depressive symptomatology (α=.79).

Emotional instability was measured using the Neuroticism dimension of the Big Five Inventory (BFI-N)(John, Donahue, & Kentle, 1991; Plaisant, Courtois, Réveillère, Mendelsohn, & John, 2010). Neuroticism refers to the tendency to experience unpleasant affects (e.g., anger, anxiety, sadness) and to the lack of emotional stability. It comprises 8 items rated on a 5-point scale ranging from 1 (*not agree at all*) to 5 (*completely agree*). Items 9, 24, and 34 are reverse coded. The total score varies from 5 to 40, with a high total score indicating a high emotional instability (Study 1: α=.85; Study 2: α=.84).

Perceived stress was evaluated using the Perceived Stress Scale (PSS) (Bellinghausen, Collange, Botella, Emery, & Albert, 2009; Cohen & Williamson, 1988). The 10 items of this scale measure the degree to which everyday life situations are appraised as stressful on a 5-point scale ranging from 0 (*never*) to 4 (*very often*). Items 4, 5, 7, and 8 are reverse coded. The total score varies from 0 to 40, with a high score indicating a high level of perceived stress (Study 1: α=.88; Study 2: α=.89).

Coping strategies were assessed using the Brief Cope (Carver, 1997; Muller & Spitz, 2003). The 28 items of this scale measure fourteen coping strategies on a 4-point scale ranging from 1 (*not at all*) to 4 (*absolutely*). Due to a large number of coping styles, we grouped them into three categories: *(a)* functional coping (mean of active coping, planning, positive reframing, and acceptance) (Study 1: α=.86; Study 2: α=.80), *(b)* dysfunctional coping (mean of denial, behavioral disengagement, substance use, and self-blame) (Study 1: α=.73; Study 2: α=.70), and (c) coping with varying functionality (mean of self-distraction, humor, venting, use of emotional support, use of instrumental support, and religion) (Study 1: α=.81; Study 2: α=.72) (Muller & Spitz, 2003). We then created a difference score between functional and dysfunctional coping (F-

D) to highlight the use of appropriate and effective strategies. A high difference score suggests a functional coping.

Other health assessments. Somatic disorders, eating disorders, cardiovascular diseases, and medication intake were assessed using four questions measured on a binary scale coded as 1 (yes) and 0 (no). Individuals who reported medication intake had to specify the type of medication they were taking.

Procedure

After providing informed consent, the participants completed a set of questionnaires online via the LimeSurvey platform. The students completed the protocol at the university while individuals from the general population completed the surveys at home. All participants completed the questionnaires in the following order: *1)* STAI-T, *2)* TAS-20, *3)* HADS-D (Study 1) /BDI-13 (Study 2), *4)* BFI-N, *5)* PSS, and *6)* Brief cope. Finally, the participants had to complete the four binary questions about health measures.

Statistical analysis

First, we performed descriptive statistics of the health and psychological data. The aim of this paper was not to compare the samples with each other but to verify whether our results are consistent across studies. However, for information purposes, comparative analyses were performed using ANOVAs to check for differences between samples in socio-demographic, psychological, and health measures. To compare alexithymia scores between samples, we transformed the 4-point Likert scale used in Study 1 to a 5-point Likert scale for each item and calculated the dimensions of alexithymia (*i.e.*, DIF, DDF, EOT). For depression, we used two different scales (depression subscale of HADS in Study 1 and BDI-13 in Study 2) that assess different features of depression; therefore, we could not compare depression scores between samples. When the homoscedasticity assumption was violated, we used adjusted *Welch's F.* In addition, to compare gender and health data between studies, we performed Pearson chi-square. We performed an EFA with direct Oblimin rotation and principal axis factoring to examine the factorial structure of the TAS-20. To verify the sampling adequacy for the analysis, we computed the Kaiser-Meyer-Olkin (KMO) values for all individual items. For each factor, we estimated the internal consistency using Cronbach's alpha. Based on those results, in both Study 1 and Study 2, we decided to omit items 16 and 20, which belonged to a factor with very low reliability. We then conducted another EFA to examine the structure of the remaining 18 items, and we called the resulting factors as the *latent factors* (LF). Any items with component loadings <.30 are considered to explain only a small part of the factor (Field, 2013). We decided not to report the value of these component loadings in the Tables unless items explained the factor. Reliability analysis was carried out for each component. We considered Cronbach's alphas <.50 as not satisfactory (Taber, 2017).

We finally performed multivariate regression analyses to examine whether the LFs were predictive of the psychological and health measures. Specifically, we conducted multivariate

logistic regressions on each (binomial) health-related measure (somatic disorders, eating disorders, cardiovascular diseases, and medication intake), and multivariate linear regressions on each psychological measure (anxiety, depression, emotional instability, perceived stress, and coping strategies).
Statistical analysis was carried out with SPSS version 24.0 for Macintosh (Statistical Package for the Social Sciences, IBM Corporation, NY, USA). The *p*-value for statistical significance was set at $p<.05$, and the trend for significance was set at $p<.07$.

Results

Descriptive statistics are presented in Table 1. When comparing samples from Study 1 and Study 2, we found that the participants in Study 2 included more women (χ^2 *Pearson* (1)=27.21, $p<.001$) and younger (*Welch F*(1,257.83)=133.29, $p<.001$), more anxious (F(1,538)=16,52, $p<.001$), emotionally more unstable (*F*(1,538)=19.28, $p<.001$) individuals who perceived more stress (*F*(1,538)=17.06, $p<.001$) and used more dysfunctional coping strategies (*F*(1,538)=6.99, $p=.008$) in comparison to participants in Study 1. Moreover, the participants in Study 2 scored higher on alexithymia (TAS-20) compared to participants in Study 1 (*F*(1,538)=9.58; $p=.002$) and had more difficulty to identify (*Welch F*(1,532.23)= 57.35; $p<.001$) and to describe feelings (*F*(1,538)=19.92; $p<.001$). However, the participants in Study 2 had less externally oriented thinking compared to the participants in Study 1 (*F*(1,538)=42.09 ; $p<.001$).

[Insert Table 1]

Exploratory Factor Analysis of the TAS-20

In Study 1, the KMO verified the sampling adequacy for the analysis (*KMO*=.85; individual *KMO* values ≥.55 and ≤.94). The Kaiser criterion indicated five factors (F1 to F5), which accounted for 57.54% of the total variance. F1 consisted of seven items (items 1,2,6,9,11,13,14; $\alpha_1=.85$), F2 consisted of five items (items 5,8,10,18,19; $\alpha_2=.62$), F3 consisted of two items (items 3,7; $\alpha_3=.66$), F4 consisted of two items (items 16,20; $\alpha_4=.36$), and F5 consisted of four items (items 4,12,15,17; $\alpha_5=.68$) (Table 2).
F4, which included item 16 ("*I prefer to watch "light" entertainment shows rather than psychological dramas*") and item 20 ("*Looking for hidden meanings in movies or plays distracts from their enjoyment*"), had very low reliability ($\alpha_4=.36$). Therefore, we conducted another EFA without these items. The KMO verified the sampling adequacy (*KMO*=.87; individual *KMO* values ≥.66 and ≤.90). The results revealed a new structure with four latent factors, LF1 (items 1,2,6,9,11,13,14; $\alpha_1=.85$), LF2 (items 5,8,10,18,19; $\alpha_2=.62$), LF3 (items 3,7; $\alpha_3=.66$), and LF4 (items 4,12,15,17; $\alpha_4=.68$), which accounted for 56% of the total variance. This reallocation was conceptually relevant, since LF1 (5 items of DIF and 2 items of DDF) referred to difficulty in the awareness of feelings, LF2 (5 items of EOT) referred to externally oriented thinking, LF3 (2 items of DIF) referred to difficulty in interoceptive capacities, and LF4 (3 items of DDF and 1 item of EOT) referred to poor affective sharing (Table 2).

[Insert Table 2]

In Study 2, the KMO verified the sampling adequacy for the analysis (*KMO*=.86; individual *KMO* values ≥.59 and ≤.92). The Kaiser criterion indicated six factors (F1 to F6), which accounted for 62.57% of the total variance. F1 consisted of seven items (items 1,2,4,6,9,13,14; α_1=.88), F2 consisted of three items (items 10,18,19; α_2=.51), F3 consisted of four items (items 11,12,15,17; α_3=.70), F4 consisted of three items (items 3,7,13[2]; α_4=.71), F5 consisted of two items (items 16,20; α_5=.43), and F6 consisted of two items (items 5,8; α_6=.37) (Table 3).
F5, which included item 16 ("*I prefer to watch "light" entertainment shows rather than psychological dramas*") and item 20 ("*Looking for hidden meanings in movies or plays distracts from their enjoyment*"), had a low reliability (α_5=.43) and seemed to have limited relevance to alexithymia trait. Hence, we decided to omit them. Moreover, F6, which included item 5 ("*I prefer to analyze problems rather than just describe them*") and item 8 ("*I prefer to just let things happen rather than to understand why they turned out that way*"), had also very low reliability (α_6=.37); however, these items seemed to be representative of alexithymia trait. Suppressing them would be against the theory. Therefore, we decided to keep them.
As in Study 1, we conducted another EFA without items 16 and 20. The KMO verified the sampling adequacy (*KMO*=.87; individual *KMO* values ≥.59 and ≤.92). The results showed a new structure with five factors, F1 (items 1,2,4,6,9,14; α_1=.86), F2 (items 5,8,10,18,19; α_2=.51), F3 (items 11,12,15,17; α_3=.70), F4 (items 3,7,13; α_4=.71), and F5, which did not have dominant items. This structure accounted for 60.94% of the total variance.
Due to the absence of factor loading on the F5, we decided to conduct another EFA by forcing the factorization to four latent factors. The KMO verified the sampling adequacy for the analysis (*KMO*=.87; individual *KMO* values ≥.59 and ≤.92). LF1 consisted of seven items (items 1,2,4,6,9,13,14; α_1=.88), LF2 consisted of five items (items 5,8,10,18,19; α_2=.51), LF3 consisted of two items (items 3,7; α_4=.64), and LF4 consisted of four items (items 11,12,15,17; α_3=.70), which accounted for 55.27% of the total variance. Parameter estimates from the EFA are presented in Table 3. This reallocation was conceptually relevant, since LF1 (5 items of DIF and 2 items of DDF) referred to difficulty in awareness of feelings, LF2 (5 items of EOT) referred to externally oriented thinking, LF3 (2 items of DIF) referred to difficulty in interoceptive capacities, and LF4 (3 items of DDF and 1 item of EOT) referred to poor affective sharing (Table 3).

[Insert Table 3]

In both studies, the four resultant factors of our analyses seemed to evaluate *a difficulty in awareness feelings*, *an externally oriented thinking, interoceptive capacities, and a poor affective sharing.* The only main difference between Study 1 and Study 2 concerned items 4 and 11. Item 4, which refers to the capacity to describe own feelings, loaded on LF4 (*poor affective sharing*)

in Study 1 and on LF2 (*externally oriented thinking*) in Study 2. The reversed pattern was observed for item 11, which refers to the capacity to describe one's feelings about others. Moreover, both items 5 and 8 loaded on LF2 in Study 1, whereas they belonged to a separate factor with a low Cronbach alpha in Study 2. Therefore, it would have been statistically correct to suppress those items in Study 2, but we decided to keep them for theoretical reasons. Indeed, their meaning clearly reflects an external oriented thinking style, which is one of the features of alexithymia. However, the analyses showed that item 8 had a low correlation (.20) with other items from LF2 in Study 1 (.20) and in Study 2 (.33). This item may therefore be only slightly representative of the alexithymia trait.

Predictive Value of the Latent Factors

The results of the multivariate logistic regression analyses are reported in Table 4. When entering all NFs as predictors, the models with both somatic disorders (Study 1: $\chi^2(4)=11.09$, $p=.026$, Nagelkerke $R^2=.14$; Study 2: $\chi^2(4)=22.38$, $p<.001$, Nagelkerke $R^2=.26$) and medication intake, (Study 1: $\chi^2(4)=14.09$, $p=.007$, $R^2=.10$; Study 2: $\chi^2(4)=12$, $p=.017$, $R^2=.08$) were significant in both Studies. For eating disorders, the model was significant in Study 1 ($\chi^2(4)=11.07$, $p=.026$, $R^2=.09$) and in Study 2 ($\chi^2(4)=9.17$, $p=.057$, $R^2=.08$). For cardiovascular diseases, the model was only significant in Study 2 (Study 1: $\chi^2(4)=3.40$, $p=.493$, $R^2=.04$; Study 2: $\chi^2(4)=10.98$, $p=.027$, $R^2=.12$). LF1 predicted eating disorders only in Study 1. LF2 was not a predictor of any of the parameters. In both Studies, LF3 was positively predictive of somatic disorders and medication intake. In Study 2, LF3 predicted eating disorders and cardiovascular diseases. Finally, LF4 negatively predicted medication intake in Study 1, although it was a trend in Study 2.

The results of the multivariate linear regression analyses are reported in Table 5. When entering all NFs as predictors, the models that included the anxiety trait score (Study 1: $F(4,248)=32.10$, $p<.001$, $R^2=.34$; Study 2: $F(4,282)=33$, $p<.001$, $R^2=.32$), the depression score (Study 1: $F(4,248)=23.16$, $p<.001$, $R^2=.27$; Study 2: $F(4,282)=21.03$, $p<.001$, $R^2=.23$), the emotional instability score (Study 1: $F(4,248)=17.25$, $p<.001$, $R^2=.22$; Study 2: $F(4,282)=22.12$, $p<.001$, $R^2=.24$), the perceived stress score (Study 1: $F(4,248)=21.91$, $p<.001$, $R^2=.26$; Study 2: $F(4,282)=23.67$, $p<.001$, $R^2=.25$), and the coping difference score (Study 1: $F(4,248)=21.47$, $p<.001$, $R^2=.26$; Study 2: $F(4,282)=21.97$, $p<.001$, $R^2=.24$) were significant in both studies. In both studies, LF1 was positively associated with all measures (anxiety, depression, emotional instability, perceived stress, and effective coping strategies). LF2 was positively associated with depression and negatively associated with effective coping strategies in Study 1, whereas LF2 approached significance in predicting effective coping strategies in Study 2. LF3 was positively associated with depression and perceived stress in both studies. LF3, however, was also positively associated with anxiety, emotional instability, and effective coping strategies in Study 2, and approached significance in predicting the emotional instability and effective coping strategies in Study 1. Finally, LF4 was negatively associated with emotional instability in both studies. We discuss those relationships in the general discussion.

[Insert Table 4]

[Insert Table 5]

General discussion

The aim of the two studies was to examine the existence of a potential latent factor in the TAS-20 structure. We also examined its external validity by investigating the relationships of the new latent alexithymia factors with psychological and physical health measures. As expected, our results mainly highlight the presence of a new latent factor in the assessment of alexithymia, which seems to reflect interoceptive abilities.

The EFA performed on the TAS-20 showed the existence of factors that did not refer strictly to the theoretical factors mentioned in the literature (Bagby et al., 1994; Taylor et al., 2003). Among these factors, items 16 and 20 had very low internal reliability. These items represent the preference for entertainment rather than an exploration of a deeper meaning in movies or plays, which appears to reflect social norms rather than a core alexithymia trait (Dere et al., 2013). Moreover, previous studies have found that items 16 and 20 correlate weakly or not at all with the EOT subscale, suggesting that these items would not be the ideal candidates for the assessment of alexithymia (González-Arias, Martínez-Molina, Galdames, & Urzúa, 2018; Kooiman et al., 2002). Therefore, we decided to remove them from the scale, which resulted in a new TAS comprising 18 items. Furthermore, while the items 5,8,10,18, and 19 loaded on the same factor in Study 1, both items 5 and 8 emerged as separate single factors in Study 2 with very low internal reliability. Indeed, items 5 and 8 focus on problem-solving whereas the remaining items (e.g.,10,18,19) focus on emotions, which could explain why they did not load on the same factor in the first EFA in Study 2. These two items, however, represent a concrete cognitive style and seem to be representative of alexithymia trait. Based on these considerations, suppressing them would have been against the theory, so we decided to retain them. Despite this, correlations between item 8 and the other items loading on the same factor were still low (<. 30), so it may be more appropriate to reconsider its place in the evaluation of alexithymia or to rewrite it.

Our results highlight mainly the presence of new latent factors in the assessment of alexithymia. Interestingly, those factors were present in an earlier structure of the TAS, originally called TAS-26 (Taylor et al., 1985). We found that in the present structure, LF1 (*difficulty in awareness feelings*) always included items from DIF/DDF dimensions of the TAS-20, and all of these items belonged to the previous *capacity to identify and to distinguish between feelings and bodily sensations* of the TAS-26. Furthermore, LF2 (*externally oriented thinking*) included the same items from EOT dimension in both studies, and three of them previously belonged to the old *preference for focusing on external events rather than inner experiences* dimension of the TAS-26. The remaining two items were created after the TAS-26 review. This clustering is consistent with previous works supporting an oblique two-dimensional model in which DIF and DDF

belonged to the same factor while EOT formed a single factor (Erni et al., 1997; Kooiman et al., 2002; Loas et al., 1996). Moreover, the authors also proposed this clustering for the TAS-R version (Taylor et al., 1992). Besides, the associations that we found between LF1 (*difficulty in awareness of feelings*, grouping DIF and DDF items) and all psychological outcomes support the idea of a massive deficit in emotion regulation in individuals suffering from an overall decrease in awareness of feelings (Izard et al., 2011). Moreover, the negative association of LF2 with effective coping strategies in both studies suggests that it is difficult for alexithymic people to cope with difficult situations, which reflects their deficits in emotion regulation (Luminet & Zamariola, 2018). These results are highly consistent with the literature, since deficits in emotion regulation have been well documented in people with alexithymia (Luminet & Zamariola, 2018; Lumley et al., 2007). In spite of this empirical evidence, grouping DIF and DDF dimensions was not consistent in the literature, since this clustering depends on the types of statistical tools chosen (EFA *vs.* CFA), although a three-dimensional model (*i.e.,* DIF, DDF, EOT) is still considered as the best fit (Loas et al., 2001).

As expected, our results confirmed the existence of a new latent factor in the assessment of alexithymia, which seems to reflect interoceptive abilities. The LF3 (*difficulty in interoceptive abilities*) included two items (3[1] and 7[2]) from the DIF dimension of the TAS-20. These are the only items that explicitly refer to physical and bodily sensations and therefore reflect the presumed clustering of awareness of feelings and interoceptive abilities. In the TAS-26, these items were again part of the *capacity to identify and to distinguish between feelings and bodily sensations*. Even if later scale development of the TAS excluded the specific assessment of difficulty in distinguishing between feelings and bodily sensations, some items, which still evaluated this feature (items 3 and 7), were included in the TAS-20 review. The present research thus supports the existence of an independent latent dimension permitting to assess this ability. This finding is quite consistent with the literature indicating an *atypical* interoception in alexithymic individuals (Murphy et al., 2017). As observed in alexithymia, such an atypical functioning, in association with an alteration of emotional awareness, could lead in the long run to the development of psychosomatic diseases (Kanbara & Fukunaga, 2016; Porcelli & Taylor, 2018). It also corroborates our results that showed a positive association between this dimension and the presence of somatic diseases. In both studies, individuals with high scores on LF3 (*difficulty in interoceptive awareness*) were more likely to exhibit somatic disorders and to take medications compared to those with low scores. Study 2 showed that LF3 would also be related to cardiovascular diseases. Regarding psychological issues, individuals with high scores on LF3 were more likely to exhibit eating disorders, high emotional instability, and dysfunctional coping strategies. Therefore, it is important not to neglect the evaluation of this interoceptive dimension, considering that it would allow to refer alexithymic individuals to appropriate therapies in the fields of somatic and psychological health. In addition to promoting the recognition and

[1] Item 3: *"I have physical sensations that even doctors don't understand"*.

[2] Item 7: *"I am often puzzled by sensations in my body"*.

regulation of feelings for individuals with high scores on LF1 (Thoma & Greenberg, 2015), proposing therapies based mainly on the processing of interoceptive signals emanating from the body could constitute a new perspective for preventive health programs in patients with high scores on LF3. With this in mind, the LF3 subscale would benefit from supplementary items dealing with interoception.

LF4 (*poor affective sharing*) included items from the DDF/EOT dimensions of the TAS-20. Two of them belonged to the *difficulty describing feelings* dimension of the TAS-26, which refers to the ability to communicate feelings to other people, and the other items were created during the TAS-26 review. The main difference between Study 1 and Study 2 concerned items 4 and 11. In Study 1, item 4 belonged to LF4 and item 11 to LF1 while in Study 2, it was the opposite. Interestingly, these two items also belonged to two axes in TAS-26. They were used to assess both the *capacity to identify and to distinguish between feelings and bodily sensations* and *ability to communicate feelings to other people.* These two items may, therefore, be ambiguous, even if they belonged to the DDS dimension in TAS-20. Finally, LF4 (*poor affective sharing*) was a negative predictor of emotional instability and medication intake. Since we performed multivariate regression analyses, the predictive effect of LF4 was analyzed in the unique context of social-affective sharing, thereby controlling for the effect of the other LFs. The predictive effect of LF4 might, therefore, reveal that the least emotionally stable individuals are less likely to feel the need to share their emotions and affects with others. In such a context, high scores on LF4 could predict low levels of emotional instability and medication intake.

Conclusions

Despite the fact that we used TAS-20 versions measured on a 4-point scale in Study 1 and on a 5-point scale in Study 2, we found a very similar distribution of items across studies. The latent structure of the TAS-20 reflects a substantial part of the older structure of the scale**.** Strikingly, one of those latent factors is linked to an important concept from the TAS-26: the interoceptive abilities. Its associations with somatic issues highlight the key role of the body awareness component in alexithymia, which is currently neglected in the evaluation of this construct. The alexithymia scale with a full dimension covering interoceptive abilities would open new possibilities in the research field of alexithymia. From a health perspective, this could also contribute to better management of alexithymic individuals, as it would allow health professionals to refer them to the most appropriate preventive therapies.

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Table 1(on next page)

Socio-demographic, general health, and psychological data for both samples.

Notes. Data represents means ± SD. [a] regards differences between Study 1 and Study 2; ANOVA Test or Chi2 –Test. To compare the samples, alexithymia scores from Study 1 were transformed into a 5-point Likert scale. ** $p < .01$, *** $p < .001$.

1

	Total sample STUDY 1	**Total sample** STUDY 2	*p-value*[a]
Socio-demographic data			
Number of participants	253	287	
Percentage of Women	69.57%	87.8%	<.001***
Age	29.65±13.82	19.56±1.58	<.001***
Health data			
Cardiovascular disease, n (% of sample)	13 (5.14)	13 (4.53)	.841
Eating disorders, n (% of sample)	24 (9.49)	22 (7.66)	.537
Somatic disorders, n (% of sample)	11 (4.35)	13 (4.53)	1
Medication intake, n (% of sample)	36 (14.23)	32 (11.15)	.30
Psychological data			
TAS-20 (/ 100)	48.58±10.87	51.59±11.62	.002**
DIF (/ 35)	15.09±5.02	18.79±6.33	<.001***
DDF (/ 25)	13.41±4.53	15.19±4.70	<.001***
EOT (/ 40)	20.08±4.70	17.61±4.15	<.001***
STAI-T (/ 80)	42.14±9.66	45.53±9.71	<.001***
HADS-D (/21)	3.71±2.90	_	
BDI-13 (/ 39)	_	18.85±4.56	
BFI-N (/ 40)	21.02±6.94	23.62±6.80	<.001***
PSS (/ 40)	26.74±7.48	29.40±7.47	<.001***
Brief Cope			
Functional coping (/ 8)	5.20±1.30	5.14±1.10	.535
Coping with varying functionality (/ 8)	4.43±1.02	4.52±0.92	.105
Dysfunctional coping (/ 8)	3.03±0.86	3.22±0.83	.008**

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Table 2(on next page)

Loadings after Oblimin rotation from the EFA of the TAS-20, from the EFA of the TAS without items 16 and 20, and comparative attribution of items in Study 1.

Notes. Factor loadings are highlighted in bold type. For easy reading, all values of loading <.30 were not reported, except if they explained the factor.

1

Items	Factor (F)					Latent Factor (LF)				Theoretical attribution	New attribution
	F1	F2	F3	F4	F5	LF1	LF2	LF3	LF4		
1	**.75**					**.76**				DIF	LF1
2	**.58**				.41	**.60**			.37	DDF	LF1
3			**.57**					**.57**		DIF	LF3
4					**.45**	.38			**.44**	DDF	LF4
5		**.29**					**.38**			EOT	LF2
6	**.59**					**.58**				DIF	LF1
7			**.74**					**.77**		DIF	LF3
8		**.24**					**.33**			EOT	LF2
9	**.75**					**.74**				DIF	LF1
10		**.61**					**.59**			EOT	LF2
11	**.51**					**.53**				DDF	LF1
12					**.50**	.30			**.47**	DDF	LF4
13	**.69**					**.72**				DIF	LF1
14	**.47**					**.45**				DIF	LF1
15		.35			**.41**		.37		**.41**	EOT	LF4
16				**.41**		–	–	–	–	EOT	–
17					**.61**				**.65**	DDF	LF4
18		**.35**					**.37**			EOT	LF2
19		**.71**					**.73**			EOT	LF2

20				**.68**		–	–	–	–	EOT	–
Eigenvalues	5.49	2.15	1.55	1.20	1.12	5.47	2.06	1.47	1.09		
% of variance	27.44	10.76	7.74	5.98	5.61	30.37	11.43	8.17	6.04		
α	.85	.62	.66	.36	.68	.85	.62	.66	.68		

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Table 3(on next page)

Loadings after Oblimin rotation from the EFA of the TAS without items 16 and 20, and comparative attribution of items in Study 2.

Notes. Factor loadings are highlighted in bold type. For easy reading, all values of loading <.30 were not reported, except if they explained the factor.

1

Items	Factor (F)						Factor (F)					Latent Factor (LF)				Theoretical attribution	New attribution
	F1	F2	F3	F4	F5	F6	F1	F2	F3	F4	F5	LF1	LF2	LF3	LF4		
1	**.72**						**.72**					**.81**				DIF	LF1
2	**.69**						**.81**					**.81**				DDF	LF1
3				**.68**						**.64**				**.62**		DIF	LF3
4	**.59**				.31		**.71**					**.69**				DDF	LF1
5						**-.67**		**.46**					**.44**			EOT	LF2
6	**.62**						**.45**				.36	**.54**				DIF	LF1
7				**.65**						**.72**				**.66**		DIF	LF3
8						**-.32**		**.20**					**.20**			EOT	LF2
9	**.65**						**.73**					**.76**				DIF	LF1
10		**.50**						**.54**					**.53**			EOT	LF2
11			**-.59**				.33		**-.56**						**-.59**	DDF	LF4
12			**-.57**						**-.57**						**-.60**	DDF	LF4
13	**.37**			**.37**			.33			**.40**		**.38**		.35		DIF	LF1
14	**.61**						**.45**				.40	**.56**				DIF	LF1
15			**-.44**						**-.49**						**-.45**	EOT	LF4
16					**-.41**		–	–	–	–	–	–	–	–	–	EOT	–
17			**-.70**						**-.62**						**-.63**	DDF	LF4

18		**.40**						**.43**					**.44**			EOT	LF2
19		**.62**						**.54**					**.55**			EOT	LF2
20					**-.40**		–	–	–	–	–	–	–	–	–	EOT	–
Eigenvalues	5.57	2.07	1.49	1.20	1.12	1.07	5.51	1.87	1.47	1.10	1.02	5.51	1.87	1.10	1.47		
% of	27.8	10.3					30.6	10.3	8.14	6.13	5.67	30.6	10.3	6.13	8.14		
variance	5	6	7.43	6.00	5.59	5.34	1	9				1	9				
α	.88	.51	.70	.71	.43	.37	.86	.51	.70	.71	–	.88	.51	.64	.70		

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Table 4(on next page)

Detailed results of the multivariate logistic regression analyses.

Note. ^{t} $p < .07$, * $p < .05$, ** $p < .01$, *** $p < .001$.

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	Latent Factor 1 (LF1)				Latent Factor 2 (LF2)				Latent Factor 3 (LF3)				Latent Factor 4 (LF4)			
STUDY 1																
	B	**Wald**	***Exp (B)***	***p***	***B***	**Wald**	***Exp (B)***	***p***	***B***	**Wald**	***Exp (B)***	***p***	***B***	**Wald**	***Exp (B)***	***p***
Somatic disorders	-0.10	1.19	0.9	.276	-0.06	0.23	0.94	.632	0.62	11.40	1.86	.001***	0.01	0.004	1.01	.951
Eating disorders	0.13	5.64	1.14	.018*	-0.05	0.32	0.95	.570	0.14	0.86	1.15	.354	-0.03	0.08	0.97	.781
Medication intake	0.03	0.29	1.03	.593	-0.01	0.03	0.99	.874	0.36	8.13	1.43	.004**	-0.19	4.83	0.83	.028*
Cardiovascular diseases	0.07	0.78	1.07	.376	-0.14	1.46	0.87	.227	0.17	0.75	1.18	.387	-0.001	0.00	1	.995
STUDY 2																
Somatic disorders	-0.07	1.01	0.94	.315	-0.06	0.28	0.94	.597	0.74	15.68	2.09	<.001***	-0.13	1.45	0.88	.228
Eating disorders	-0.06	1.53	0.94	.216	-0.03	0.121	0.97	.728	0.33	8.72	1.40	.003**	0.01	0.01	1.01	.941
Medication intake	0.04	1.1	1.04	.294	-0.07	1.05	0.93	.305	0.22	5.40	1.25	.020*	-0.12	3.38	0.89	.066 t
Cardiovascular diseases	0.06	0.89	1.06	.346	0.08	0.56	1.08	.454	0.34	5.22	1.41	.022*	-0.10	1.05	0.9	.306

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Table 5(on next page)

Detailed results of the multivariate regression analyses.

Note. ^{t} p < .07, * p < .05, ** p < .01, *** p < .001. STAI-T=State-Trait Anxiety Inventory, HADS-D= Depression subscale of the Hospital Anxiety and Depression Scale, BDI-13= Beck Depression Inventory-13, BFI-N= Neuroticism dimension of the Big Five Inventory, PSS= Perceived Stress Scale, F-D=Difference score between functional and dysfunctional coping from Brief Cope.

1

	Latent factor 1 (LF1)			Latent factor 2 (LF2)			Latent factor 3 (LF3)			Latent factor 4 (LF4)		
	B	**t**	***p***	***B***	**t**	***p***	***B***	**t**	***p***	***B***	**t**	***p***
STUDY 1												
STAI-T	1.17	8.13	<.001***	0.32	1.56	.120	0.67	1.72	.088	-0.20	-0.94	.346
HADS-D	0.22	4.74	<.001***	0.21	3.23	.001***	0.31	2.53	.012*	0.03	0.50	.618
BFI-N	0.72	6.40	<.001***	0.07	0.46	.646	0.56	1.83	.068 t	-0.36	-2.15	.033*
PSS	0.73	6.17	<.001***	0.19	1.13	.261	0.65	2.02	.045 *	-0.03	-0.20	.844
F-D	-0.09	-3.36	.001***	-0.23	-5.71	<.001***	-0.15	-1.93	.054 t	0.01	0.17	.868
STUDY 2												
STAI-T	0.67	7.04	<.001***	-0.14	-0.79	.433	0.98	3.96	<.001***	-0.16	-1.06	.290
BDI-13	0.23	4.88	<.001***	-0.06	-0.64	.523	0.40	3.21	.001***	0.06	0.75	.451
BFI-N	0.42	5.87	<.001***	-0.04	-0.32	.750	0.67	3.66	<.001***	-.26	-2.34	.020*
PSS	0.45	5.81	<.001***	-0.03	-0.21	.833	0.57	2.84	.005**	0.02	0.19	.846
F-D	-0.10	-6.00	<.001***	-0.06	-1.95	.053 t	-0.10	-2.42	.016*	0.03	1.30	.195

2