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REGULAR ARTICLE

Repressive coping and alexithymia in idiopathic environmental intolerance

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Abstract
Objective To examine if the non-expression of negative emotions (i.e., repressive coping) and differences in the ability to process and regulate emotions (i.e., alexithymia) is associated with idiopathic environmental intolerance (IEI).
Methods The study included participants who had previously participated in a general population-based study and reported symptoms of environmental intolerance ($n = 787$) and patients with IEI ($n = 237$). The participants completed questionnaires assessing IEI, namely, a measure of repressive coping combining scores on the Marlowe–Crowne Social Desirability Scale (MCSDS) and the Taylor Manifest Anxiety Scale (TMAS), the Toronto Alexithymia Scale (TAS-20), and a negative affectivity scale (NAS). Multiple, hierarchical linear regression analyses were conducted using IEI variables as the dependent variables.
Results The TMAS and MCSDS scores were independently associated with the IEI variables, but there was no evidence of a role of the repressive coping construct. While the total alexithymia score was unrelated to IEI, the TAS-20 subscale of difficulties identifying feelings (DIF) was independently associated with symptoms attributed to IEI. Negative affectivity was a strong independent predictor of the IEI variables and a mediator of the association between DIF and IEI.
Conclusion Our results provide no evidence for a role of repressive coping in IEI, and our hypothesis of an association with alexithymia was only partly supported. In contrast, strong associations between IEI and negative emotional reactions, defensiveness and difficulties identifying feelings were found, suggesting a need for exploring the influence of these emotional reactions in IEI.

Keywords Alexithymia · Chemical sensitivity · Functional somatic syndromes · Negative affectivity · Repressive coping · Stress

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Abbreviations

CHS	Chemical Hypersensitivity Scale
CNSS	CNS Symptom Scale
CSAS	Consequences for Social Activities Scale
CSS-SHR	The Chemical Sensitivity Scale for Sensory Hyper-reactivity
DIF	Difficulties identifying feelings
DDF	Difficulties describing feelings
EOT	Externally oriented thinking
IEI	Idiopathic environmental intolerance
MCSDS	Marlowe–Crowne Social Desirability Scale
MUSS	Mucosal Symptom Scale
NAS	Negative Affectivity Scale
TAS-20	The Toronto Alexithymia Scale
TMAS	The Taylor Manifest Anxiety Scale

Introduction

Idiopathic environmental intolerance (IEI) is a disorder characterized by non-specific symptoms from various organ systems attributed by the individual to exposure to common airborne chemicals at levels below those known to induce adverse health effects [1]. IEI is also referred to as multiple chemical sensitivity (MCS), a case-definition introduced by Cullen [2] based on his observations of cases at the Institute of Occupational Medicine, Yale University. However, "MCS" has been criticized for implying unproven assumptions about causation, and a workshop organized by the International Programme on Chemical Safety held in 1996 recommended that it be replaced by IEI [3]. Other case definitions have been proposed [2, 4, 5], but none is currently widely accepted.

Several studies have reported associations between symptoms of IEI and emotional distress, such as increased levels of anxiety, somatization and depressive symptoms [6–15]. Evidence also points to an association between IEI and psychological traits thought to be involved in the maintenance of symptoms in functional somatic disorders [6, 7, 13, 16, 17], which taken together may suggest a role of affect regulation. Affect regulation is a term involving various types of both conscious and unconscious styles of experiencing, processing and modulating emotions [18]. Intensely experienced emotions that are avoided, inhibited or not expressed may lead to physiological hyper-reactivity and physical symptoms [19]. Patients with chronic illness have been described as having difficulties identifying and describing emotions, being unaware of repressing emotions or avoiding and being ambivalent about expressing emotions [18]. Likewise, affect regulation characterized by avoidance and non-expression has been related to maladjustment to chronic illness [19]. Such strategies may, if sufficiently dominant, serve as a moderator of the association between negative emotional reactions and health outcomes and could thus be considered both as a process of relevance to the pathology of certain disorders and as a potential focus of intervention [20, 21]. Research has focused on different types of emotional regulation. One theoretical construct, *emotional repression*, focuses on unconscious emotional inhibition [22]. The theory suggests that individuals characterized by repressive coping will have a tendency to disattend to important *negative emotional feedback*, thereby exhibiting a *discrepancy* between psychological reactions (e.g., no perception or recall of negative emotions) and physiological responses (e.g., high skin conductance levels) to stressful stimuli. If the repressive/defensive response pattern constitutes a relatively stable trait, it may prevent the individual from coping effectively [23, 24] and lead to the misinterpretation of emotions as physiological reactions or symptoms [25, 26]. One approach to assess repressive coping, suggested by Weinberger [22], combines a trait measure of anxiety, such as the Taylor Manifest Anxiety Scale (TMAS), with the Marlowe–Crowne Social Desirability Scale (MCSDS), which is believed to measure defensiveness [27]. This two-dimensional approach combines high and low scores on each scale into four prototypical coping styles.

The alexithymia construct was originally developed to specify a set of personality characteristics often observed in patients with somatoform disorders [28–30]. Alexithymic individuals are believed to exhibit difficulties in identifying emotions and distinguishing them from bodily sensations of emotional arousal. They also have difficulties describing feelings, an impoverished fantasy life and a stimulus-bound, externally oriented cognitive style [29]. The theory of alexithymia suggests that cognitive deficits in distinguishing emotions from their physiological correlates may lead the individual to become preoccupied with physiological sensations and misinterpret them as symptoms of disease [31]. The alexithymia construct has found support in recent evidence suggesting a contribution of genetic factors in the development of this trait [30].

Trait negative affectivity reflects individual differences in mood and self-concept [17], and individuals who are high in this trait are believed to experience higher levels of distress over time and across different situations and to report more somatic symptoms than low negative affect individuals in the absence of differences in objective health status [17, 32]. Alexithymia has been associated with negative affectivity in a study by Kirmayer and Robbins that examined the relationship between alexithymia and sociodemographic and emotional variables in a group of family medicine patients [33].

Taken together, emotional regulation may hypothetically contribute to the aggravation of IEI by increasing focus on physiological sensations and interpreting these as symptoms of disease [27].

We tested three hypotheses in the study reported here: (1) a repressive coping style and/or (2) alexithymia would be independently associated with IEI; (3) an association between IEI and alexithymia would be either completely or partly mediated by negative affectivity.

Methods

Participants

Three groups were invited to participate in the study: (1) individuals (age range 18–69 years) from the general population, (2) patients with physician-diagnosed IEI and (3) individuals who had contacted the Danish Research Centre because of symptoms attributed to common

airborne chemicals. Group 1 participants were respondents to a population-based cross-sectional survey ($n = 4260$) randomly drawn from the Danish Civil Registration System [34]. Respondents ($n = 1134$) were invited to participate in the study providing they had (1) reported being bothered by exposure to at least one chemical (e.g., fragranced products, newly printed magazines); (2) confirmed that such exposure was associated with symptoms and not perceived as merely unpleasant; (3) given consent to be contacted again ($n = 787$). Group 2 included individuals who had contacted the Danish Research Centre for Chemical Sensitivities because of IEI between 1 January 2006 and 1 August 2007 and who had agreed to participate in the study ($n = 101$). Group 3 included individuals who had received a diagnosis of IEI based on the criteria described by Cullen [2] either at the Copenhagen University Hospital, Rigshospitalet, or at Hamlet, Private Hospital, Denmark, between 1 January 1990 and 1 January 2007. This group received a letter inviting them to participate ($n = 136$).

Measurements

A number of self-report measures were used in the study.

Repressive coping was assessed by combining the Danish translations of the 33-item MCSDS [35] and the Bendig 20-item version of the TMAS [36]. Responses are rated as true or false. The Danish versions of both scales have previously been shown to have acceptable internal consistencies and test–retest reliabilities [27]. As suggested by Weinberger [22], emotional repressors were defined as individuals scoring below the median of TMAS and above the median of the MCSDS, with the remaining individuals characterized as true low anxious (low TMAS/low MCSDS), true high anxious (high TMAS/low MCSDS) and defensive high-anxious (high TMAS/high MCSDS), respectively. Sex-dependent cut-off values were used if statistically significant sex differences were found for either of the scales.

Alexithymia was assessed using the Danish translation of the Toronto Alexithymia Scale (TAS-20) [37–39]. The TAS-20 is a 20-item questionnaire with responses rated on a 5-point Likert scale and scores ranging from 20 to 100. The presence of alexithymia can be investigated using a continuous approach that includes both the total score and the scores of the three subscales, namely, difficulties identifying feelings (DIF), difficulties describing feelings (DDF) and externally oriented thinking (EOT), corresponding to the original factor structure [30, 38]. Moderate to good internal consistency has been reported for the Danish translation of TAS-20 for both the total scale (Cronbach's $\alpha = 0.81$) and the three subscales (DIF, Cronbach's $\alpha = 0.82$; DDF, Cronbach's $\alpha = 0.77$; EOT, Cronbach's $\alpha = 0.66$) [30].

The Negative Affectivity Scale (NAS) includes 15 items measuring the tendency to experience and report negative emotions, including anxiety, guilt, hostility and depression, with low negative affect reflecting a state of calmness [40]. Respondents are asked to respond in relation to experiences of negative emotions within the past week. Responses are rated on a 5-point Likert scale and summarized into a total score. Satisfactory internal consistency (0.87) and moderate test–retest reliability (0.48) has been reported [40].

The Chemical Sensitivity Scale for Sensory Hyperreactivity (CSS-SHR) is composed of 11 statements regarding affective reactions to and behavioural disruptions in daily activities from odorous/pungent environmental chemicals [41]. The metric properties of the CSS-SHR, i.e., test–retest reliability, internal consistency and concurrent validity, have been reported as being favourable [41]. In order to adapt the CSS-SHR for use in Danish studies on MCS, the CSS-SHR was translated into Danish by a professional translation office. The Danish translation was subsequently tailored to Danish usage and then translated back to the original language by a different translator. This translation was then compared with the original version in order to identify potential sense altering discrepancies. The individual CSS-SHR score is calculated from each point obtained from the 11 statements with a total score ≤ 55. A score >43 somewhat predicts increased airway sensory reactivity [41, 42]. The internal consistency (Cronbach's α) of CSS-SHR was 0.77 in our study.

IEI was assessed by (1) number and severity of 20 symptoms used in a previous Danish population-based study on the prevalence of symptoms attributed to common airborne chemicals [34], including headache, exhaustion, dizziness, difficulties concentrating, grogginess, sleep difficulties, panic attacks, breathlessness, symptoms from the eyes, nose, sinuses, mouth, throat and lungs; (2) number of symptom-inducing airborne chemicals, including fragranced products, cleaning agents, nail polish remover, newly printed papers or magazines, new furniture, soft plastic or rubber, cooking fumes, motor vehicle exhaust, tar or wet asphalt, smoke from a wood burner and new electric equipment; (3) social consequences that were assessed by the following question: "*Do reactions caused by environmental odours lead you to avoid*": (a) social activities (e.g., family or other private parties), (b) inviting guests, (c) going on holiday, (d) sports activities, (e) using public transportation, (f) going to the cinema or theatre (g) going to restaurants?

Statistical analysis

Groups

Subjects in groups 2 and 3 had contacted either a physician and/or The Danish Research Centre for Chemical Sensitivities because of IEI, suggesting that all of these individuals

were severely affected. We therefore hypothesized that these two groups would not differ in terms of their scores on the CSS-SHR measuring affective reactions to and behavioural disruptions in daily activities due to odorous environmental chemicals, nor would they differ in terms of sex and age; consequently, the data collected on these two groups could be pooled in subsequent statistical analyses to increase statistical power. The mean score for groups 2 and 3 on the CSS-SHR was 50.5 [standard deviation (SD) 5.4] and 49.8 (SD 4.9), respectively ($p = 0.53$), and the mean age of the subjects was 53.3 (SD 10.4) and 51.8 (SD 11.3) years, respectively ($p = 0.43$). The two groups did not differ in terms of the distribution of sex ($p = 0.51$). Data on groups 2 and 3 were therefore pooled in the statistical analyses and are subsequently referred to in this article as the patient group.

Principal components analysis

As a first step, we used principal components analysis with Varimax rotation to analyse 63 items from the questionnaire covering symptoms, symptom-eliciting chemical agents and consequences in terms of the degree to which reactions had influenced social relations and work. These items are described in more detail in the "Methods" section. Factors were selected on the basis of an eigenvalue >1 and on items showing loadings ≥0.5 for the central factor. Seven factors were identified, of which four grouped into clusters of five or more items with cross-loading of no higher than 0.25 [43]. Factor 1 can be described as the responses to symptom-eliciting environmental odours, i.e., fragranced products, cleaning agents, nail polish remover, newly printed papers or magazines, new furniture, soft plastic or rubber, cooking fumes, motor vehicle exhaust, tar or wet asphalt, smoke from a wood burner and new electric equipment. These 11 items were summarized in the Chemical Hypersensitivity Scale (CHS) which, based on the response format to the questions, yields a total score ranging from 0 to 33. Cronbach's α for the CHS was 0.95. Factor 2 includes seven items on social or public events that are avoided because of symptoms attributed to common environmental odours, i.e., social activities (e.g., family or other private parties), inviting guests over, going on holiday, sports activities, using public transportation, going to the cinema or theatre or going to restaurants. These items were summarized in the Consequences for Social Activities Scale (CSAS) that yields a total score ranging from 0 to 14. Cronbach's α for the CSAS was 0.92. Factor 3 consists of eight items that describe symptoms from the central nervous system, i.e., headache, exhaustion, dizziness, difficulties in concentrating, grogginess, sleep difficulties, panic attacks and breathlessness. These items were summarized in the CNS Symptoms Scale (CNSS), with total scores ranging from 0 to 8. Cronbach's α for the CNSS was 0.68. Factor 4 consists of six items describing mucosal symptoms, i.e., eyes, nose, sinuses, mouth, throat, and lungs, which were summarized in the Mucosal Symptoms Scale (MUSS), with total scores ranging from 0 to 6. Cronbach's α for the MUSS was 0.59.

All continuous variables were inspected for normality. Non-normally distributed variables were log-transformed. If the transformation was considered successful, the log-transformed variables were used in subsequent analyses.

Repressive coping

The possible influence of repressive coping was analysed using three approaches [22, 27]: (1) the hypothesis of an association between repressive coping and higher scores on any of the independent variables (CHS, MUSS, CNSS, CSAS) was considered to be supported if emotional repressors scored significantly higher than the remaining three coping groups—this was tested using one-way analysis of variance (ANOVA) with the four coping styles as grouping factor and Scheffe post hoc tests controlling for multiple comparisons; (2) the hypothesis of an effect of repressive coping was also tested with a two-factor ANOVA, with high versus low anxiety (TMAS) and high versus low defensiveness (MCSDS) as grouping variables—a confirmation of the hypothesis required the finding of a significant TMAS × MCSDS interaction; (3) to minimize the risk of type-2 error due to dichotomization, the continuous scores of TMAS and MCSDS were entered at the first step in a multiple, hierarchical linear regression analysis, and the continuous interaction variable [MCSDS × (max TMAS-score − actual TMAS score)] at the second step—this interaction algorithm yields a continuous variable, with high scores representing high repressive coping and low scores representing a high degree of true high anxiety. Confirmation of our hypothesis required a significant effect of the interaction variable when the latter was entered at the second step of the regression.

Alexithymia

Alexithymia was analysed as a continuous variable using both the total TAS-20 and scores on the three subscales (DIF, DDF, EOT). Multiple, hierarchical linear regression analyses were performed with the four dependent IEI variables (CHS, MUSS, CNSS and CSAS), with the total TAS-20 score as the independent variable, entered at step 1. NAS was entered at step 2, age and sex at step 3 and patient versus population group at step 4. Corresponding analyses were performed using the three TAS-20 subscales as independent variables at step 1.

Mediation analyses

Finally, if associations were found between alexithymia and the four IEI variables, the possible mediating effects of NAS were explored using the method described by Baron and Kenny [44] in which they define four analytical steps necessary to establish mediation: (1) the independent variable should be a significant predictor of the dependent variable; (2) the independent variable should predict the mediator; (3) the mediator should predict the dependent variable, when controlling for the independent variable; (4) the association between the independent variable and the dependent variable should be reduced when controlling for the mediator. Complete mediation of the independent variable–dependent variable association requires that the independent variable–dependent variable association is reduced to zero when controlling for the mediator. Partial mediation requires the association to be reduced to a nontrivial amount but not to zero. In addition, for each of the three dependent variables, the Sobel test was used as a direct test of mediation [45].

Level of significance

The level of significance was set at $p < 0.05$.

Approval

The study was approved by the Danish Data Protection Agency. According to Danish legislation, questionnaire studies do not need approval by an ethics committee.

Results

Group characteristics

A total of 1024 women and men were invited to participate in this study. The overall response rate was 71.5% ($n = 732$), with the response rate being 72.5 and 67.9% in the population group and patient group, respectively. The characteristics of the two groups are summarized in Table 1. Testing group differences using independent t tests revealed significant differences between the groups in terms of sex, age and mean scores on the CHS, MUSS, CNSS, CSAS and for the variables MCSDS, TMAS, TAS-20, TAS20-DIF, TAS20-DDF and TAS20-EOT. No significant differences were found for NAS.

Non-respondents

Our comparison of respondents and non-respondents in the population group revealed that respondents to our questionnaire were significantly older (mean ± SD: 46.5 ± 12.4 vs. 42.9 ± 12.8 years, respectively; $p < 0.001$) and were more likely to be women [odds ratio (OR) 1.2, $p = 0.08$]. The respondents did not differ from non-respondents ($p = 0.6$) in terms of severity of self-reported IEI symptoms (OR 0.9). There was no different in mean age among respondents and non-respondents in the patient group (52.7 ± 10.9 vs. 51.8 ± 12.1 years, respectively; $p = 0.56$). Correspondingly, no difference was found for the distribution of sex ($p = 0.54$). No information regarding symptoms was obtained from non-respondents in the patient group.

Correlations

Relatively high intercorrelations were found between CHS, MUSS, CNSS, and CSAS, while relatively small correlations were found between these variables, the independent variables (MCSDS, TMAS, TAS-20, TAS20-DIF, TAS20-DDF and TAS20-EOT) and the control variables (NAS, age and sex). Moderate to high correlations were found between TMAS, TAS-20 and the three subscales and NAS (Table 2).

Repressive coping

MCSDS scores appeared to be normally distributed, whereas those for TMAS were positively skewed; consequently, TMAS data were log-transformed prior to further analysis. Women had significantly higher TMAS scores than men ($p < 0.001$) (Table 1), and sex-dependent scores were therefore used in the classification of coping styles. As seen in Table 2, a significant inverse correlation was found between the TMAS and MCSDS scores, and a significant positive correlation was seen between age and MCSDS scores. The TMAS scores showed moderate positive correlations with all four IEI variables, while correlations between MCSDS scores and the dependent variables were small, with the exception of those for CSAS.

Categorical data

Approach 1: When comparing the four coping styles with one-way ANOVA, significant effects were found for CHS, CNSS and CSAS scores. Emotional repressors had significantly higher CSAS scores than true low-anxious. No other differences were found (data not shown).

Approach 2: Both TMAS and MCSDS scores were independently significantly associated with scores on the CHS, CNSS, and CSAS ($F = 16.0$–2.3; $p = 0.04$–0.001)

Table 1 Characteristics of the population and patient group in terms of the dependent and independent variables

Dependent and independent variables	Population group			Patient group			p value[a]
	Men	Women	Total	Men	Women	Total	
n	194 (34%)	377 (66%)	571 (100%)	21 (13%)	140 (87%)	161 (100%)	≤0.001*
Age, years	50.1 (11.8)	47.1 (12.6)	48.1 (12.4)	50.9 (11.2)	53.3 (10.6)	53 (10.6)	≤0.001*
CHS	12.3 (6.9)	13.7 (6.8)	13.2 (6.9)	26.3 (5.6)	25.2 (6.3)	25.3 (6.2)	≤0.001*
MUSS	2.2 (1.3)	2.3 (1.4)	2.3 (1.3)	3.5 (1.8)	3.9 (1.7)	3.8 (1.7)	≤0.001*
CNSS	1.9 (1.3)	2.1 (1.3)	2.0 (1.3)	5.2 (1.4)	4.8 (1.9)	4.9 (1.9)	≤0.001*
CSAS	0.3 (0.82)	0.4 (1.5)	0.4 (1.3)	6.5 (4.0)	6.2 (4.1)	6.2 (4.1)	≤0.001*
MCSDS	18.8 (5.0)	19.2 (5.6)	19.1 (5,4)	21.9 (3.7)	20.6 (4.5)	20.8(4.4)	<0.001*
TMAS	5.3 (4.3)	6.7 (4.6)	6.2 (4.5)	5.6 (3.7)	7.1 (4.4)	6.8 (4.4)	<0.05*
TAS20 total	47.5 (11.6)	43.0 (11.5)	44.5 (11.7)	44.3 (12.3)	42.1 (11.2)	42.3 (11.3)	<0.05*
TAS20-DIF	13.1 (5.0)	13.5 (5.2)	13.4 (5.1)	14.4 (6.2)	14.4 (5.1)	14.4 (5.2)	<0.05*
TAS20-DDF	13.0 (4.5)	10.9 (4.4)	11.6 (4.5)	10.0 (4.3)	10.2 (4.4)	10.2 (4.4)	<0.001*
TAS20-EOT	21.5 (5.5)	18.5 (5.3)	19.6 (5.6)	19.6 (5.2)	17.6 (5.3)	17.9 (5.3)	<0.001*
NAS	12.4 (9.0)	13.6 (9.0)	13.2 (9.0)	11.8 (9.5)	14.4 (10.0)	14.0 (9.9)	0.35

Values are given as the mean ± standard deviation (in parenthesis), with the exception of *n*

CHS Chemical Hypersensitivity Scale, *MUSS* Mucosal Symptom Scale, *CNSS* CNS Symptom Scale, *CSAS* Consequences for Social Activities Scale, *MCSDS* Marlowe–Crowne Social Desirability Scale, *TMAS* Taylor Manifest Anxiety Scale, *TAS-20* The Toronto Alexithymia Scale, *TAS20-DIF* Difficulties identifying feelings, *TAS20-DDF* Difficulties describing feelings, *TAS20-EOT* Externally oriented thinking, *NAS* Negative Affectivity Scale

* Significant at $p < 0.05$

[a] Independent samples *t* test for equality of means (total) between population and patient sample

Table 2 Correlations between the CHS, MUSS, CNSS, CSAS, TAS-20, TAS-DIF, TAS-DDF, TAS-EOT, MCSDS, TMAS, NAS, age, and sex

	CHS	MUSS	CNSS	CSAS	MCSDS	TMAS	TAS-20	DIF	DDF	EOT	NAS	Age	Sex
CHS	–	0.47**	0.60**	0.58**	0.09*	0.16**	−0.01	0.13**	−0.10**	−0.05	0.16**	0.26**	0.18**
MUSS	–	–	0.60**	0.44**	0.06	0.14**	−0.09*	0.08*	−0.11**	−0.18**	0.14**	0.09*	0.14**
CNSS	–	–	–	0.62**	0.04	0.18**	−0.07	0.14**	−0.12**	−0.18**	0.18**	0.06	0.15**
CSAS	–	–	–	–	0.16**	0.09*	−0.06	0.05	−0.13**	−0.07	0.09*	0.15**	0.15**
MCSDS	–	–	–	–	–	−0.27**	−0.13**	−0.23**	−0.15**	0.05	−0.29**	0.17**	0.05
TMAS	–	–	–	–	–	–	0.31**	0.50**	0.26**	−0.01	0.57**	−0.05	0.15**
TAS-20	–	–	–	–	–	–	–	0.73**	0.86**	0.73**	0.25**	0.07	−0.17**
DIF	–	–	–	–	–	–	–	–	0.55**	0.16**	0.43**	0.03	0.05
DDF	–	–	–	–	–	–	–	–	–	0.47**	0.18**	0.00	−0.20**
EOT	–	–	–	–	–	–	–	–	–	–	−0.01	0.12**	−0.25**
NAS	–	–	–	–	–	–	–	–	–	–	–	−0.16**	0.08
Age	–	–	–	–	–	–	–	–	–	–	–	–	−0.05
Sex	–	–	–	–	–	–	–	–	–	–	–	–	–

CHS Chemical Hypersensitivity Scale, *MUSS* Mucosal Symptom Scale, *CNSS* CNS Symptom Scale, *CSAS* Consequences for Social Activities Scale, *MCSDS* Marlowe–Crowne Social Desirability Scale, *TMAS* Taylor Manifest Anxiety Scale, *TAS-20* The Toronto Alexithymia Scale, *TAS20-DIF* Difficulties identifying feelings, *TAS20-DDF* Difficulties describing feelings, *TAS20-EOT* Externally oriented thinking, *NAS* Negative Affectivity Scale

* Correlation is significant at $p < 0.05$ level (2-tailed)

** Correlation is significant $p < 0.01$ (2-tailed)

(data not shown). No significant interactions between TMAS and MCSDS scores were found for any of the four dependent IEI variables ($F = 0.00$–0.44; $p = 0.51$–0.91) in the two-way ANOVA analysis using high–low TMAS/high–low MCSDS as the group factor (data not shown).

Table 3 Results of multiple, hierarchical linear regression analysis with the CHS, MUSS, CNSS and CSAS as the dependent variables and defensiveness (MCSDS), anxiety (TMAS), and repressive coping (MCSDS–TMAS interaction) as independent variables

Step	Independent variables	Dependent variables							
		CHS		MUSS		CNSS		CSAS	
		Beta	*p* value	Beta	*p* value	Beta	*p* value	Beta	*p* value
1	MCSDS[a]	0.15	0.001*	0.10	0.006*	0.10	0.009*	0.20	0.001*
	TMAS[b]	0.21	0.001*	0.17	0.001*	0.21	0.001*	0.16	0.001*
2	MCSDS	0.16	0.09	0.03	0.78	0.17	0.07	0.28	0.003*
	TMAS[b]	0.20	<0.05*	0.24	0.007*	0.14	0.14	0.09	0.34
	MCSDS–TMAS interaction term	−0.01	0.97	0.13	0.37	−0.11	0.44	−0.12	0.37
3	MCSDS	0.02	0.82	−0.06	0.47	0.09	0.24	0.15	<0.05*
	TMAS[b]	0.13	0.09	0.20	0.02	0.05	0.52	0.00	1.0
	MCSDS–TMAS interaction term	0.00	0.97	0.14	0.26	−0.14	0.21	−0.11	0.23
	Age	0.18	0.001*	0.04	0.26	−0.05	0.12	0.02	0.44
	Sex (men = 1, women = 2)	0.06	0.05*	0.05	0.13	0.00	0.99	0.00	0.99
	Population (1) vs. patient group (2)	0.54	0.001*	0.39	0.001*	0.63	0.001*	0.72	0.001*
	Total adjusted R^2	0.40		0.19		0.41		0.55	

* Significant at $p < 0.05$

[a] Due to missing values, the final step of the regression model includes the following number of participants: CHS, $n = 618$; MUSS, $n = 624$; CNSS, $n = 596$; CSAS, $n = 624$

Marlowe–Crowne Social Desirability Scale (defensiveness); *TMAS* Taylor Manifest Anxiety Scale

[b] Log-transformed

Continuous data

Approach 3: The results of a series of multiple, hierarchical linear regression analyses are shown in Table 3. At the first step, TMAS and MCSDS scores were significantly independently associated with all four dependent IEI variables. Entering the TMAS–MCSDS interaction term did not significantly explain any additional variation. At the final step, age and sex explained a significant proportion of the variance of CHS, and group explained a significant proportion of the variance for all four dependent IEI variables. MCSDS and TMAS scores only explained a minor proportion of the variance ($R^2 = 0.03$–0.05), while age, sex and group explained an additional 16–54%.

Alexithymia

The TAS-20 total and EOT subscale scores appeared to be normally distributed, whereas those for DIF and DDF were negatively skewed and therefore log-transformed prior to analyses. Mean scores are shown in Table 1. Significant differences were found between the population and patient group and between men and women ($p < 0.05$), with patients and women exhibiting lower scores than individuals from the population group and men, respectively. These differences were also generally found for the scores for the TAS-20 subscales of DDF and EOT, but not DIF, where patients and women showed slightly higher scores.

Associations between TAS-20 and the dependent variables

Multiple, hierarchical linear regression analyses were performed using the four IEI variables (CHS, MUSS, CNSS and CSAS) as the dependent variables, and the total TAS-20 score as the independent variable. The results are shown in Table 4.

While no associations were found between alexithymia and CHS and CSAS scores, alexithymia was associated with significantly *lower* severity scores for MUSS. Alexithymia also showed a statistically significant inverse association with CNSS scores when controlling for NAS, age and sex, and a near-significant association when group was entered into the model. Conversely, NAS was associated with higher scores on all four dependent variables. Alexithymia, NAS, age and sex accounted for only

Table 4 Results of multiple, hierarchical linear regression analysis with the CHS, MUSS, CNSS and CSAS as the dependent variables and alexithymia (TAS-20) as the independent variable, controlling for age, sex, and group

Step	Independent variables	Dependent variables							
		CHS		MUSS		CNSS		CSAS	
	Model 1	Beta	p value	Beta	p value	Beta	p value	Beta	p value
1	TAS-20	−0.01	0.84	−0.09	0.03*	−0.07	0.10	−0.04	0.31
2	TAS-20	−0.05	0.22	−0.13	0.001*	−0.12	0.01*	−0.07	0.11
	NAS	0.17	0.001*	0.17	0.001*	0.21	0.001*	0.10	0.01*
3	TAS-20	−0.05	0.21	−0.13	0.01*	−0.11	0.01*	−0.06	0.17
	NAS	0.21	0.001*	0.18	0.001*	0.21	0.001*	0.12	0.01*
	Age	0.31	0.001*	0.13	0.001*	0.11	0.01*	0.18	0.001*
	Sex (men = 1, women = 2)	0.17	0.001*	0.11	0.01*	0.12	0.01*	0.14	0.001*
4	TAS-20	−0.01	0.80	−0.10	0.02*	−0.06	0.07	0.00	0.99
	NAS	0.17	0.001*	0.16	0.001*	0.17	0.001*	0.07	0.02*
	Age	0.20	0.001*	0.06	0.13	−0.01	0.80	0.04	0.19
	Sex (men = 1, women = 2)	0.07	0.03*	0.04	0.33	0.00	0.91	0.01	0.77
	Population (1) vs. patient group (2)	0.54	0.001*	0.38	0.001*	0.62	0.001*	0.74	0.001*
Final model	Total adjusted R^2	0.41	$F = 85.3$ $p < 0.001$	0.19	$F = 29.4$ $p < 0.001$	0.42	$F = 87.0$ $p < 0.001$	0.57	$F = 159.5$ $p < 0.001$

Due to missing values, the final step of the regression model includes the following number of participants: CHS, $n = 598$; MUSS, $n = 603$; CNSS, $n = 579$; CSAS, $n = 603$

* Significant at $p < 0.05$

small-to-moderate proportions of the variance, with R^2 ranging from 0.02 to 0.12. Belonging to the patient group was the strongest predictor, accounting for an additional 14–51% of the variation in symptoms (data not shown).

Associations between TAS-20 subscales and the dependent variables

The results for the TAS-20 subscales are shown in Table 5. When entered independently, DIF was significantly associated with more severe scores on all dependent variables (CHS, $p < 0.001$; MUSS, $p < 0.01$; CNSS, $p < 0.001$; CSAS, $p < 0.001$). DIF continued to be significantly associated with greater severity for CHS ($p < 0.01$) and CNSS ($p < 0.001$), while a borderline association was seen for CSAS ($p < 0.09$) when controlling for NAS, age and sex. In contrast, DDF was associated with less severe scores, with the exception of those for MUSS, both at step 1 and 2. When group was entered at the final step, only DIF remained significantly associated with more severe scores on the CNSS ($p < 0.05$). NAS was associated with higher scores for all four dependent variables, and again group appeared to be the most significant predictor of severity, explaining from 17 to 57% of the variance (data not shown).

Mediation analyses

As shown in Table 2, NAS was positively associated with TAS-20, DIF and DDF and the four dependent variables. Therefore, a series of mediation analyses were conducted:

TAS-20: MUSS was the only dependent variable significantly associated with TAS-20. However, entering the mediator (NAS) did not reduce the independent variable–dependent variable association (from $B = -0.012$; $p = 0.016$ to $B = -0.017$; $p = 0.002$).

DIF: For the dependent variables CHS, MUSS and CNSS, the independent variable–dependent variable associations were reduced to non-significance ($p = 0.14$–0.84) when the mediator was entered into the equation. Direct tests of mediation (Sobel test) confirmed that NAS acted as a mediator of the association between DIF and CHS, MUSS and CNSS ($Z = 2.99$–3.29; $p = 0.001$–0.002).

DDF: NAS could only be considered a mediator for the association between DDF and CHS. Entering the mediator did not reduce the independent variable–dependent variable association, as the associations grew stronger, not weaker (data not shown).

Table 5 Results of multiple, hierarchical linear regression analysis with the CHS, MUSS, CNSS and CSAS as the dependent variables and the TAS-20 subscales of DIF, DDF and EOT as independent variables, controlling for age, sex, and group

Step	Independent variables	Dependent variables							
		CHS		MUSS		CNSS		CSAS	
		Beta	p value	Beta	p value	Beta	p value	Beta	p value
1	TAS20-DIF[a]	0.23	0.001*	0.14	0.01*	0.25	0.001*	0.16	0.001*
	TAS20-DDF[a]	−0.20	0.001*	−0.10	0.07	−0.19	0.001*	−0.19	0.001*
	TAS20-EOT	0.00	0.97	−0.13	0.01*	−0.14	0.01*	0.08	0.87
2	TAS20-DIF	0.12	0.01*	0.06	0.23	0.18	0.001*	0.09	0.09
	TAS20-DDF	−0.16	0.01*	−0.08	0.14	−0.18	0.001*	−0.16	0.003*
	TAS20-EOT	0.01	0.83	−0.12	0.01*	−0.12	0.01*	0.02	0.66
	NAS	0.17	0.001*	0.15	0.001*	0.15	0.001*	0.09	<0.05*
	Age	0.26	0.001*	0.16	0.001*	0.09	0.05*	0.16	0.001*
	Sex	0.13	0.001*	0.06	0.18	0.05	0.23	0.12	0.01*
3	TAS20-DIF	0.03	0.48	0.00	0.99	0.09	0.05*	−0.03	0.38
	TAS20-DDF	−0.06	0.16	−0.02	0.74	−0.08	0.07	−0.04	0.26
	TAS20-EOT	0.04	0.26	−0.01	0.05*	−0.09	0.05*	0.06	0.05*
	NAS	0.16	0.001*	0.15	0.001*	0.14	0.001*	0.09	0.005*
	Age	0.17	0.001*	0.10	0.01*	−0.01	0.78	0.03	0.23
	Sex	0.05	0.11	0.00	0.93	0.02	0.49	0.02	0.46
	Population (1) vs. patient group (2)	0.57	0.001*	0.39	0.001*	0.58	0.001*	0.74	0.001*
Final model	Total adjusted R^2	0.42	$F = 62.5$ $p < 0.001$	0.22	$F = 23.4$ $p < 0.001$	0.41	$F = 57.3$ $p < 0.001$	0.56	$F = 109.4$ $p < 0.001$

Due to missing values, the final step of the regression model includes the following number of participants: CHS, $n = 598$; MUSS, $n = 603$; CNSS, $n = 579$; CSAS, $n = 603$

* Significant at $p < 0.05$

[a] DIF and DDF were log-transformed due to skewed distributions

Discussion

The primary aim of this study was to test if two different aspects of emotional regulation, namely, repressive coping and alexithymia, were associated with IEI.

Repressive coping

While the TMAS and MCSDS scores were independently associated with the four descriptive IEI factors, the repressive coping approach did not yield any significant results. These results are in agreement with those of another study which was unable to demonstrate the validity of the Weinberger construct [27]. Although we were unable to confirm the hypothesis of a role of repressive coping, our results provide evidence for an influence of the somewhat broader concept of defensiveness in IEI [46]. Defensiveness as assessed by the MCSDS has been investigated in two studies by Bell et al. [47, 48] on IEI: however, no differences were found in either study when individuals with IEI were compared to healthy controls. In another study, using a subscale from the Minnesota Multiphasic Inventory (MMPI-2) as a measure of defensiveness, chemical sensitivity litigants were found to be more defensive about expressing distress and psychopathology [49]. The authors of this study concluded that unauthenticated somatic symptoms may be exaggerated, suggesting malingering. While the results of this latter study may be seen as supportive of our findings, it should be noted that a different measure of defensiveness was used and the sample investigated were plaintiffs [49]. It should also be noted that the MCSDS has been criticized for being unable to distinguish between other-deception and self-deception [50], and future studies of IEI should attempt to distinguish between these two aspects of social desirable responding.

Alexithymia

Overall, the mean scores on the TAS-20 did not deviate from normative scores obtained in a community population sample [51]. We were only partly able to confirm our second hypothesis concerning alexithymia, since only one

subscale, DIF, was independently associated with more severe self-reported reactions. In contrast, DDF was associated with less severe IEI scores, and no clear pattern was found for the EOT-subscale. We are aware of only one other study of alexithymia and IEI, which found no differences between IEI patients, individuals with asthma and controls [12]. Differences between the separate domains of TAS-20 and their relationships with symptomatology and other personality constructs have also been reported by Kirmayer and Robbins, who argue that the TAS-20 may measure psychometrically and conceptually separate states or traits [33]. This was partly supported by the results of our mediation analyses, which confirmed that negative affectivity acted as a mediator between the DIF-subscale and the CHS, MUSS and CNSS.

Negative affectivity

We found a relatively strong association between negative affectivity and IEI, and the results of the mediation analyses partly support our third hypothesis as negative affectivity acted as a significant partial mediator of the association between DIF and the CHS, MUSS and CNSS. Associations between negative affectivity and somatic symptoms has been reported in several studies [19, 32, 52], but the mechanism remains unclear. In a study of negative affectivity as a predictor of objective and subjective symptoms of respiratory viral infections, Cohen et al. [52] attributed the association to cognitive bias rather than as a pathophysiological response to infection. Results from a study by Van Den Bergh et al. [53] on respiratory symptom perception in persons with high and low negative affectivity suggest that negative affective cues or arousal may activate somatic memory in persons high in negative affectivity. This process may lead to bias in the interpretation of bodily sensations and actual physiological responses, resulting in less interoceptive accuracy [53]. In line with these results, it has been suggested that negative affectivity is more likely to influence reports of vague, general symptoms (e.g. headache and fatigue) in conditions that are not clearly defined, whereas such symptoms are less likely to be incorporated in conditions with a specific symptom pattern [54]. It is not clear whether these suggested mechanisms also apply to IEI, and the current status of the IEI diagnosis makes the distinction between illness-specific symptoms and vague, general symptoms problematic. The causal relationship, i.e., whether negative affectivity influences an attribution of symptoms or vice versa, was not possible to determine in our cross-sectional study design. It may be important to note that negative affectivity was also a strong predictor of self-reported social consequences, which could suggest that individuals high in negative affectivity are more severely affected. The possible mechanisms underlying this association are clearly in need of further elaboration.

Methodological issues

Some methodological questions can be raised. The lack of consensus criteria for IEI leads to some uncertainty regarding the case definition. We investigated symptoms, symptom-inducing environmental odours as well as social consequences as proxies for estimating subjectively reported severity. Although this severity classification may be scientifically inadequate in terms of defining pathophysiological mechanisms, it represents a pragmatic approach by describing the subjectively experienced manifestations. Due to the broad definition of IEI and the possibility that some respondents may interpret the reactions as indicative of other health problems, such as allergy or asthma, we cannot rule out classification or recall bias. Including a healthy control group could have strengthened our design by adding information regarding the influence of psychological features on the presence of IEI independent of severity. This research question, however, was not the objective of our study.

Conclusion

In conclusion, we were unable to support the hypothesis that repressive coping is associated with IEI. While this was also the case for alexithymia, we did find some evidence of an influence of one alexithymia domain: difficulties identifying feelings. Further analyses, however, indicated that this association could be mediated by negative affectivity, a conclusion which was further supported by our findings of relatively strong independent associations between negative affectivity and trait anxiety and the four descriptive factors of IEI. We also found evidence of a role of defensiveness. Further studies are needed to elucidate the possible interplay between negative emotional reactions, defensiveness and difficulties identifying feelings in IEI, and our results may direct future therapeutic interventions towards focusing on increasing emotional awareness and functioning.

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