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Abnormalities in cognitive-emotional information processing in idiopathic environmental intolerance and somatoform disorders

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ABSTRACT

Idiopathic environmental intolerance (IEI) represents a functional somatic syndrome marked by diverse bodily complaints attributed to various substances in the environment. Evidence for abnormalities in affective information processing similar to somatoform disorders (SFD) has recently been found in people with IEI. In order to further investigate these cognitive-emotional abnormalities, we compared people with IEI ($n = 49$), SFD only ($n = 43$), and non-somatoform controls ($n = 54$) with respect to their performance in the extrinsic affective Simon task (EAST). This task allowed us to dissociate indicators of automatic affective associations and emotional intrusion effects of both bodily complaints and IEI-trigger words. Negative association effects toward IEI-trigger words were strongest for IEI participants. Emotional intrusion effects of symptom words were larger both in IEI and SFD than in controls. The results of enhanced negative automatic evaluations of IEI-trigger words and greater attention allocation to symptom words support cognitive models of IEI.

1. Introduction

Idiopathic environmental intolerance (IEI), formerly called multiple chemical sensitivity (MCS), is marked by an unspecific pattern of various medically unexplained complaints (e.g., headache, fatigue,

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muscle pain, arthralgia, sleep disturbance) attributed to diverse chemical environmental substances like dental amalgam, lead, metals, organic solvents, wood preservatives, pesticides, and strong odors in general (Bailer, Witthöft, Paul, Bayerl, & Rist, 2005; Bornschein, Hausteiner, Zilker, & Förstl, 2002). The etiology of IEI is still unknown and the pathogenesis remains poorly understood (Labarge & McCaffrey, 2000). Between 15% and 30% of respondents in population based studies report minor problems with environmental chemicals, between 1% and 6% meet more restrictive criteria of a disabling chemical intolerance in the sense of IEI (e.g., Bell & Schwartz, 1993; Meggs, Dunn, Bloch, Goldman, & Davidoff, 1996; Reid et al., 2002).

1.1. Theoretical approaches to IEI

Theories of IEI have favored either a toxicological mechanism (e.g., Miller, 2001), a primarily psychological mechanism (based on cognitive fear-like reactions and Pavlovian conditioning processes; e.g., Staudenmayer, Binkley, Leznoff, & Phillips, 2003b) or a complex psychophysiological interaction of both (e.g., the olfactory-limbic model: Bell, Miller, & Schwartz, 1992). Little evidence exists for a simple toxicological notion of IEI or an involvement of toxicological factors in more complex psychophysiological models as limbic kindling or sensitization (Staudenmayer et al., 2003a, 2003b). Neither an elevated toxic burden in environmental patients (e.g., Bornschein, Hausteiner, Konrad, Förstl, & Zilker, 2006), nor lowered olfactory thresholds or abnormalities in olfactory information processing parameters are typically found (e.g., chemosensory event-related potentials; Papo et al., 2006). In contrast to toxicological or organic conceptualizations of IEI, empirical evidence about the involvement of psychological factors in IEI is accumulating.

1.2. Psychological mechanisms in IEI

Among the most promising psychological processes involved in IEI are conditioning processes: in a series of experiments, van den Bergh and colleagues have demonstrated that psychosomatic complaints can easily be associated with and subsequently triggered by unpleasant odors (Van den Bergh et al., 2001; Van den Bergh, Stegen, & Van de Woestijne, 1997; Van den Bergh, Winters, Devriese, & Van Diest, 2002). Furthermore, cognitive psychological aspects have been hypothesized to be involved in IEI, as for instance selective attention and hypervigilance to bodily changes and specific fear-networks and mental representations concerning IEI-trigger substances (e.g., Barsky & Borus, 1999). However, only few studies have experimentally addressed cognitive variables in IEI. In a provocation test study with a non-clinical sample, expectations about the effects of a chemical agent alone systematically influenced both the report of complaints and perceived irritation (Dalton, Wysocki, Brody, & Lawley, 1997).

Regarding cognitive psychological aspects, we consider the model of medically unexplained symptoms (MUS) proposed by Brown (2004) as useful for our understanding of symptom chronicity in individuals with IEI, because of the growing evidence that IEI might best be understood as a variant of somatoform disorders (e.g., Bailer et al., 2005; Bailer, Rist, Witthöft, Paul, & Bayerl, 2004). According to Brown (2004), the chronification of (functional) somatic complaints is mainly a function of the amount of attention allocated to prior formed cognitive symptom representations (e.g., as the result of physiological disorders or traumatic experiences). The repeated attention allocation to complaints decreases the threshold for the automatic selection of symptom representations and fosters the experience of subjectively "real" but actually "rogue" symptoms.

1.3. Previous findings regarding cognitive abnormalities in IEI

Evidence for enhanced attention allocation to symptom words in patients with traditional somatoform disorder (SFD) and IEI has recently been demonstrated (Witthöft, Gerlach, & Bailer, 2006). In this study, participants with IEI were compared to participants with SFD and non-somatoform controls (CG) regarding their performance in an emotional Stroop task (e.g., Algom, Chajut, & Lev, 2004; Bar-Haim et al., 2007; Williams, Mathews, & MacLeod, 1996). Members of the SFD and IEI group took longer to name colors of symptom words (e.g., headache, fatigue, dizziness) than of neutral words. This emotional intrusion effect indicates greater attention allocation to these words. In contrast to our expectation, people with IEI did not allocate more attention to IEI-trigger words than the other groups (e.g., paint smell, cigarette smoke; Witthöft et al., 2006). However, a subsequent recognition task revealed that the IEI group recognized IEI-trigger words more accurately compared to the other two groups. Additionally, the IEI group produced more negative explicit emotional ratings regarding word valence of IEI-trigger words. Therefore, we concluded that IEI-trigger words, compared to symptom words, do not affect early attentional processes, but rather later elaborative and evaluative processes driven by IEI-specific schemata in memory. The primary aim of the current study and a major extension to our previous findings is therefore to directly probe for such schemata in people with IEI, using a different experimental paradigm, the Extrinsic Affective Simon Task (EAST) that we will outline in detail in the next paragraph.

1.4. Operationalization of selective attention and affective association processes

In order to replicate the previous finding of enhanced attention allocation toward complaints, we will use experimental indicators of selective attention analogous to the emotional Stroop task. In order to test for the presence of IEI-specific cognitive schemata, we will use measures of automatic associative strengths between concepts in memory (e.g., Greenwald, McGhee, & Schwartz, 1998). The extrinsic affective Simon task (EAST, De Houwer, 2003) is an innovative variant of the Implicit Association Task (IAT) that was constructed to measure automatic attitudes or associations. As noted by de Jong, Van den Hout, Rietbroek, and Huijding (2003), the affective Simon task belongs to the class of irrelevant feature paradigms consisting of three main components: Firstly, target stimuli whose valence is irrelevant for the task execution and which should be ignored (in our case e.g., IEI-trigger words and physical symptom words). Secondly, attributes to which the associative strength of the target words are to be determined (e.g., adjectives representing the two concepts "good" and "bad"). Thirdly, two response keys that are simultaneously matched to both attributes (e.g., right key "good" and left key "bad") and a second task *relevant* feature (e.g., right key "blue" and left key "green") to which participants have to respond. The central dependent variable is the reaction time difference between *extrinsic* "bad" responses (e.g., headache in blue) and *extrinsic* "good" responses (e.g., headache in green). Dysfunctional or negative automatic associations have recently been demonstrated with the EAST in different areas of clinical psychology, for instance spider phobia (Ellwart, Becker, & Rinck, 2005), childhood obesity (Craeynest et al., 2005), and alcoholism (De Houwer, Crombez, Koster, & De Beul, 2004). The possibility of simultaneously assessing emotional intrusion effects (i.e., slower responses to critical words compared to neutral words) within an affective Simon paradigm was already briefly discussed in de Jong, et al. (2003, p. 532)[1] and Teige, Schnabel, Banse, and Asendorpf (2004).

1.5. Aims and hypotheses

The current study is based on a previously examined sample of participants with IEI and two comparison groups with (SFD) and without (CG) a somatoform disorder according to DSM-IV (Witthöft et al., 2006). The study design is quasi-experimental and thus does not allow one to decide between competing toxicogenic or psychogenic models of the etiology of IEI. Nor does it allow one to exclude the possibility of significant contributions of toxicological factors in certain IEI cases. However, the present study aims at gaining further evidence for the relevance of cognitive processes in the majority of people with IEI. According to the assumption that bodily complaints in IEI are chronic and comparable to complaints in SFD, we hypothesize that the emotional intrusion effect toward bodily symptom words found in IEI and SFD participants compared to non-somatoform controls should be methodologically replicable one year later, using a similar experimental paradigm, namely the EAST. Regarding the processing of IEI-trigger words, we originally hypothesized stronger emotional intrusion effects in people with

[1] The study by de Jong et al. interprets this finding as a "negativity bias" (p. 532). Our actual understanding of the emotional Stroop phenomenon casts doubt on the view that "(negative) word valence" is the crucial and sufficient factor in producing such slowing effects. Relatedness to "personal concerns" seems more important than "negative valence".

IEI. In contrast, our previous results (Witthöft et al., 2006) suggested that these stimuli affect cognitive processes in a way different from symptom words: IEI-trigger words did not produce stronger emotional intrusion effects in people with IEI compared to the CG. In contrast, evidence for an enhanced recognition memory for IEI-trigger words in people with IEI was obtained. Since stronger negative automatic associations (as evidence of specific cognitive schemata) might underlie this better recognition, we used the EAST to assess differences in automatic negative affective association effects toward IEI-trigger words. The primary aims of the current study are therefore twofold: Firstly, to further elucidate possible differences in the processing of IEI-trigger words in people with IEI; secondly, to methodologically replicate the emotional intrusion effects toward symptom words in people with IEI and SFD.

2. Method

This study was approved by the Ethics Committee for Clinical Research of the medical faculty at the University of Heidelberg, Germany.

2.1. Participants

Participants took part in a prospective follow-up study of the specificity and the course of IEI. The majority of the participants (74%) were recruited from the community by advertisements in local newspapers; the remaining participants were patients from polyclinics of environmental medicine, psychiatry, psychosomatic, and dental medicine at the University of Heidelberg (Germany). Those who completed the study were paid 60 Euros. All participants provided written informed consent. A detailed description of the study rationale, recruitment, selection criteria, diagnostic assessments, reliability, and baseline results is provided elsewhere (Bailer et al., 2005; Witthöft et al., 2006) and will therefore be only briefly summarized.

At baseline ($t1$), participants from all three groups ($n = 152$) underwent a medical examination, a psychiatric interview (SCID I; German version by Wittchen, Wunderlich, Gruschwitz, & Zaudig, 1997), and the IEI interview to be described below. The IEI interview was repeated at $t2$. According to the interview results at $t1$, participants were assigned to three groups: participants with IEI ($n = 54$), participants with a somatoform disorder (SFD) according to DSM-IV ($n = 44$) but without IEI, and participants with neither IEI nor SFD (CG: $n = 54$).

2.1.1. IEI case definition

At the first assessment one year ago, all participants from all groups were carefully examined with a structured interview (SI-IEI; Bailer, Witthöft, & Rist, 2006a) to decide if they fulfilled our IEI case criteria. Participants who met the following three criteria were diagnosed as IEI: (a) reporting at least three complaints experienced during the past 6 months, (b) naming at least three trigger substances which mostly or always provoke complaints, (c) avoiding at least three trigger substances mostly or always. The IEI interview contained two sections. Section 1 covered 15 characteristic trigger substances (e.g., car exhaust, perfumes, pesticide). Section 2 covered 15 complaints potentially linked to environmental chemicals (e.g., dry nose, smell sensitivity, muscle or joint pains). Interrater reliabilities of the IEI interview were derived from 30 participants, each evaluated by a rater and a co-rater in a conjoint interview. Intraclass correlation coefficients for consistency (based on the two-way fixed-effects model; McGraw & Wong, 1996) between raters 1 and 2 were: $r = 0.99$ for the IEI-trigger substances, $r = 0.99$ for the IEI complaints, and $r = 0.99$ for IEI avoidance behavior. Kappa coefficients were 0.92 for the IEI diagnosis. Clinical psychologists who were trained to use the standardized interviews carried out the two interviews.

2.1.2. Current study sample (t2)

Participants were allocated to the three experimental groups according to their interview results (IEI interview and SCID) at $t1$. We re-examined nearly all participants ($n = 146$; 96%) of the original sample at $t1$ ($n = 152$) one year later ($t2$), with only six participants lost (five IEI, one SFD). The IEI interview was repeated at $t2$ and 45 (91.8%) participants in the IEI group still met the full IEI case definition 12 months later. There were also 10 (10.3%) new IEI cases that came predominantly from the

SFD group ($n = 7$). Participants of the two clinical groups did not receive any systematic treatment as part of the quasi-experimental design during the 12 month period. At $t2$, participants in the SFD and the IEI group reported significantly more doctor visits for this period than the CG, both of family doctors (percentage of more than 12 visits: CG: 13.0%; SFD: 51.2%; IEI: 45.8%) and of specialists (percentage of more than 12 visits: CG: 11.1%; SFD: 35.7%; IEI: 32.7%) for the last 12 months. However, this increased use of medical help did obviously influence neither the number and severity of medically unexplained complaints nor the IEI-specific complaints significantly (Bailer, Witthöft, Bayerl, & Rist, 2007).

2.2. Self-report measures

2.2.1. The Chemical Odor Sensitivity Scale (COSS)

The COSS (Bailer, Witthöft, & Rist, 2006b) contains 11 statements describing strong physical responses (e.g., trouble breathing, nausea, cough, dizziness) to the odor of common environmental chemicals (e.g., sprays, paints, cigarette smoke, cleansing agents, perfumes, exhaust fumes, gasoline). Reliability of the COSS has been established across diverse samples (Cronbach's α in the current sample $t1$ and $t2 = 0.96$; r_{tt} $(t1,t2) = 0.90$). The COSS was found to be dimensionally independent of respiratory complaints not related to IEI triggers and from self-reported allergy to pollen and food.

2.2.2. Other psychopathological measures

The Screening for Somatoform Symptoms (SOMS) consists of a list of 53 somatic complaints relevant for the diagnosis of somatization disorder. Reported complaints are added to yield a symptom total score. Cronbach's α in the current sample was 0.94 ($t1$) and 0.93 ($t2$). Retest reliability from $t1$ to $t2$ was 0.71. Good retest reliability and discriminative validity have also been previously shown for the SOMS (Rief, Hiller, & Heuser, 1997). The Somatic Symptom Index from the Patient Health Questionnaire (PHQ-15; Cronbach's α in the current sample = 0.88 ($t1$) and 0.87 ($t2$); r_{tt} $(t1,t2) = 0.84$) is a measure of somatic symptom severity and comprises 15 somatic complaints from the Patient Health Questionnaire (PHQ). The PHQ-15 has good reliability and validity (Kroenke, Spitzer, & Williams, 2002). The PHQ-9 is the depressive symptom severity scale from the PHQ (Kroenke et al., 2002), consisting of nine items (Cronbach's α in the current sample = 0.88 ($t1$) and 0.91 ($t2$); r_{tt} $(t1,t2) = 0.81$). The State-Trait Anxiety Inventory (STAI; Laux, Glanzmann, Schaffner, & Spielberger, 1981) was used to assess trait anxiety (Cronbach's α in the current sample = 0.95 ($t1$ and $t2$); r_{tt} $(t1,t2) = 0.83$).

2.3. Experimental measures

2.3.1. Stimulus material in the EAST

Ten positive and 10 negative adjectives presented in white color were chosen to represent the two concepts "good" and "bad". The target stimulus words (presented in green and blue) were identical to those used at $t1$ (Witthöft et al., 2006) and consisted of four sets of 15 words, belonging to one of three semantic categories: (1) IEI-trigger substances (e.g., amalgam, solvents, exhaust emissions), (2) non-specific symptom words (e.g., headache, fatigue, dizziness) and (3, 4) two sets of household related items (e.g., oven, fork, bowl) as neutral stimuli (see the Appendix for the entire list of stimuli). One set of neutral words was matched to the 15 trigger words, the other neutral set to the 15 symptom words according to word length and word frequency (Belica, Herberger, & al-Wadi, 1992).

2.3.2. The extrinsic affective Simon paradigm (EAST; De Houwer, 2003)

The EAST consisted of three practice blocks and four test blocks. In the first practice block, participants were shown 10 unambiguous positive (e.g., nice, honest, friendly) and 10 negative (e.g., dangerous, bad, hostile) adjectives displayed in white (on a black background) to which they should respond as fast as possible by pressing either a right key (P) labeled "positive" or a left key (Q) labeled "negative" of a computer keyboard. The assignment of response keys was the same for every participant and remained constant throughout the experiment. During the second practice block, five words of each category (IEI-trigger words, neutral words I and II, and symptom words) were presented in pseudo random order. Each word was presented in blue and in green for a total of 40 trials. Participants were instructed to respond to the color of the words by pressing P for green and Q for blue colored words;

assignment of response keys was the same for every participant. In the third practice block, participants were confronted with a block of mixed trials with white positive or negative adjectives, colored IEI-trigger and symptom words, or neutral words (displayed in blue or green). Participants were instructed to respond to the meaning of the word in the case of white words and to the color of the word in the case of green or blue words. After this practice procedure, four test blocks followed. Word order was fixed pseudo randomized, with the restriction that the same word did not appear twice in a row and that the same response button was never required more than three times in a row. Each block included 85 stimuli in a different randomized order and was preceded by five warm-up trials that did not enter into the final data analysis. Throughout the experiment each of the 60 stimulus words was presented four times (two times in blue and two times in green). Every adjective in white color was also presented four times, comprising a total number of 340 trials.

2.4. Apparatus and software

The EAST stimuli were presented on a 17″ color monitor, connected to an IBM-compatible PC. The task was run with the ERTS software (Beringer, 1996).

2.5. Procedure

All participants were tested individually in a session lasting about 1.5 hours. Participants were first interviewed with the SI-IEI. After a short break, they performed the EAST and finally completed a number of psychological self-report instruments that are described above.

2.6. Parameterization of response times

Prior to any analysis of the response time (RT) data, false reactions were eliminated from any further analysis (1.88% of trials in the CG, 2.37% trials in the IEI and 1.87% in the SFD group). The remaining RTs were corrected for outliers following a two-step procedure: (1) RTs shorter than 200 ms and longer than 2000 ms were eliminated (0.81% of trials in the CG, 2.92% in the IEI, and 1.08% in the SFD group). (2) Separately for each experimental condition, RTs larger than the individual mean plus 3SDs were set to the individual mean value plus 3SDs (0.78% of trials in the CG, 0.64% trials in the IEI and 0.68% in the SFD group).

2.7. Statistical analysis of the EAST

It is crucial for interpreting the relevant indicators of the EAST (i.e., emotional intrusion and automatic association effects) to control for general speed of processing. Therefore, we used analyses of covariance (ANCOVA) with the RTs from the critical experimental condition as dependent variable (e.g., symptom words and IEI-trigger words), group (IEI, SFD, CG) as between-subjects factor, and the respective control condition (e.g., corresponding neutral words) as covariates. The use of covariates or residual values is considered superior to the use of differences scores (e.g., Salthouse & Hedden, 2002). Because difference scores based on raw RTs are still more common and on a descriptive level easier to interpret than residual scores, we depicted the differences of raw RT scores in Figs. 1 and 2, but report the results based on residuals (i.e., analyses of covariance) in the following results section. As statistical analyses of RTs, results of the overall model and results of one-sided planned contrasts (Hager, 2002) according to our a priori hypotheses will be reported. Effect sizes will be reported as partial η^2 (η_p^2) for ANCOVA effects and as Cohen's *d* for planned comparisons between groups.

3. Results

3.1. Psychological and symptom measures

Table 1 depicts sociodemographic information and clinical diagnoses for the baseline assessment ($t1$) and the results of the diagnostic ratings and symptom measures at one-year follow-up ($t2$). As

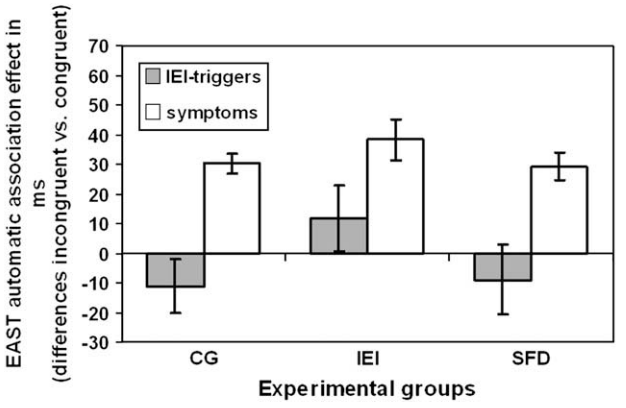

Fig. 1. Mean indices (in ms) and standard errors of the automatic affective association effect derived from the extrinsic affective Simon tasks (EAST) for the experimental groups and the two disorder related word categories (IEI triggers and symptoms).

a result of the group definition criteria at *t*1, participants in the three groups still differed highly significantly with regard to the degree of chemical odor sensitivity (COSS) and the number of somatoform complaints (SOMS, PHQ-15). As originally intended by our experimental design, the group with IEI was marked by a higher degree of chemical odor sensitivity compared to the other two groups (SFD and CG). Additionally, the level of somatization was elevated in the IEI group compared to the CG, and comparable to the SFD group. The two clinical groups (IEI and SFD) reported significantly higher levels of depression (PHQ-9) and trait anxiety (STAI) than the CG.

3.2. Extrinsic affective Simon task (EAST)

Data of three participants (two IEI and one SFD participant) were excluded from further analysis because of more than 10% error responses in the EAST. The following analyses are based on the remaining 143 participants ($N_{CG} = 54$; $N_{IEI} = 47$; $N_{SFD} = 42$).

3.2.1. Analysis of (automatic) association and emotional intrusion effects

Fig. 1 depicts the indicators of automatic association effects for IEI-trigger and complaint words separately for the experimental groups. As we subtracted latencies for extrinsically negative responses

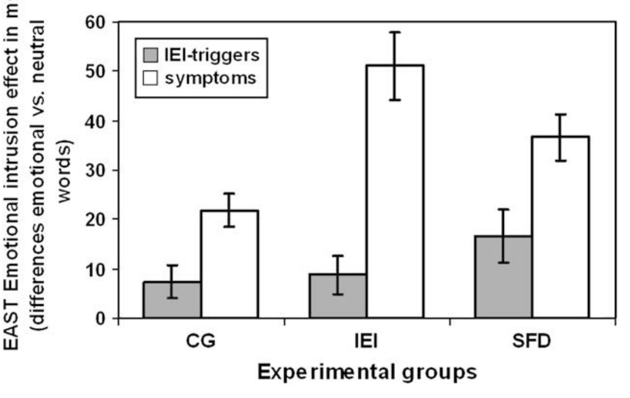

Fig. 2. Mean indices (in ms) and standard errors of the emotional intrusion effect derived from the extrinsic affective Simon tasks (EAST) for the experimental groups and the two disorder related word categories (IEI triggers and symptoms). Data represent difference scores between the matched neutral words and the two disorder related word categories.

Table 1
Sample characteristics and symptom measures (mean ± SD) at baseline assessment ($t1$) and at one-year follow-up ($t2$)

	1	2	3	ANOVA/χ^2		Post-hoc[a]
	CG ($n=54$)	IEI ($n=54$)	SFD ($n=44$)	F/χ^2	η^2_p/φ	
Baseline assessment (t1)						
Age	44.9 ± 11.4	50.0 ± 8.8	44.2 ± 12.8	4.0	0.05	3 > 2
Gender: n female (%)	37 (68.5)	35 (71.4)	35 (81.4)	2.3	0.12[b]	n.s.
Education (≥12 years) n (%)	24 (44.4)	13 (26.5)	18 (41.9)	4.0	0.17[b]	n.s.
Any somatoform disorder[d] n (%)	0 (0)	31 (57.4)	44 (100)	99.2	0.81[b]	3 > 2 > 1
Current depression[d] n (%)	2 (3.7)	9 (16.7)	19 (43.2)	5.3	0.19[b]	n.s.
Current anxiety disorder[d] n (%)	6 (11.1)	12 (22.2)	17 (38.6)	10.4	0.26[b]	3 > 1[e]
IEI diagnosis at $t1$ n (%)	0 (0)	54 (100)	0 (0)	146.0	1.0[b]	2 > 3,1
One-year follow-up (t2)[f]						
Somatoform symptoms (SOMS)	2.1 ± 5.1	14.2 ± 10.4	14.3 ± 8.1	38.3	0.35	2,3 > 1
Chemical Odor Sensitivity (COSS)	11.6 ± 9.8	44.5 ± 9.7	19.8 ± 9.5	157.1	0.69	2 > 3 > 1
PHQ-15	3.4 ± 2.7	11.3 ± 6.4	12.0 ± 4.5	51.8	0.42	2,3 > 1
PHQ-9 (depression)	2.2 ± 2.4	7.8 ± 6.2	9.1 ± 5.0	29.5	0.29	2,3 > 1
Trait anxiety (STAI)[c]	45.9 ± 10.5	56.8 ± 12.3	61.1 ± 9.8	25.5	0.26	2,3 > 1
IEI diagnosis at $t2$ n (%)	3 (5.6)	45 (91.8)	7 (16.3)	93.3	0.80[b]	2 > 3,1

[a] Scheffé post-hoc test significant at $p \leq 0.05$ or repeated 2×2 χ^2 tests at $p \leq 0.05$.
[b] Measure of effect size for χ^2 (φ-coefficient: small = 0.10, medium = 0.30, large = 0.50).
[c] STAI values are t-transformed on the basis of population norms.
[d] According to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.).
[e] Comparisons between Groups 1 and 2 and Groups 2 and 3 were not significant.
[f] Sample sizes at one-year follow-up: $n_{CG}=54$; $n_{IEI}=49$; $n_{SFD}=43$.

from extrinsically positive responses for critical words (IEI triggers and complaints), positive difference scores indicate a negative evaluation (i.e., a stronger association with the concept "negative"). As for the emotional intrusion effect, we analyzed data for the two critical word categories (IEI-trigger words and symptom words) separately.

3.2.2. Do people with IEI and SFD show different (automatic) associations in memory for symptom words?

Results of an ANCOVA with experimental group as a between-subjects factor, latencies for extrinsic positive symptom words (i.e., symptom words in green paired with the positive response key) as dependent variable, and extrinsic negative symptom words (i.e., symptom words in blue paired with the negative response key) as a covariate did not yield a significant main effect for experimental group ($F(2, 139) = 1.16$, $p = 0.32$, $\eta^2_p = 0.02$).[2] Planned contrasts according to our a priori hypotheses indicated a trend toward stronger negative association in the IEI group compared to the CG ($p = 0.08$, $d = 0.28$). In contrast, no significant difference between the SFD and the CG was detected ($p = 0.45$, $d = 0.03$). A replication of this ANCOVA with the corresponding neutral words revealed that groups did not differ ($F(2, 139) = 0.60$, $p = 0.55$, $\eta^2_p = 0.01$) in their association effects for household related words. Since recent evidence suggests that association effects in the EAST might be moderated by task switching effects between white attribute words and colored target words (e.g., Huijding & de Jong, 2005), we repeated the analyses for the symptom words for trials with and without preceding shift trial separately. No significant group effect was obtained, neither with ($F(2, 139) = 1.88$, $p = 0.16$, $\eta^2_p = 0.03$) nor without prior shift trial ($F(2, 139) = 0.63$, $p = 0.53$, $\eta^2_p = 0.01$).

3.2.3. Do people with IEI show different (automatic) associations in memory for IEI-trigger words?

The ANCOVA for IEI-trigger words revealed a significant main effect for group ($F(2, 139) = 4.37$, $p = 0.01$, $\eta^2_p = 0.06$).[2] Planned contrasts according to our a priori hypotheses revealed disproportionally slower responses for IEI-trigger words paired with extrinsically positive responses in participants with IEI compared to the CG ($p = 0.01$, $d = 0.56$) and to the participants with SFD ($p = 0.02$, $d = 0.44$). The two

[2] The effect remained unaltered when excluding participants according to the IEI interview at $t2$ (i.e., participants in the CG or SFD that fulfilled the IEI criterion or participants in the IEI group that did not fulfill the IEI criterion at $t2$).

non-IEI comparison groups did not differ significantly ($p = 0.49$). Post-hoc analyses motivated by the task switching hypothesis of EAST effects indicated that the group effect for IEI-trigger words was robust under both conditions, i.e., without ($F(2, 139) = 3.22$, $p = 0.04$, $\eta_p^2 = 0.04$) and with ($F(2, 139) = 4.60$, $p = 0.01$, $\eta_p^2 = 0.06$) a prior shift trial. Although the effect turns out as descriptively larger with a prior shift trial, the presence of a shift trial did not moderate the group effect significantly. A replication of the main ANCOVA analysis with the corresponding neutral words revealed that groups did not differ ($F(2, 139) = 1.58$, $p = 0.21$, $\eta_p^2 = 0.02$) in their association effects for household related words.

3.2.4. *Comparison of association effects for symptom words and IEI-trigger words*

To allow for a direct comparison of the strength of the association effects for IEI-trigger and complaint words we subjected the association effects for both word categories (based on residuals) to a 3 (Group) × 2 (Word Category) mixed ANOVA. The analysis yielded a significant main effect for Group ($F(2, 140) = 3.58$, $p = 0.03$, $\eta_p^2 = 0.05$), but not for the factor Word Category ($F(1, 140) < 0.1$, $p = 0.95$, $\eta_p^2 < 0.01$). The Group × Word Category interaction effect did not reach significance ($F(2, 140) = 1.31$, $p = 0.27$, $\eta_p^2 = 0.02$).[2] Simple main effect analyses indicated that the significant main effect for Group was mainly attributable to significantly less positive association effects for IEI-trigger words in the IEI group compared to the other two groups.

3.2.5. *Analysis of emotional intrusion effects*

Fig. 2 depicts the emotional intrusion effects as the differences between the latencies for symptom and IEI-trigger words and corresponding neutral words separately for the three experimental groups.

3.2.6. *Is the emotional intrusion effects for physical complaint words enhanced in participants with IEI and SFD?*

An ANCOVA for the symptom words, using the corresponding neutral words as a covariate, revealed a significant main effect for experimental group ($F(2, 139) = 6.50$, $p < 0.01$, $\eta_p^2 = 0.09$).[2] Planned comparisons according to our a priori hypotheses indicated that IEI participants responded disproportionately slower to symptom words than the CG ($p < 0.01$, $d = 0.72$). Similarly, SFD participants had significantly slower reactions to symptom words than the CG ($p = 0.02$, $d = 0.41$). The size of the intrusion effect did not differ significantly between the IEI and SFD participants ($p = 0.14$, $d = 0.32$).

3.2.7. *Do participants with IEI show enhanced emotional intrusion effects for IEI-trigger words?*

An analogue ANCOVA for the IEI-trigger words with the corresponding neutral words as a covariate revealed no significant effect for experimental group ($F(1, 139) = 2.07$, $p = 0.13$, $\eta_p^2 = 0.03$).[2] Post-hoc tests with Bonferroni adjustment did not indicate significant differences between single experimental groups ($p > 0.17$).

3.2.8. *Comparison of intrusion effects toward symptom words and IEI-trigger words*

To allow for a direct comparison of the strength of the two emotional intrusion effects (for IEI-trigger and physical complaint words) we subjected the intrusion effects for both word categories (based on residuals) to a 3 (Group) × 2 (Word Category) mixed ANOVA. The analysis yielded a significant main effect for Group ($F(2, 140) = 4.55$, $p = 0.01$, $\eta_p^2 = 0.06$), but not for the factor Word Category ($F(1, 140) < 0.1$, $p = 0.95$, $\eta_p^2 < 0.01$). Most importantly, there was a significant Group × Word Category interaction effect ($F(2, 140) = 3.96$, $p = 0.02$, $\eta_p^2 = 0.05$).[2] Simple main effect analyses indicated that the significant main effect for Group was due to higher emotional intrusion effects in the two clinical groups (IEI and SFD) compared to the CG. The significant interaction effect suggested that the group main effect was moderated by the factor Word Category, i.e., significantly higher emotional intrusion effects were only obtained for symptom words but not for IEI-trigger words.

3.3. *Correlational analyses*

Table 2 depicts the correlations between the different experimental indicators of the EAST (i.e., the emotional intrusion effects for IEI-trigger and symptom words and the automatic affective association

Table 2
Correlations between experimental indicators (based on residuals) of attentional bias and automatic affective associations (EAST) and psychological (symptom) measures for the total sample ($n = 143$) and the IEI group (values in parentheses represent Spearman's ρ for IEI group)

	Emotional intrusion effect (EAST)		Automatic association effect (EAST)	
	IEI triggers	Symptoms	IEI triggers	Symptoms
Somatic Symptoms (SOMS)	0.04 (−0.07)	**0.23*** (0.24)	0.19 (0.05)	0.08 (0.14)
Trait anxiety (STAI)	0.02 (−0.28)	**0.19**** (0.05)	0.06 (−0.13)	0.03 (0.06)
PHQ-15 (somatic symptoms)	0.04 (−0.11)	**0.30*** (**0.36****)	0.14 (−0.07)	0.18 (0.19)
PHQ-9 (depression)	0.03 (−0.19)	**0.19**** (0.21)	0.04 (−0.24)	0.13 (0.10)
COSS (chemical odor sensitivity)	−0.05 (0.04)	**0.28*** (0.06)	0.16 (−0.19)	0.09 (0.05)
IEI interview (complaints)	−0.07 (−0.28)	**0.17**** (0.14)	**0.17**** (−0.02)	0.10 (0.05)
IEI interview (IEI triggers)	−0.11 (−0.04)	**0.36*** (**0.49***)	**0.28*** (**0.31****)	0.15 (0.26)
IEI interview (avoiding triggers)	−0.05 (0.02)	**0.31*** (**0.35****)	**0.25*** (0.24)	0.12 (0.16)

Significant correlations in bold print; significance levels: *$p \leq 0.01$; **$p \leq 0.05$; none of the correlations within the CG and SFD group reached significance.

effects for IEI-trigger and symptom words of the EAST) with self-report instruments and IEI-interview scores (number of IEI complaints, triggers, and avoidance of IEI triggers) for the entire sample and the IEI group. The emotional intrusion effect for symptom words is positively associated with somatic symptom measures (SOMS, PHQ-15), both in the entire sample and the IEI group. Furthermore, significant associations of the symptom word intrusion effect with the number of complaints and triggers reported in the IEI interview are present. The association with the number of reported triggers turned out even stronger when looking at the IEI group only.

Regarding the automatic association effects, significant relations were only found between the association effect for IEI-trigger words and the IEI-interview scores for number of reported IEI triggers and the avoidance behavior of such triggers. The correlation between the association effect for IEI-trigger words and the number of triggers reported in the IEI interview remained significant also within the IEI group. This finding indicates that more negative automatic associations of IEI-trigger words are associated with reporting more personally harmful triggers in the IEI interview. Regarding correlations between the different experimental indicators, the two association measures for complaint words and IEI-trigger words were moderately correlated in the entire sample ($r = 0.40$) and within the three groups ($r_{CG} = 0.57$; $r_{IEI} = 0.34$; $r_{SFD} = 0.29$). Of the remaining correlations, only the relation between the emotional intrusion effect for symptom words and the association effect for IEI-trigger words reached significance in the entire sample ($r = 0.17$) and was marginally significant within the IEI group ($r = 0.25$). Thus, negative associations of trigger words are associated with greater emotional intrusion effects for complaint words.

4. Discussion

Based on the hypothesis that IEI might be considered as a variant of somatoform disorders (or functional somatic syndrome), the aim of the current study was to explore abnormalities in cognitive-emotional information processing in IEI in comparison to people with traditional somatoform disorders (SFD) and non-clinical control participants without IEI and SFD. Since cognitive abnormalities in the processing of symptom and illness information are a central feature of current models for the explanation of medically unexplained symptoms (e.g., Brown, 2004), similar cognitive abnormalities (e.g., greater attention allocation to symptom words) should be observable in IEI if this phenomenon belongs to the MUS domain. In line with this hypothesis, both people with SFD and IEI demonstrated greater attention allocation to physical complaint words. Thus, the current findings methodologically replicate the results of our first assessment with the emotional Stroop paradigm (Witthöft et al., 2006). Also consistent with the findings at the first assessment, no such difference in attention allocation was found for IEI-trigger words. The current results therefore support the two main findings of our first report, i.e. (a) that with regard to the processing of physical complaint words, abnormalities in people with IEI resemble those of people with traditional SFD and (b) that groups do not differ regarding attention allocation to IEI-trigger words. In addition to this replication of previous finding, the results of the EAST demonstrate for the first time more negative (automatic) association effects for IEI-trigger words that are specific for people with IEI (at least regarding a somatoform comparison group), lending support for the hypothesis of IEI-specific cognitive schemata. Such schemata might also explain the finding of a better recognition memory performance for IEI-trigger words in the IEI group found in our first study (Witthöft et al., 2006).

As a prerequisite for the valid interpretation of these experimental findings, the experimental group membership that was initially determined during the first assessment one year ago could be validated by the psychological self-report measures of somatoform complaints and chemical sensitivity: the IEI group was still marked by elevated levels of chemical sensitivity and medically unexplained somatic complaints, whereas the SFD group reported only elevated levels of somatoform complaints in the absence of marked chemical sensitivity values. Both clinical groups still reported similar symptom patterns and overlapping psychological risk factors (e.g., trait anxiety) for somatization and were clearly distinguishable from non-somatoform and non-IEI participants (CG).

However, the asymmetry in findings with regard to the two stimulus classes, namely IEI-trigger words and physical complaint words, and the two experimental indicators (emotional intrusion and automatic association effect) clearly needs explication. Why do people with IEI and SFD show emotional intrusion effects for complaints words but not stronger negative automatic association effects for those stimuli? Regarding a systematic comparison of emotional intrusion effects as a measure of attention allocation (derived from Stroop-like tasks) and automatic association effects (derived from IAT-like tasks), little empirical and theoretical work exists so far. In our data, we found only small associations between the two measures. We attribute the comparatively low correlation to fundamental differences in the constructs that are tapped by the two measures: Theoretically, the emotional intrusion effect derived from Stroop-like paradigms might best be understood as a threat response (e.g., Algom et al., 2004) in terms of an interruption of current information processing. It is determined by different stimulus characteristics, i.e., not only negative valence, but also level of arousal, and relatedness to individual concerns. In contrast, the association effect refers to a predominantly automatic evaluation process that taps associations with the attribute concepts "good" and "bad". Therefore negative (automatic) associations might represent a necessary but not sufficient component of stimuli to cause emotional intrusion effects in terms of a cognitive threat response. Accordingly, the threat value of the IEI-trigger words might not be high enough and sufficient to produce emotional intrusion effects, though negative association effects occur in the IEI group. However, the small positive correlation between the association effect for IEI-trigger words and the intrusion effect for complaint words in people with IEI might be interpreted as a first empirical evidence for the cognitive model of IEI, i.e., IEI-specific cognitive schemata may foster attention allocation to physical complaints. Finally, we would suggest to replicate probing for the existence of possible negative automatic association effects for IEI-trigger and physical complaint words. Psychometric limitations regarding the assessment of automatic associations with the EAST have been acknowledged previously (De Houwer & De Bruycker, 2007; Teige et al. 2004); thus, it would be premature to question the existence of altered evaluation effects regarding physical symptoms in people with medically unexplained complaints based on our studies alone. Further studies with more reliable implicit measures (like the classical IAT) are necessary to finally decide on this issue. Especially promising for a further investigation of IEI-specific schemata appears an odor-IAT, which was recently proposed by Bulsing, Smeets, and van den Hout (2007). This procedure allows assessing implicit attitudes toward the concept "odor". As this concept represents the most relevant trigger category for people with IEI, this group should demonstrate negative implicit attitudes also in the odor-IAT.

What do negative automatic associations mean in the context of IEI? Focusing on the nature of the EAST, we can summarize that this task indirectly (i.e., without the participants knowing the exact mechanisms of the task) assesses associations to negative and positive concepts. Those evaluative connotations are strong enough to automatically (i.e., without volitional cognitive effort) influence the response behavior of participants in the EAST task, as seen for the IEI-trigger words in the IEI group and for symptom words across all three groups. We may infer that these associations similarly affect information processing outside the experimental context and possibly contribute to the initiation of safety or defense strategies (e.g., avoidance behavior) which are considered as an important perpetuating factor in psychological models of IEI (Guglielmi, Cox, & Spyker, 1994). The first empirical support for the claim that implicitly measured association effects incrementally predict automatic or spontaneous avoidance behavior has been presented by Huijding and de Jong (2006) for fear of spiders. Our correlational finding of a significant association between the number of IEI triggers reported in the IEI interview and the negative association effect for the IEI-trigger words points in a similar direction.

Regarding the emotional intrusion effect, many studies have employed the emotional Stroop paradigm in clinical and normal settings (e.g., Bar-Haim et al., 2007). Still the question remains which processes the intrusion effect (i.e., a response slowing in the presence of negative and individually relevant information) actually reflects. Is it the exact meaning of a word in terms of its semantic content or rather an emotional connotation (attached via associative learning) associated with the word stimulus? Evidence for the latter view is growing (e.g., Richards & Blanchette, 2004). However, even if the emotional Stroop task assesses the strength of emotional connotations, intrusion effects result from at least two sources: firstly, a strong emotional association or connotation and secondly a poor ability to overcome or override the activation resulting from the emotional association in order to perform the actual task. Thus, strong emotional intrusion effects remain ambiguous, either demonstrating easy activation of emotional connotations, or poor inhibition of such associations, or a combination of both. Consequently, the interpretation of our experimental findings is limited by the current knowledge regarding the nature of so called "implicit" or automatic association effects (e.g., Nosek, Greenwald, & Banaji, 2007) and emotional intrusion effects (e.g., Bar-Haim et al., 2007).

5. Limitations

Although the current study successfully demonstrated general (attentional bias to symptom words) and specific (negative implicit associations for IEI-trigger words) alterations in cognitive-emotional processing in people with IEI, we cannot decide the critical question of etiology (i.e., psychogenic vs. toxicogenic). The use of a comparison group with a clear-cut toxically induced symptomatology (e.g., toxic encephalopathy) might have revealed more insight regarding this issue. However, given similar experimental effects in a toxically harmed control group would not exclude the possibility of a psychogenic genesis in people with IEI. In other words, cognitive abnormalities reported in this study might results from various sources, e.g., either from a real toxic trauma-like event or from the acquisition/generation of specific cognitive schemata that guide further information processing. Since no single study could so far demonstrate any association between an elevated toxic burden and cognitive abnormalities (e.g., chemical symptom attribution processes) in IEI, we currently consider the latter explanation (e.g., the misattribution hypotheses of IEI) as more likely. Also, the current study cannot answer the question of a possible causal relationship between the documented cognitive abnormalities and individual symptom perception, i.e., cognitive abnormalities might be the cause as well as the consequence of chronic MUS. Future studies that either aim at systematically modifying those cognitive processes or that use a longitudinal design may clarify this issue of causality.

In summary, the current results demonstrate different cognitive-emotional abnormalities in IEI: The finding of stronger negative automatic association effects for IEI-trigger words in people with IEI is in line with our cognitive model that assumes the existence of IEI-specific cognitive schemata. With regard to attentional processes, the findings demonstrate that similarities in the processing of physical complaint words between people with SFD and people with IEI outweigh the differences. Therefore, evidence for a symptom focused attentional style was found in both IEI and SFD. Consequently, cognitive-behavioral interventions that aim at changing the negative connotations of suspected IEI triggers (e.g., through cognitive restructuring, in vivo exposure, and the reduction of safety behaviors) and the simultaneous reduction of catastrophizing interpretations of bodily complaints (e.g., through interoceptive exposure procedures) seem most promising in treating people with IEI. Controlled intervention studies are needed to prove this hypothesis and to further explore if the cognitive-affective abnormalities demonstrated in this study can be reversed by cognitive-behavioral treatments.

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Appendix.

Original stimuli in German used in the extrinsic affective Simon task

IEI-trigger words	Neutral words (1)	Symptom words	Neutral words (2)
Amalgam	Backofen	Schwindel	Toaster
Wohngifte	Spülbecken	Übelkeit	Kochlöffel
Asbest	Gabel	Kopfschmerzen	Waschbecken
Lackgeruch	Schneebesen	Schwäche	Waage
Zigarettenrauch	Küchenmaschine	Lähmung	Teller
Autoabgase	Küchenmesser	Durchfall	Besteck
Insektizide	Alufolie	Atemnot	Teelöffel
Luftverschmutzung	Geschirrhandtuch	Muskelschmerzen	Kaffeekanne
Radioaktivität	Kaffeemaschine	Hitzewallung	Suppenteller
Lösungsmittel	Kaffeetasse	Müdigkeit	Herdplatte
Strahlung	Schüssel	Nervosität	Eierkocher
Benzindämpfe	Flaschenöffner	Herzrasen	Handfeger
Elektrosmog	Waschmaschine	Erbrechen	Esslöffel
Pestizide	Pfeffermühle	Bauchschmerzen	Topflappen
Formaldehyd	Gefriertruhe	Ohnmacht	Schale

Original adjectives for the two categories “good” and “bad” (in German): “gut”: gesund, ehrlich, schön, freundlich, lustig, angenehm, entspannend, erholsam, zurfrieden, geborgen; “schlecht”: böse, schlecht, gefährlich, feindselig, bedrohlich, verletzend, erschreckend, giftig, störend, unangenehm.

English translation of stimuli

IEI-trigger words	Neutral words (1)	Symptom words	Neutral words (2)
Amalgam	Oven	Dizziness	Toaster
Toxins in the house	Sink	Nausea	Wooden spoon
Asbestos	Fork	Headache	Basin
Paint smell	Eggbeater	Weakness	Scales
Cigarette smoke	Cuisinart	Paralysis	Plate
Emissions	Kitchen knife	Diarrhea	Canteen
Insecticides	Tin foil	Breathlessness	Tea spoon
Air pollution	Dish towel	Muscle pain	Coffee pot
Radioactivity	Coffee machine	Hot flash	Soup plate
Solvents	Coffee cup	Fatigue	Hot plate
Radiation	Bowl	Nervousness	Egg boiler
Petrol fumes	Bottle opener	Tachycardia	Hand brush
Electromagnetic pollution	Washing machine	Sickness	Soup spoon
Pesticides	Pepper mill	Belly ache	Oven gloves
Formaldehyde	Chest freezer	Blackout	Bowl

Adjectives for the two categories “good” and “bad”: “good”: healthy, honest, nice, friendly, funny, agreeable, relaxing, recreative, happy, secure; “bad”: evil, bad, dangerous, hostile, threatening, violating, terrifying, toxic, bothersome, unpleasant.

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