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Empirical Article

Cognitive Biases in Pathological Health Anxiety: The Contribution of Attention, Memory, and Evaluation Processes

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Abstract
Pathological health anxiety refers to the medically unfounded fear of suffering from a severe illness. Differences in cognitive processes related to attention, memory, and evaluation of health threat have been hypothesized to underlie pathological health anxiety. In no study, however, have researchers systematically and simultaneously assessed different cognitive biases. On the basis of the idea that multiple cognitive biases simultaneously contribute to psychopathology (the combined-cognitive-bias hypothesis), we compared 88 patients with pathological health anxiety, 52 patients with depressive disorder, and 52 healthy participants on their performance in several cognitive tasks involving health-threatening content. Individuals with pathological health anxiety showed a stronger attentional bias to health-threat-related information, more negative explicit (but not implicit) evaluations of health threat, and biased response behavior in light of health threat. The results suggest that stronger bindings between feelings of arousal and health-threatening information in working memory might be crucial for the higher salience of health-threatening contents in pathological health anxiety.

Abnormalities in information processing are of paramount importance for our understanding of mental disorders (e.g., Dalgleish & Watts, 1990; Mathews & Wells, 2000). During the past decade, numerous cognitive biases regarding attention, memory, and interpretation have been identified in anxiety and affective disorders (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Mathews & MacLeod, 2005; Mitte, 2008). Studies that successfully modified cognition recently have demonstrated that cognitive biases are not irrelevant by-products of mental disorders but, rather, serve as causal factors in the pathogenesis of the core psychopathology (e.g., Hakamata et al., 2010; MacLeod & Mathews, 2012).

Regarding health anxiety and, especially, full-blown hypochondriasis,[1] the systematic study of relevant cognitive biases is still in its infancy (Marcus, Gurley, Marchi, & Bauer, 2007; Norris & Marcus, 2014). Pathological health anxiety (i.e., the medically unfounded fear or conviction that one suffers from a severe illness on the basis of the misinterpretation of bodily sensations), formerly termed hypochondriasis in the *Diagnostic and Statistical Manual*

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of Mental Disorders (4th ed., text rev.; *DSM–IV–TR*; American Psychiatric Association, 2000; e.g., Witthöft & Hiller, 2010), currently is officially classified among the somatic symptom and related disorders in the fifth edition of the *DSM* (*DSM–5*; American Psychiatric Association, 2013; e.g., Rief & Martin, 2014), although theoretical and empirical evidence is growing that pathological health anxiety might better be considered as an anxiety disorder (Olatunji, Deacon, & Abramowitz, 2009; Weck, Bleichhardt, Witthöft, & Hiller, 2011). Consistent with this suggestion, cognitive-behavioral models of pathological health anxiety (Abramowitz, Schwartz, & Whiteside, 2002; Warwick & Salkovskis, 1990; Williams, 2004) are strongly informed by cognitive models of anxiety and, especially, panic disorder (e.g., Clark, 1986). These models stress the importance of biased attentional processes as well as negative evaluative processes of illness-related or ambiguous health information, which result in elevated arousal and the preoccupation with falling victim to a life-threatening illness.

Existing models of pathological health anxiety have remained comparatively vague with regard to specific cognitive processes and biases that are central to the maintenance of this condition—a state that is partly attributable to missing links between basic cognitive-psychology and existing cognitive-behavioral approaches. From a basic cognitive-psychology perspective and according to dual-process models of the mind (e.g., Feldmann Barrett, Tugade, & Engle, 2004), information processing comprises both automatic and controlled cognitive processes that conjointly determine the contents of thoughts, feelings, and resulting behavioral responses. Accordingly, sensory stimuli (in the case of pathological health anxiety, health-threatening stimuli originating either from the outside or from within the body) are subject to processes of attention allocation, evaluation, selection, and encoding, and many of these processes operate in parallel according to both sensory-stimulus characteristics and preexisting knowledge structures ("schemata"). According to the generic cognitive model of emotional disorders (e.g., Brewin, 2006), cognitive biases at different stages simultaneously and interactively contribute to negative affective states and the maintenance of intrusive negative thoughts, images, and behaviors that are characteristic of a given mental disorder (e.g., posttraumatic stress disorder, obsessive-compulsive disorder, and social phobia). Although different cognitive biases regarding attention, interpretation, and memory have mostly been studied in relative isolation, the combined-cognitive-bias hypothesis (Hirsch, Clark, & Mathews, 2006), which was initially applied to anxiety and later to affective disorders (Everaert, Koster, & Derakshan, 2012), provides a valuable unifying framework to consider patterns of multiple cognitive biases that conjointly contribute to states of

psychopathology in emotional disorders. Among these biases, the attentional bias as well as memory and interpretive biases have been investigated in health anxiety.

Whereas researchers in several analogue studies in student samples with high and low health anxiety have used the emotional Stroop task (EST; e.g., Karademas, Christopoulou, Dimostheni, & Pavlu, 2008; Owens, Asmundson, Hadjistavropoulos, & Owens, 2004; Witthöft et al., 2013; Witthöft, Rist, & Bailer, 2008) or the dot-probe task (Jasper & Witthöft, 2011) to provide evidence for an attentional bias toward illness-related information in individuals with high health anxiety, similar studies in patients with the diagnosis of hypochondriasis are rare (for exceptions, see Gropalis, Bleichhardt, Hiller, & Witthöft, 2013; van den Heuvel et al., 2005). Because the EST appears as one of the most robust paradigms to assess biased attention allocation and because it has been applied rarely in individuals with the diagnosis of hypochondriasis (compared with studies with subclinical levels of health anxiety in college students), this paradigm was used in the current study in concert with other paradigms to obtain an overall picture of biased information processing.

Regarding interpretive or evaluative biases, findings by Markus (1999) and Weck, Neng, Richtberg, and Stangier (2012) have suggested that health anxiety and hypochondriasis are associated with the tendency to consider catastrophic illnesses as more likely than benign causes. Similarly, Haenen, de Jong, Schmidt, Stevens, and Visser (2000) found that patients with hypochondriasis expected negative outcomes more frequently when asked to judge ambiguous health-related vignettes. In a study on evaluation and memory biases, Ferguson, Moghaddam, and Bibby (2007) found evidence for a link between automatic negative evaluation processes of health-related information and a better recognition memory for this content. This association lends support to the assumption that activation of an object in memory depends on the strength of its association with its emotional evaluation (associative-strength-of-object-evaluation model; Ferguson et al., 2007). According to this approach, pathological health anxiety might be characterized by stronger associations of illness-related information and corresponding (negative) emotional evaluations, thereby fostering a greater availability of these contents in working memory. Consistent with this assumption, studies have investigated memory biases in the realm of pathological health anxiety. Two studies have shown evidence for a better free-recall performance of health-related information in patients with hypochondriasis (Brown, Kosslyn, Delamater, Fama, & Barsky, 1999; Pauli & Alpers, 2002). Moreover, Pauli and Alpers (2002) found a more liberal recognition performance for illness-related information in hypochondriasis, which suggests that patients with this

condition tend to overestimate the occurrence of health threats.

These findings suggest that several cognitive biases regarding attention, interpretation, and memory are crucially and simultaneously involved in maintaining active illness information in the working memory of individuals with high health anxiety. The observed biases include not only deliberate, controlled information processing but also alterations regarding implicit or automatic stages of information processing, which may contribute to patients' feelings of uncontrollable and intrusive thoughts and images about severe illnesses. Existing research on cognitive biases in health anxiety, however, has been limited by either the reliance on a single experimental paradigm (i.e., lack of a multimethod approach), the use of nonclinical samples with a restricted range of health-anxiety severity, or comparatively small sample sizes in studies on patients with a clinical diagnosis of hypochondriasis. In addition, the question of specificity of cognitive processes observed in hypochondriasis compared with other mental disorders (e.g., depression) has rarely been addressed. Closing these gaps and extending our knowledge regarding information processing in pathological health anxiety should enable us to tailor psychotherapeutic interventions for this disorder more precisely.

Our current study was designed to overcome these limitations and to gain a thorough understanding of biased information processing by (a) selecting a large sample of patients who suffer from clinically relevant pathological health anxiety (the pathological health anxiety group, or PHG), (b) using four different experimental paradigms to assess cognitive-emotional characteristics in the processing of health-related information, and (c) using a clinical control group of patients diagnosed with a depressive disorder (the depressive control group, or DCG) in addition to a healthy control group (HCG) of individuals without any current mental disorder. The DCG was chosen to test the notion that possible differences regarding cognitive processes between patients with pathological health anxiety and healthy control participants are not merely attributable to higher levels of negative affect or increased symptoms of depression that are characteristic of both patients with pathological health anxiety and patients with a depressive disorder but, rather, are specific to pathological health anxiety.

We expected to find multiple cognitive biases (regarding attention, evaluation, and memory) in individuals with pathological health anxiety when they are confronted with illness-related stimuli, which would be consistent with the combined-cognitive-bias hypothesis (Hirsch et al., 2006). In particular, we hypothesized that individuals with pathological health anxiety would show an attentional bias toward illness-related information and that this attentional bias would be significantly stronger in patients with pathological health anxiety compared with patients with a depressive disorder and with healthy control participants. Similarly, we assumed that patients with pathological health anxiety (compared with the two other groups) would exhibit stronger negative evaluation effects of illness-related stimuli on both an implicit and an explicit level. Finally, we hypothesized that patients with pathological health anxiety, compared with patients with a depressive disorder and healthy control participants, would show evidence for a memory bias for illness-related information (i.e., better recognition ability or a more liberal response criterion). Consistent with the associative-strength-of-object-evaluation hypothesis, our hypothesis assumed that in patients with pathological health anxiety, the evaluation bias of health-threat-related information and the memory bias for illness-related information would be positively associated.

Method

Participants

The study was approved by the Medical Ethics Committee of the Medical Faculty Mannheim at the University of Heidelberg, Germany. A case-control design was used to compare psychopathology and performance in experimental tasks among three diagnostic groups: (a) a group of individuals with pathological health anxiety (PHG), (b) a group of depressed but not health-anxious individuals (DCG), and (c) a group of healthy individuals (HCG). The participants of both clinical groups (PHG and DCG) were separately recruited from a cognitive-behavioral-therapy outpatient unit that specialized in the treatment of affective and somatoform disorders at the Central Institute of Mental Health, Mannheim. The healthy participants were recruited via advertisements in local newspapers and on the Web page of the Central Institute of Mental Health. Because of substantial criticism of the diagnostic criteria for hypochondriasis according to the fourth edition of the *DSM* (*DSM–IV*; American Psychiatric Association, 1994; e.g., for being overrestrictive and unspecific; Fink et al., 2004), the diagnosis of pathological health anxiety was based on the following empirically established criteria as proposed by Fink et al. (2004): obsessive rumination with intrusive thoughts, ideas, or fears of harboring an illness that cannot be stopped or can be stopped only with great difficulty (Criterion A); presence of one or more out of five characteristic symptoms (e.g., illness worries and preoccupation with health concerns, intense awareness of bodily functions, illness related suggestibility or autosuggestibility; Criterion B); exclusion of a medical condition that fully explains the patient's reaction (Criterion C); exclusion of another psychiatric condition that better explains the symptoms

(Criterion D); presence of the symptoms for at least 2 weeks (Criterion E); and differentiation between mild and severe health anxiety (Criterion F).

We used a two-phase selection design. In the first stage of the recruitment process, potential participants (*N* = 483) completed a screening package of self-report measures. Those individuals who were in the age range of 18 to 65 years and who met the group-specific screening-based inclusion and exclusion criteria were selected for a comprehensive clinical interview for mental disorders (the Structured Clinical Interview for Health Anxiety, developed by Fink et al., 2004, and the Structured Clinical Interview for *DSM–IV* Axis I Disorders, SCID-I; First, Spitzer, Gibbon, & Williams, 1997). General exclusion criteria were a lifetime diagnosis of psychotic disorders, substance-use disorders, organic brain disease or organic mental disorders, presence of a somatic illness that could account for the health-related concerns, and inadequate command of the German language. A total of 192 participants (all Caucasian Germans) who met both the screening- and the interview-based inclusion criteria were included in the final study sample.

Group-specific inclusion and exclusion criteria: PHG, DCG, and HCG.

Participants in the PHG (*n* = 88) all scored above a predefined cutoff in at least one of two screenings for pathological health anxiety (i.e., a score of 8 or more on the Whiteley Index, WI, and a score of 15 or more on the 14-item Short Health Anxiety Inventory, SHAI) and had to fulfill interview-based research criteria for pathological health anxiety as defined by Fink et al. (2004).

The participants with depression (*n* = 52) had to meet the following criteria: (a) a negative screening result for pathological health anxiety (scores of less than 8 on the WI and of less than 15 on the SHAI), (b) a positive screening result for depression (score of 10 or more on the Patient Health Questionnaire, PHQ-9), (c) a negative result in the Fink-criteria-based interview for pathological health anxiety, and (d) a current depressive episode or dysthymia in the SCID-I. Additional exclusion criteria were a comorbid panic disorder, obsessive-compulsive disorder, or a generalized anxiety disorder.

Participants in the HCG (*n* = 52) had to meet the following criteria: negative screening results for (a) pathological health anxiety (scores of less than 8 on the WI and of less than 15 on the SHAI) and (b) depression (score of less than 10 on the PHQ-9), (c) no current *DSM–IV* diagnosis in the SCID-I, and (d) no diagnosis of pathological health anxiety in the Fink interview. All but 2 participants met these criteria; specifically, the 2 participants reported symptoms of mild to moderately severe animal phobias (spiders and mice).

Measures

Structured clinical interview.

Mental disorders were assessed with all sections of the SCID-I (First et al., 1997) in face-to-face interviews. The SCID-I was expanded with additional items from the Schedules for Clinical Assessment in Neuropsychiatry (World Health Organization, 1998), which allowed for diagnosis of pathological health anxiety according to the diagnostic criteria introduced by Fink et al. (2004).

The clinical interviews were conducted by six experienced clinical psychologists specially trained by an expert in the SCID-I and the Schedules for Clinical Assessment in Neuropsychiatry and continuously supervised throughout the study period by a senior researcher (J. Bailer). Interrater reliabilities of the seven items (Criteria A and B) of the Fink interview were based on 30 videotaped interviews (20 PHG patients, 6 DCG patients, and 4 HCG participants) evaluated by a second diagnostician blind to participants' group allocation. They were good to excellent; intraclass correlation coefficients for the single items ranged from .66 to .90.

Self-report measures of health anxiety and other psychopathology: WI, SHAI, and PHQ.

The WI is a widely used 14-item instrument with a dichotomous answer format for the dimensional assessment of health anxiety (Hiller & Rief, 2004; Pilowsky, 1967) that has shown good reliability and validity (Hiller & Rief, 2004). Cronbach's coefficient alpha was .93 for the total study sample.

The SHAI consists of 14 items in multiple-choice format, based on a cognitive model of health anxiety and hypochondriasis (Warwick & Salkovskis, 1990), which assess the range of health anxiety irrespective of physical health status (Salkovskis, Rimes, Warwick, & Clark, 2002). The SHAI has been shown to be valid and reliable (e.g., Abramowitz, Deacon, & Valentiner, 2007; Witthöft et al., 2008). Cronbach's coefficient alpha was .97 for the total study sample (Bailer et al., 2013).

To assess the level of depressive symptoms and somatoform symptoms, we used the depression (PHQ-9; α = .85) and somatization (PHQ-15; α = .91) modules of the well-validated PHQ (Kroenke, Spitzer, Williams, & Löwe, 2010; Spitzer, Williams, & Kroenke, 1999).

Experimental tasks.

Psychopathology and performance in several experimental tasks were compared among the three diagnostic groups.

Stimulus material. Word stimuli were chosen from a previous study (Witthöft et al., 2008) and consisted of 40 nouns divided into four sets of 10 words each: (a) symptom words that referred to common bodily complaints

or physical sensations (e.g., dizziness, headache, nausea) considered as relevant for triggering illness concerns in patients with pathological health anxiety (e.g., Barsky, Coeytaux, Sarnie, & Cleary, 1993), (b) illness-related words that referred to known triggers and consequences of real physical disease processes (e.g., tumor, cancer, virus), and (c) kitchen- and (d) furniture-related words that served as corresponding neutral stimulus categories (see the appendix). The two health-threat-related word categories and their corresponding neutral words were matched in respect to category according to word length and average frequency in the written German language.

EST. To assess emotional-interference effects due to health-relevant stimuli as an index of attentional bias, we used a computerized version of the EST with a blocked design of the four different word categories (i.e., symptom words, corresponding neutral words, illness words, and corresponding neutral words). Within blocks, words were presented in random order generated anew for each participant. Every word was presented in four colors (green, red, blue, and yellow) and was shown until the participant responded to its color by pressing a corresponding key on the keyboard. After a brief stimulus interval of 40 ms (Hooff, Dietz, Sharma, & Bowman, 2008), the next word was presented on the screen. To familiarize participants with the positions of the four response keys, we used 80 practice trials that contained letter strings in the four different colors and provided feedback in case of errors.

Implicit Association Test (IAT). To study possible differences in implicit association regarding health-threatening information in patients with pathological health anxiety, we used two different computerized IATs: one that contained symptom words together with neutral comparison words (symptom-word IAT) and one that contained illness words and neutral comparison words (illness-word IAT). The applied words were the same as in the EST. The two adjectives "dangerous" and "harmless" served as attribute dimensions. In the congruent conditions, we combined symptom and illness words with "dangerous" and neutral words with "harmless." In the incongruent conditions, symptom and illness words were paired with "harmless" and neutral words with the attribute "dangerous." To reduce method variance, a fixed order of conditions (the incongruent condition was presented first) was used for both IATs and every participant.

The IAT (Greenwald, McGhee, & Schwartz, 1998) provides a measure of the strength of automatic associations between concepts and attributes. The underlying assumption is that responses will be faster and more accurate when concepts that are closely associated with attributes (e.g., "tumor" and "dangerous") share the same response.

The difference between latencies of correct responses to either congruent or incongruent pairings provides indices of relative associative strength (Nosek, Greenwald, & Banaji, 2007).

Recognition task (RET). In the RET, the original 40 stimuli (i.e., illness words, symptom words, and corresponding neutral words) were randomly mixed with 40 novel stimuli that were matched pairwise to the original stimuli according to word length, word frequency, and word category. The three preceding tasks (i.e., the EST and the two IATs) served as an incidental encoding phase. After completing the tasks, and after a short break of 2 min, participants were informed for the first time that they would now have to complete the RET. They were also informed about the ratio (50:50) of previously presented and novel distractor stimuli. The 80 words were presented in random order on the computer screen. The presentation of a single word lasted until participants pressed a button labeled with "yes" (word was already presented in the completed tasks) or with "no" (new word) on a standard computer keyboard.

The Self-Assessment Manikin (SAM). The SAM is a non-verbal pictorial method for the self-report of affective evaluation (Bradley & Lang, 1994). According to Bradley and Lang (1994), valence and arousal are two distinct dimensions fundamental to individual differences in emotional evaluations. In our computerized version of the SAM, we operationalized valence (from pleasant to unpleasant) and arousal (from very arousing to not arousing) by using the original 9-point answer format. Participants used a standard computer mouse to click on one of nine buttons corresponding to the different categories of the SAM valence and arousal dimensions. The 40 stimulus words were presented in fully randomized order generated anew for each participant. The SAM was administered to assess explicit emotional evaluations of the stimuli used in the experimental tasks described earlier.

Parameterization of experimental tasks. For the EST, reaction times (RTs) of erroneous responses (0.96% of all responses) were excluded from the analysis. The remaining RTs were corrected for outliers by excluding extremely long RTs (more than 2,000 ms; 1.02% of responses). No extremely short RTs (less than 300 ms) were observed.

For the IAT, implicit association effects were analyzed using three different approaches: First, difference scores between the RTs of the congruent- and incongruent-task condition were computed. Second, the D_2 measure proposed by Greenwald, Nosek, and Banaji (2003) was computed. For this measure, the difference between RTs of the congruent- and incongruent-task condition is divided

by the standard deviation of all the latencies in the two test blocks—$D_2 = [M(RTcongruent) – M(RTincongruent)] / SD(RTcongruent + RTincongruent)$. Before computing the D score, latencies of less than 400 ms and more than 10,000 ms are excluded from the analysis. The D_2 measure contains a built-in error penalty, that is, latencies of erroneous responses and the time required to produce a correct response are included in the computation of the D_2 measure. Despite its common usage, it is necessary to acknowledge that the D score represents a rather atheoretical scoring algorithm in which accuracy and latency information are combined in a rather heuristic way and speed-accuracy trade-offs might be blurred.

To overcome this problem, we computed diffusion-model parameters according to the EZ-diffusion model (Wagenmakers, Van der Maas, & Grasman, 2007). The EZ-diffusion model is a simplified variant of the full diffusion model (e.g., Ratcliff, Gomez, & McKoon, 2004), which represents an elegant theory-driven solution to combine the analysis of speed and accuracy information on the basis of a cognitive theory of response behavior in speeded two-choice RT tasks (Wagenmakers, 2009). In the EZ-diffusion model, RTs, variabilities of RTs, and response accuracies are used to compute three theory-driven indicators of task performance: (a) the quality and ability of information uptake (drift rate), (b) response conservativeness (boundary separation), and (c) processes of stimulus encoding and motor-response preparation (nondecision time). The diffusion-model approach has been previously used to analyze the data of the IAT (e.g., Klauer, Voss, Schmitz, & Teige-Mocigemba, 2007) and has been suggested to "provide a theory-based mean to partial out construct-irrelevant variance in IAT effects" (Schnabel, Asendorpf, & Greenwald, 2008, p. 211).

Recognition performance in the RET was analyzed by computing the discrimination parameter d' (i.e., a measure of the ability to discriminate new stimuli from words formerly presented in the EST and the two IATs; Macmillan & Creelman, 1990) from signal detection theory. Response bias was analyzed by computing the parameter c as a measure for quantifying the likelihood of responding yes or no in a decision task ($c = 0.5 \times [z(hits) + z(false alarms)]$; Macmillan & Creelman, 1990). A c value of 0 corresponds to unbiased responding, whereas negative values of c indicate a liberal response style and positive values a more conservative response style.

Procedure

All participants were tested individually in a session lasting approximately 1.5 hr. Before starting the experiment, participants provided written informed consent. Subsequently, they were asked to answer further questionnaires measuring potential vulnerability and maintaining factors for health anxiety and depression. Then, participants completed the EST, followed by the illness-word IAT, the symptom-word IAT, and the RET. Finally, participants used the SAM to evaluate the valence and arousal level of the stimuli included in the experiments.

Results

Participant characteristics and symptom measures

Table 1 shows sociodemographic characteristics as well as the results of the symptom measures and diagnostic interviews. The groups did not differ significantly with respect to age, gender, and education. Yet proportionally fewer of the participants in the DCG were married or in a stable relationship than were those from the two other groups. Participants in the PHG scored significantly higher on the WI, SHAI, and PHQ-15 than did members from both the DCG and the HCG. The DCG had significantly higher scores on the PHQ-9 Depression Scale than did the other groups. Health-anxiety-related comorbid anxiety disorders (generalized anxiety disorder, panic disorder, and obsessive-compulsive disorder) were significantly more frequent in the PHG than in the DCG (see Table 1).

EST

To test the hypothesis of a stronger attentional bias toward symptom- and illness-related word stimuli in the PHG, compared with the two control groups (i.e., HCG and DCG), we subjected the mean RT data of the four different word categories (i.e., symptom words, corresponding neutral words, illness words, corresponding neutral words) to a 3 (Group: PHG vs. HCG vs. DCG) × 2 (Word Valence: health related vs. neutral) × 2 (Type of Health Threat: illness words vs. symptom words) mixed analysis of variance (ANOVA). Results showed a main effect of word valence, $F(1, 189) = 35.05$, $p < .001$, $\eta_p^2 = .16$, thereby indicating that health-related words elicited an emotional-interference effect (i.e., elicited slower responses than did neutral words). This main effect of word valence was significantly moderated by the group factor (Word Valence × Group interaction), $F(2, 189) = 8.38$, $p < .001$, $\eta_p^2 = .08$, which suggested group differences regarding emotional interference toward health-related stimuli. No other main or interaction effect reached significance ($Fs \leq 1.97$, $ps \geq .14$). As expected, post hoc t tests revealed that the Word Valence × Group interaction was attributable to generally stronger emotional-interference effects in the PHG compared with the HCG ($p \leq .001$, $d = 0.69$) and the DCG ($p = .014$, $d = 0.44$), whereas the HCG and the DCG did not differ in

Table 1. Sample Characteristics by Group

Measure	Pathological health anxiety group (n = 88)	Depressive control group (n = 52)	Healthy control group (n = 52)	F	χ^2	Post hoc group comparisons[a]
Age (years)	43.5 (11.7)	42.7 (11.6)	42.1 (12.9)	0.2		—
Gender (% female)	62.5	55.8	59.6		0.6	—
Education (% ≥ 12 years)	63.6	59.6	69.2		1.1	—
Married/stable relationship (% yes)	63.6	36.5	57.7		9.9**	2 < 1, 3
Whiteley Index	10.5 (1.8)	2.0 (1.5)	0.7 (0.9)	956.5***[b]		1 > 2 > 3
Short Health Anxiety Inventory	28.9 (4.9)	9.0 (3.6)	5.8 (2.8)	662.3***[b]		1 > 2 > 3
Depressive symptoms (PHQ-9)	10.4 (5.2)	17.3 (3.9)	1.7 (2.0)	360.1***[b]		2 > 1 > 3
Somatic symptoms (PHQ-15)	14.1 (5.0)	10.4 (3.8)	2.9 (2.3)	194.2***[b]		1 > 2 > 3
Global Assessment of Functioning	66.4 (11.1)	60.6 (9.6)	94.1 (6.7)	279.7***[b]		2 < 1 < 3
Health anxiety diagnosis according to Fink et al. (2004) criteria (%)						
Mild	37.5	0	0			
Severe	62.5	0	0			
Current *DSM–IV* diagnosis (%)						
Hypochondriasis	65.9	0	0		98.2***	1 > 2, 3
Somatization disorder	2.3	0	0		2.4	—
Pain disorder	4.5	0	0		4.8	—
Major depression	23.9	90.4	0		102.3***	2 > 1 > 3
Dysthymia	10.2	38.5	0		33.0***	2 > 1 > 3
Generalized anxiety disorder	10.2	0	0		11.2**	1 > 2, 3
Panic disorder	38.6	0	0		48.8***	1 > 2, 3
Social phobia	13.6	25.0	0		14.4***	1, 2 > 3
Specific phobia	17.0	13.5	3.8		5.3	—
Obsessive-compulsive disorder	10.2	0	0		11.2**	1 > 2, 3
Posttraumatic stress disorder	3.4	0	0		3.6	—
Bulimia nervosa	1.1	3.8	0		2.7	—
Current somatic diagnosis with complaints	26.2	39.2	0		21.7***	1, 2 > 3

Note: Unless otherwise indicated, the table provides means for each measure. Standard deviations are shown in parentheses. PHQ = Patient Health Questionnaire.
[a]1 = pathological health anxiety group; 2 = depressive control group; 3 = healthy control group.
[b]Welch test followed by Tamhane T2 post hoc tests.
**p < .01. ***p < .001.

their attentional bias toward health-related stimuli (p = .24, d = 0.24; see Fig. 1 for emotional-interference effects).

IAT

RTs. For each health-threat word category (e.g., illness and symptom words), we first computed RT difference scores between the congruent-IAT conditions (i.e., health-threat words paired with the attribute "dangerous") and the incongruent-IAT conditions (i.e., health-threat words paired with the attribute "harmless") as indicators of automatic evaluation processes. Subsequently, we subjected these indicators to a multivariate ANOVA (MANOVA) with group (PHG vs. HCG vs. DCG) as the between-subjects factor. Results showed a significant multivariate effect of group—Pillai's trace: $F(4, 378)$ = 2.64, p = .033,

η_p^2 = .03—and subsequent ANOVAs indicated that the three groups differed significantly in the strengths of their implicit evaluation of both illness words, $F(2, 189)$ = 3.06, p = .049, η_p^2 = .03, and symptom words, $F(2, 189)$ = 4.55, p = .012, η_p^2 = .05. Consistent with our hypotheses, results from post hoc t tests revealed that compared with the HCG, the PHG had significantly stronger negative implicit evaluations of illness (p = .025, d = 0.40) and symptom (p = .029, d = 0.39) words. However, compared with the DCG, the PHG showed stronger negative evaluations of symptom words (p = .009, d = 0.46) but not (significantly) for illness words (p = .088, d = 0.30).

D_2 *score.* We subjected the D_2 measures for illness words and symptom words to a MANOVA with group (PHG vs. HCG vs. DCG) as the between-subjects factor.
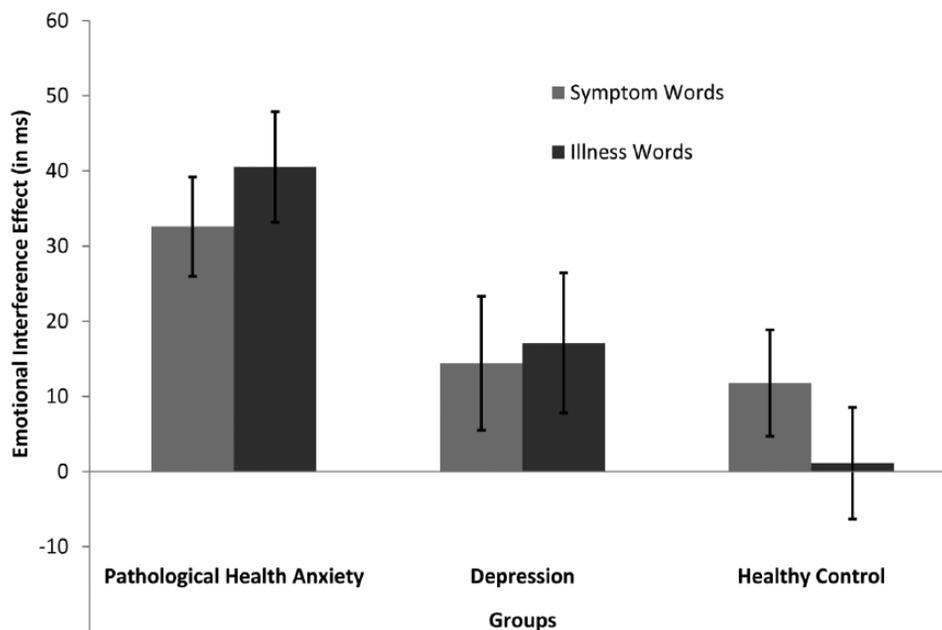
Fig. 1. Emotional-interference effects (in ms; latencies of health-related word categories minus latencies of neutral word categories) derived from the emotional Stroop task for symptom and illness words for the pathological health anxiety, depressive control, and healthy control groups. Error bars represent standard errors of the mean.

Results showed no evidence for a significant group difference regarding the D_2 measures—Pillai's trace: $F(4, 378) = 0.70$, $p = .590$, $\eta_p^2 < .01$.

EZ-diffusion-model parameters. We subjected the EZ parameters of the illness- and symptom-word IATs separately to 3 (Group: PHG vs. HCG vs. DCG) × 2 (Congruency: congruent-IAT vs. incongruent-IAT condition) mixed ANOVAs (see Fig. 1 in the Supplemental Material available online).

For the drift-rate parameter, main effects for the factor congruency were obtained—illness words: $F(1, 189) = 226.32$, $p < .001$, $\eta_p^2 = .55$; symptom words: $F(1, 189) = 297.70$, $p < .001$, $\eta_p^2 = .61$—which indicated that the quality of information accumulation was generally higher in the congruent condition compared with the incongruent condition. This main effect was not moderated by the group factor ($Fs \leq 1.63$, $ps \geq .19$), and no main effect for the group factor was observed ($Fs \leq 1.04$, $ps \geq .35$). Thus, groups did not differ significantly regarding the process of information accumulation in both IAT tasks.

In an analogous 3 × 2 mixed ANOVA for the boundary-separation parameter as an index of speed-accuracy trade-off, main effects emerged for the factor congruency—illness words: $F(1, 189) = 27.01$, $p < .001$, $\eta_p^2 = .13$; symptom words: $F(1, 189) = 56.47$, $p < .001$, $\eta_p^2 = .23$—thereby indicating that responses were executed more conservatively in the incongruent condition compared with the congruent condition. In the case of the symptom-word

IAT (but not the illness-word IAT), this congruency effect was significantly moderated by the group factor, $F(2, 189) = 4.47$, $p = .013$, $\eta_p^2 = .05$. Post hoc tests indicated that this interaction effect was mainly attributable to group differences within the incongruent-IAT condition, $F(2, 189) = 3.57$, $p = .030$, $\eta_p^2 = .04$. Post hoc t tests showed that the PHG had a significantly more conservative response behavior (i.e., a stronger tendency to avoid errors at the expense of slower response) compared with the HCG ($p = .020$) and the DCG ($p = .042$). Furthermore, significant and marginally significant main effects of the group factor were observed for illness words, $F(2, 189) = 3.55$, $p = .031$, $\eta_p^2 = .04$, and symptom words, $F(2, 189) = 2.61$, $p = .076$, $\eta_p^2 = .03$. According to post hoc t tests, the PHG responded significantly more conservatively than did the HCG in the illness-word IAT ($p = .008$, $d = 0.47$). In the symptom-word IAT, again, the PHG responded significantly more conservatively than did the HCG ($p = .022$, $d = 0.40$), but neither the PHG ($p = .508$, $d = 0.12$) nor the HCG ($p = .155$, $d = 0.28$) differed significantly from the DCG.

Analyses of the nondecision-time parameter (as an index of stimulus-encoding and response-preparation processes) showed main effects for the congruency factor—illness words: $F(1, 189) = 187.13$, $p < .001$, $\eta_p^2 = .50$; symptom words: $F(1, 189) = 235.60$, $p < .001$, $\eta_p^2 = .56$—thereby suggesting that in the incongruent condition, processes of stimulus encoding and response preparation took significantly longer than in the congruent
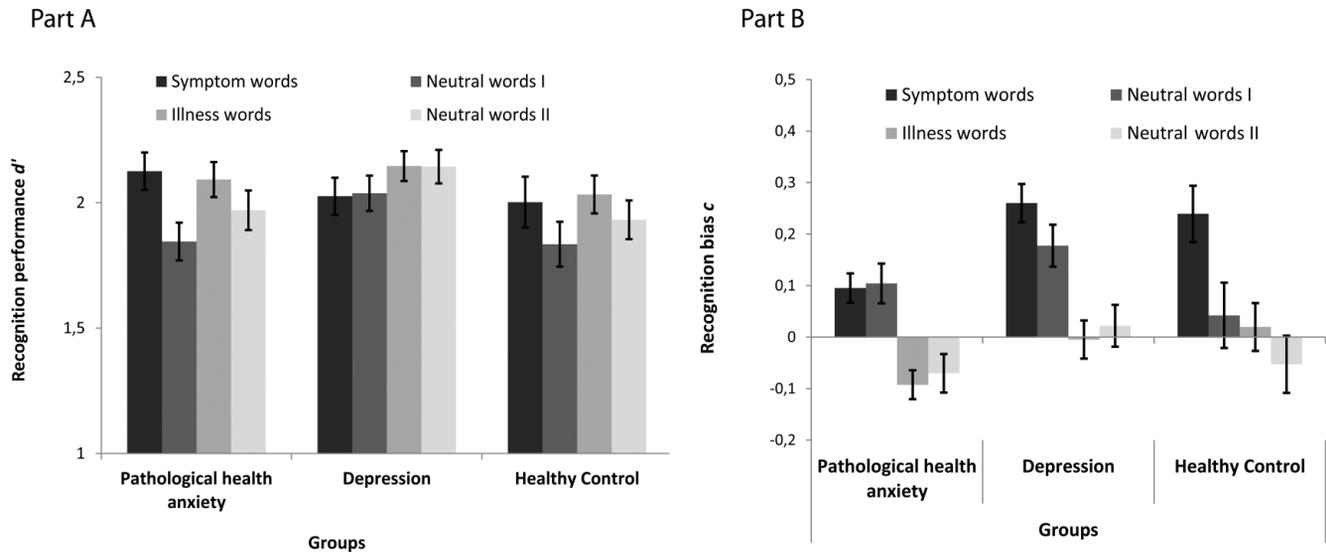
Part A

Part B

Fig. 2. Performance in the recognition task by participant group. The graphs show results for the (a) discrimination index (d') and (b) response-bias index (c). Error bars represent standard errors of the mean.

condition. In the case of the illness-word IAT (but not the symptom-word IAT), this congruency effect was significantly moderated by the group factor, $F(1, 189) = 3.40$, $p = .035$, $\eta_p^2 = .04$. According to post hoc tests, the three groups differed especially regarding their nondecision time in the congruent-IAT condition, $F(2, 189) = 4.57$, $p = .011$, $\eta_p^2 = .05$: The PHG showed significantly shorter nondecision times compared with the HCG ($p = .004$) and marginally shorter nondecision times compared with the DCG ($p = .066$). The findings suggested that processes of stimulus encoding and motor responses concerning illness stimuli were executed more quickly in the PHG than in the other groups.

RET

Sensitivity (d'). The d' scores for illness, symptom, and neutral words were subjected to a 3 (Group: PHG vs. HCG vs. DCG) × 2 (Word Valence: health related vs. neutral) × 2 (Type of Health Threat: illness words vs. symptom words) mixed ANOVA. Results showed a main effect of word valence, which indicated that health-threat-related words were better recognized than were neutral words, $F(1, 189) = 9.75$, $p = .002$, $\eta_p^2 = .05$ (see Fig. 2 for participants' performance in the RET). Most important, a significant Word Valence × Group interaction effect emerged, $F(2, 189) = 3.10$, $p = .047$, $\eta_p^2 = .03$. Post hoc t tests indicated that both the PHG ($p < .001$, $d = 0.32$) and the HCG ($p = .054$, $d = 0.25$) recognized health-threat-related words significantly more accurately than neutral words, whereas individuals in the DCG did not show this word-category effect in their recognition performance ($p = .946$, $d = 0.01$). Moreover, the PHG

recognized health-threat words, compared with neutral words, better than the DCG did ($p = .013$, $d = 0.47$) but not better than the HCG ($p = .399$, $d = 0.15$).

Response bias (c). The c values for illness, symptom, and neutral words were subjected to a 3 (Group: PHG vs. HCG vs. DCG) × 2 (Word Valence: health related vs. neutral) × 2 (Type of Health Threat: illness words vs. symptom words) mixed ANOVA. Results showed a main effect for word valence, which indicated that the response behavior toward health-threat-related words was generally more conservative than toward neutral comparison words, $F(1, 189) = 3.99$, $p = .047$, $\eta_p^2 = .02$. A significant Group × Word Valence interaction effect, $F(2, 189) = 3.41$, $p = .035$, $\eta_p^2 = .04$, indicated that groups differed in their response style (see Fig. 2). Post hoc comparisons of the groups for the single word categories indicated that the PHG responded significantly more liberally (i.e., by responding "yes, word was present") to the symptom words than did the HCG ($p = .011$, $d = 0.46$) and the DCG ($p = .001$, $d = 0.62$). A similar pattern of results was observed for the illness words: The PHG responded significantly more liberally to illness words than did the HCG ($p = .030$, $d = 0.39$) and marginally more liberally than did the DCG ($p = .060$, $d = 0.33$). The three groups did not differ significantly in their response style for neutral comparison words ($ps \geq .076$).

Explicit emotional evaluation (SAM)

To test for group differences in explicit emotional evaluations of the health-threat-related words relative to the neutral words, we subjected difference scores of the

valence and arousal ratings (i.e., evaluation of health-threat words minus evaluation of neutral words; see Fig. 2 in the Supplemental Material) of the SAM task separately to 3 (Group: PHG vs. HCG vs. DCG) × 2 (Type of Health Threat: illness words vs. symptom words) mixed ANOVAs. Prior to the analysis of the arousal ratings, 1 participant from the PHG group was excluded from analysis as a result of extreme outlier values in the SAM arousal ratings.

For the valence ratings, a main effect of type of health threat emerged, $F(1, 189) = 194.62$, $p < .001$, $\eta_p^2 = .51$, which indicated that the illness words were generally rated as more negative than were the symptom words. Moreover, a main effect of group, $F(2, 189) = 7.94$, $p < .001$, $\eta_p^2 = .08$, indicated that the three groups differed in their evaluation of the health-threat words. Post hoc t tests showed that the PHG rated symptom words significantly more negatively than did the HCG ($p = .038$, $d = 0.37$) and the DCG ($p < .001$, $d = 0.63$). Regarding illness words, the PHG showed significantly more negative evaluations compared with the DCG ($p < .001$, $d = 0.70$) but not with the HCG ($p = .175$, $d = 0.24$). The HCG and the DCG differed significantly in their evaluation of health-threat words as a result of more negative evaluations of illness words in the HCG ($p = .017$, $d = 0.47$).

Results for the arousal ratings showed a strong main effect of type of health threat, $F(1, 188) = 226.98$, $p < .001$, $\eta_p^2 = .55$, thereby indicating that illness words were rated as more arousing than were symptom words. A main effect of group, $F(2, 188) = 35.45$, $p < .001$, $\eta_p^2 = .27$, suggested that the three groups differed significantly in their evaluation of the arousal level. There was a significant interaction between group and the type of health threat as well, $F(2, 188) = 4.12$, $p = .018$, $\eta_p^2 = .04$, which suggests that group differences were moderated by the type of health-threat words. Post hoc t tests indicated that the PHG rated illness and symptom words as significantly more arousing than did both the HCG and the DCG (all ps < .001). In contrast to symptom words ($p = .185$, $d = 0.26$), the HCG differed from the DCG for illness words ($p = .017$, $d = 0.48$). The Group × Type of Health Threat interaction was attributable to significantly larger differences in arousal ratings between symptom words and illness words (i.e., a more arousing evaluation of illness words relative to symptom words) in the HCG compared with the PHG ($p = .006$, $d = 0.50$) and the DCG ($p = .024$, $d = 0.45$).

Association between evaluation bias and memory bias

To test for possible associations between the observed memory bias in the PHG (i.e., the more liberal response bias in the case of health-threat words and, especially,

symptom words) and the evaluation bias, we computed explorative correlations between the explicit (SAM) measures of evaluation and the response-bias score c of the recognition paradigm in the PHG ($n = 88$).[2] Medium-sized negative associations were observed between the c parameter for symptom words and the valence and arousal ratings of symptom and illness words within the PHG (see Table 2).[3] These findings suggested that stronger negative evaluations of health-threat words (in terms of both valence and arousal) were related to a more liberal response behavior for symptom words but not for illness words.

Discussion

Current models of pathological health anxiety highlight the importance of differences in the processing of health-related information. On the basis of the idea that multiple cognitive biases operate in concert in emotional disorders (i.e., the combined-cognitive-bias hypothesis; Hirsch et al., 2006), in the current study, we aimed to clarify the role of different information-processing biases in pathological health anxiety by focusing on processes of attention allocation, memory bias, and evaluation on both an implicit and an explicit level. In addition, associations between indicators of emotional evaluation of health-threat-related stimuli and indicators of memory bias (as proposed in the theory of associative strengths of object evaluations; Ferguson et al., 2007) were tested. Finally, we sought to investigate the specificity of altered information processing by including a clinical control group of individuals with a depressive disorder.

In general, the findings confirm and extend the results of previous studies both in patients with pathological health anxiety and in analog studies with college students. Consistent with cognitive models of health anxiety, our results showed an attentional bias to both symptom words and illness words in the PHG compared with the two control groups. This finding suggests that individuals suffering from pathological health anxiety have substantial difficulties in inhibiting symptom- and illness-related information and that this dysfunction is specific for patients with pathological health anxiety as compared with patients with a depressive disorder.

With respect to the findings of the EST paradigm, however, it is necessary to acknowledge that the issue of whether emotional-interference effects arise from automatically operating hyperactive threat-detection or defense systems or, rather, represent the consequence of a hypoactive attention-control mechanism is still under debate (e.g., Epp, Dobson, Dozois, & Frewen, 2012), with more evidence for the latter position, at least in the realm of post-traumatic stress disorder (e.g., Cisler et al., 2011). This latter interpretation of increased emotional-interference

Table 2. Pearson Correlation Coefficients Between Measures of Evaluation of Health-Threatening Stimuli and Measures of Memory Bias From the Recognition Task for the Pathological Health Anxiety Group

	Response bias (c)	
Explicit evaluation (SAM)	Symptom word	Illness word
Valence (Symptoms)	−.26*	−.19
Valence (Illnesses)	−.27*	−.10
Arousal (Symptoms)[a]	−.26*	−.15
Arousal (Illnesses)[a]	−.33**	−.16

Note: SAM = Self-Assessment Manikin (Bradley & Lang, 1994).
[a]One participant in the pathological health anxiety group was excluded from the analysis as a result of extreme outlier values in the SAM arousal ratings.
*$p < .05$. **$p < .01$.

effects as representing a failure to inhibit negative emotional stimuli also fits recent findings from our neuroimaging study in college students with high and low health anxiety (Witthöft et al., 2013) in which we observed a positive association between emotional-interference effects and hypoactivity of the rostral anterior cingulate cortex—a structure that is known for its central role in emotional-conflict resolution (Egner, Etkin, Gale, & Hirsch, 2008).

Similarly, the results concerning biased recognition memory of health-threat-related words were consistent with our hypothesis: Participants in the PHG, compared with those in the other two groups, showed a response bias (i.e., a more liberal response behavior) when they processed health-threat-related information, and this effect was strongest for symptom words. This finding is consistent with previous results (Pauli & Alpers, 2002) and suggests that pathological health anxiety is associated with a biased recognition memory for health-relevant stimuli—a finding that might be attributable to less efficient context-content binding as a result of the stronger negative valence and the higher arousal levels in response to illness and symptom words in patients with pathological health anxiety. The observation of significant associations between valence and arousal ratings (in the SAM) and recognition performance for health-threatening stimuli is consistent with this explanation. However, further studies that use more sophisticated experimental paradigms to study differences in memory and related binding processes (e.g., Oberauer, 2005) are necessary to clarify the exact mechanism of the observed memory bias in patients with pathological health anxiety.

For the hypothesized alteration in implicit evaluation, the findings were less clear. Across the different indicators of performance in the IAT, little evidence for altered implicit associations in the PHG compared with the two control groups could be observed. Although the RT data

and some of the parameters of the EZ-diffusion model yielded differences in the processing of health-threat-related stimuli, the primary dependent variables that are supposed to reflect implicit association effects (i.e., the D_2 score and the EZ-drift-rate parameter) did not show the expected stronger negative implicit association effects in the PHG compared with the two control groups. This finding comes as a surprise, given the importance assigned to dysfunctional beliefs, catastrophizing automatic thoughts, and negative evaluations of bodily sensations in cognitive models of health anxiety and hypochondriasis (e.g., Warwick & Salkovskis, 1990), and given the suggestion that the IAT might be suited to assess dysfunctional associations in experimental psychopathology research (e.g., De Houwer, 2002). It is necessary to acknowledge, however, that the IAT, in its current version (i.e., with health-threatening content), had not been used in individuals with pathological health anxiety until now.

Consequently, the validity of this approach—despite its face validity—remains to be demonstrated by future studies in which the IAT is compared with other measures that target an implicit assessment of symptom perception in health anxiety. It might therefore still be possible that an implicit evaluation bias for health-threatening content exists in pathological health anxiety but that this bias could not be observed by using the IAT methodology (e.g., as a result of the comparatively high demands on executive control processes and a high working memory load, which might disrupt a deeper emotional processing; Van Dillen & Koole, 2007). Although the main outcome parameters of the IAT did not support altered evaluation of the stimulus material, the diffusion-model analysis of the response behavior in the IAT provided first evidence for specific differences in the processing of health-related information in the PHG. These findings include a higher response conservativeness in the case of incongruent stimulus combinations for symptom words (i.e., compared with individuals in both control groups, participants in the PHG responded more slowly and more accurately when symptom words were paired with the potentially incongruent attribute "harmless") and faster stimulus-encoding and response-preparation processes for illness words. Both processes as well as the observation of stronger attention allocation in the EST and a more liberal response bias in the RET suggest alterations in cognitive processes that presumably reflect a higher salience of health-related information in the working memory of patients with pathological health anxiety, which is most likely due to hyperarousal associated with health- and illness-related stimuli (Johnson-Laird, Mancini, & Gangemi, 2006).

In contrast to the implicit emotional evaluation, the explicit emotional evaluation of health-threat-related

stimuli by means of the SAM, particularly the arousal ratings, yielded specific and robust group differences in the expected direction, that is, participants in the PHG rated symptom and illness words as more negative and more arousing than did participants in the two control groups. Stronger feelings of arousal associated with potentially health-threatening stimuli may serve as triggers or somatic cues that increase the salience of these stimuli and, in consequence, enhance the availability of the health-threatening information in the working memory of individuals with high health anxiety. This reasoning refers to "perceived arousal" rather than "physiological arousal" because, to our knowledge, there is currently no scientific evidence to suggest that individuals with pathological health anxiety have higher levels of phasic or tonic arousal or are better able to perceive phasic arousal. Psychophysiological studies, however, have suggested that compared with individuals with lower health anxiety, individuals with higher health anxiety tend to overestimate the occurrence of actual phasic changes in physiological arousal (Krautwurst, Gerlach, Gomille, Hiller, & Witthöft, 2014).

Regarding the comparison between implicit (i.e., IAT) and explicit (i.e., SAM) task performance, the findings represent first evidence for a possible dissociation between implicit and explicit emotional-evaluation processes in pathological health anxiety. At least three explanations might account for this finding: First, differences in emotional-evaluation effects might be more strongly related to explicit than to implicit processing in pathological health anxiety. Second, task characteristics and validity issues of the IAT might have prevented the detection of existing differences in implicit evaluation processes. In this regard, experimental evidence has suggested that the induction of working memory load is able to decrease emotional processing (e.g., Van Dillen & Koole, 2007), and successful performance in the IAT requires a considerable amount of working memory resources (i.e., executive control processes; Klauer, Schmitz, Teige-Mocigemba, & Voss, 2010). Third, use of the same set of word stimuli in the IATs that was previously used in the EST might have fostered emotional-habituation effects, although, because of the tendency of patients with health anxiety to ruminate about health-related information (Fink et al., 2004; Görgen, Hiller, & Witthöft, 2014), this habituation explanation appears rather unlikely. Related to this issue, we also cannot rule out the possibility that the use of the same word stimuli across the different experimental paradigms might have fostered systematic influences of the first paradigms (e.g., the EST) on the later paradigms. However, this interpretation also seems unlikely, given that the SAM ratings were conducted last after all other experiments.

Finally, our study is the first to find partial support for the hypothesis that the emotional evaluation of health-threat-related stimuli is associated with a health-threat-related memory bias in patients with pathological health anxiety. It is interesting that the valence and arousal evaluations were significantly related to the response-bias indicator (c) as an index of false-positive decisions or overreports of symptoms.

From a neuropsychological perspective, the finding that groups differed considerably in explicit emotional evaluations, particularly arousal, and that these were associated with memory-bias indicators, may suggest an enhanced involvement of the amygdala in the processing of health-threatening stimuli in the PHG. The amygdala is considered to act as a general salience detector (e.g., Santos, Mier, Kirsch, & Meyer-Lindenberg, 2011) and seems to signal the emotional significance of stimuli in EST-like tasks (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006). In a previous study from our group, we were able to demonstrate that participants with subclinical health anxiety had less efficient rostral anterior cingulate activation in response to symptom words in an EST (Witthöft et al., 2013). The rostral anterior cingulate has direct connections to the amygdala (Pezawas et al., 2005) and helps to reduce resulting emotional conflict in EST-like tasks (Etkin et al., 2006). Thus, the present results of increased arousal in response to potentially health-threatening stimuli in the PHG suggest a hyperactive amygdala that is less efficiently regulated by the rostral anterior cingulate. From this neurobiological perspective, therapeutic interventions that aim to modify the observed biases (e.g., Kerstner et al., 2015) might be most successful when targeting a reduction of the arousal level of health-threat-related information by strengthening rostral anterior cingulate–amygdala coupling (e.g., by exposure-based techniques).

Several limitations should be considered in interpreting our findings: The results regarding alterations in cognitive processes (i.e., cognitive biases) in the PHG, compared with the two control groups, are limited by the experimental tasks used to assess biased cognition. In this regard, validity issues have been raised for both the EST and the IAT, and it is necessary to acknowledge that neither the EST nor the IAT represent process-pure measures of either attentional-bias or implicit evaluation processes (e.g., De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). The EST has been fundamentally criticized because the underlying mechanism that causes the emotional-interference effect remains unclear. It has been suggested that the interference results from attempts to suppress or avoid the meaning of critical stimuli rather than from an attentional bias toward these critical stimuli (e.g., de Ruiter & Brosschot, 1994). The IAT represents a

comparatively novel approach to psychopathology research and has very rarely been used in the realm of pathological health anxiety. Accordingly, further studies are needed to investigate the validity of the IAT used in our study. Given the high rate of comorbid anxiety disorders and affective disorders in the PHG, we cannot rule out the possibility that this comorbidity is partly responsible for the observed group differences regarding cognitive biases. Finally, the lack of another clinical control group, especially a group of individuals with anxiety disorders, represents a shortcoming of the current study that should be addressed in future studies.

In sum, the current study provides a thorough investigation of cognitive processes and biases in a large sample of carefully selected and diagnosed patients who suffer from pathological health anxiety. By using another clinical comparison group of patients with a depressive disorder, it could be demonstrated that some of the observed differences regarding processes of evaluation, attention allocation, and memory were rather specific for pathological health anxiety. Consistent with the combined-cognitive-bias hypothesis (Hirsch et al., 2006), the findings suggest that multiple cognitive biases are simultaneously present in pathological health anxiety. It is hypothesized that a higher salience of health-threat-related content in the working memory of individuals with pathological health anxiety is linked to the observed biases and that higher levels of arousal associated with health-threatening content play a key role in causing the observed cognitive biases. In future studies, researchers should apply functional brain imaging to investigate altered salience of health-threatening information for patients with pathological health anxiety. Moreover, further research should aim at testing modification procedures to overcome these presumably salience-related processing biases in pathological health anxiety.

Appendix

Original (German) Stimulus Words Used in the Emotional Stroop Task, the Two Implicit Association Tasks, and the Recognition Task

Symptom word	Neutral word (1)	Illness word	Neutral word (2)
Schwindel (Dizziness)	Toaster (Toaster)	Tumor (Tumor)	Lampe (Lamp)
Übelkeit (Nausea)	Kochlöffel (Wooden spoon)	Bakterien (Bacteria)	Bücherregal (Bookshelf)
Kopfschmerzen (Headache)	Waschbecken (Basin)	Viren (Viruses)	Sessel (Chair)
Durchfall (Diarrhea)	Besteck (Canteen)	Hirnschlag (Stroke)	Schrankwand (Wall unit)
Atemnot (Breathlessness)	Teelöffel (Teaspoon)	Herzinfarkt (Heart attack)	Stehlampe (Floor lamp)
Schmerzen (Pain)	Schüssel (Bowl)	Geschwür (Abscess)	Vorhang (Curtain)
Herzrasen (Tachycardia)	Handfeger (Hand brush)	Krebs (Cancer)	Tisch (Table)
Erbrechen (Sickness)	Esslöffel (Soup spoon)	Infektion (Infection)	Wäschekorb (Laundry basket)
Bauchschmerzen (Abdominal pain)	Topflappen (Oven gloves)	Grippe (Flu)	Esstisch (Dining table)
Husten (Cough)	Teller (Plate)	Ersticken (Suffocation)	Schuhregal (Cupboard)

Note: English translations are shown in parentheses.

Author Contributions

M. Witthöft, J. Bailer, C. Diener, and F. Rist developed the study concept. D. Mier contributed to the study design. T. Kerstner, J. Ofer, and J. Bailer performed the testing and collected the data. M. Witthöft analyzed the data, and J. Bailer, D. Mier, and F. Rist contributed to the interpretation. M. Witthöft drafted the manuscript, and all authors provided critical revisions. All authors approved the final version of the manuscript for submission.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

Additional supporting information may be found at http://cpx .sagepub.com/content/by/supplemental-data

Notes

1. Following Marcus, Gurley, Marchi, and Bauer (2007), we refer to *health anxiety* as a continuous dimension (ranging from absent health anxiety to severe health anxiety) and to *hypochondriasis* as its clinical endpoint (defined by the *Diagnostic and Statistical Manual of Mental Disorders*; 4th ed., text rev.; American Psychiatric Association, 2000). Because of fundamental criticism of the diagnostic criteria for hypochondriasis according to the fourth edition of the *DSM* (American Psychiatric

Association, 1994; e.g., Fink et al., 2004) and the controversial revision of hypochondriasis in the two new diagnostic categories of somatic symptom disorder and illness anxiety disorder in the fifth edition of the *DSM* (American Psychiatric Association, 2013; e.g., Bailer et al., 2015), we based the diagnosis of *pathological health anxiety* in this study on the empirically established criteria as proposed by Fink et al. (2004). Throughout this article, we therefore use the term *pathological health anxiety* when we refer to our main study group instead of the former term *hypochondriasis*.

2. Because no consistent group differences were observed for the discrimination parameter d' of the RET, the correlational analysis was limited to the response-bias indicator for which specific effects for the PHG were observed.

3. For reasons of parsimony, correlational findings within the total sample and the two control groups (HCG and DCG) are not reported, given that none of the associations observed in the PHG reached significance in the two control groups.

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