Contamination-fear in subclinical obsessive-compulsive disorder: A further proof for no preferential processing of disorder-related stimuli

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Abstract

How do individuals with obsessive-compulsive disorder (OCD) process and respond to images of rotten food or dirty toilets? In contrast to other fear-related disorders, evidence for attentional biases and preferential processing of disorder-related stimuli in samples of OCD is mixed. To address methodological problems of previous studies and to increase validity, we used two independent samples of participants with contamination fear and two sets of standardized stimuli in an established experimental paradigm. In two experiments, we compared evaluation and visual processing of contamination-fear related (CFr) stimulus material in individuals with high (HCF) and low (LCF) contamination fear. In experiment 1, we selected CFr stimuli from a database with disgust-related images (DIRTI). Even though the HCF group rated CFr images as being more unpleasant, arousing, and disgusting, we found no indicators of preferential processing (larger priming effects or faster response times). In experiment 2, we selected CFr stimuli from a database with images specifically chosen to evoke symptom-related anxiety in OCD patients (BOCD-PS). Again, negative evaluations of stimuli did not transfer into enhanced information processing. We conclude that early information processing of CFr stimuli is fundamentally different to that of fear-related stimuli in anxiety disorders; probably because of the triggered disgust response.

Keywords: Obsessive–compulsive disorder; washer; priming; attentional bias; visuomotor processing

1. Introduction

The fast detection and response to fear-related situations and stimuli in our environment is one of the most important and evolutionary significant tasks of the human visual and motor system. However, which situations and stimuli are regarded as fear-related is not at all universal. Different individuals strongly differ in their evaluations with respect to fear relevance. This is most evident when considering individuals with anxiety disorders such as social (Eastwood et al., 2005) or specific phobias (Lipp & Waters, 2007; Öhman, Flykt, & Esteves, 2001; but see Tipples, Young, Quinlan, Broks, & Ellis, 2002) or individuals with contamination fear in obsessive-compulsive disorder (OCD; Cisler, Olatunji, & Lohr, 2009). Individuals suffering from OCD are affected by intrusive thoughts and preoccupations, as well as rituals and compulsions that are often related to specific stimuli. Specifically, identifiable, potentially contaminated objects such as door handles and toilettes evoke contamination fear typically resulting in washing rituals (Summerfeldt & Endler, 1998).

In line with findings for other fear-relevant stimuli, some studies do report fast detection and reaction to such contamination-fear-related (CFr) stimuli. But why is it important for diagnosis and therapy of OCD to (further) understand the related cognitive processes (such as attentional biases)? According to Armstrong and colleagues (2012) attentional biases in OCD–and specifically in contamination fear–might influence the course of the disorder. The authors suggest that “an attention bias for contamination may predict behavioral avoidance of contamination risks encountered in everyday life” (p. 233). This would also have consequences for therapy, specifically, attention retraining studies might be effective in treating contamination-fear-related OCD (Najmi & Amir, 2010). Given the potential relevance of attentional biases for diagnosis and therapy of OCD, further studies should document the presence and estimate the magnitude of these biases in contamination fear.

1.1 Studies on attention in OCD

Unfortunately, the evidence for attentional biases in patients suffering from OCD is mixed. Some studies with patients having different subtypes of OCD (e.g. washer and checker) reported different attentional effects: That means they either reported an attentional bias/vigilance bias towards threatening stimuli (Amir, Najmi, & Morrison, 2009; da Victoria, Nascimento, & Fontenelle, 2012) or an disengagement/maintenance attentional bias (Bradley et al., 2016; Moritz, Mühlenen, Randjbar, Fricke, & Jelinek, 2009) or both (Lavy, van Oppen, & van den Hout, 1994; Rao, Arasappa, Reddy, Venkatasubramanian, & Reddy, 2010)–while others did not find attentional effects (Harkness, Harris, Jones, & Vaccaro, 2009; Kampman, Keijsers, Verbraak, Näring, & Hoogduin, 2002; Kyrios & Iob, 1998; Moritz et al., 2004; Moritz et al., 2008; van den Heuvel et al., 2005). Since OCD is a heterogeneous disorder (e.g. symmetry vs. checking vs. contamination; Mataix-Cols, Rosario-Campos, & Leckman, 2005), attentional effects may vary between different subtypes and, thus, the reported results might be mitigated by averaging across subtypes within the experimental group. Additionally, different studies used different experimental paradigms (such as *Dot Probe,* MacLeod, Mathews, & Tata, 1986; *Emotional* Stroop Watts, McKenna, Sharrock, & Trezise, 1986; *Inhibition Of Return,* Posner & Cohen, 1984) which measure different aspects of information processing such as attentional facilitation, difficulty to disengage attention, or attentional inhibition (Cisler & Koster, 2010). Another reason for the diverse findings might be the choice of stimuli. A number of previous studies used OCD-related words which might be less effective in eliciting emotions and, thus, less effective in grabbing attention of participants compared to natural images of fear-related objects (Lench, Flores, & Bench, 2011). Hinojosa, Carretié, Valcárcel, Méndez-Bértolo and Pozo (2009) argue affective pictures might be preferentially processed due to their higher ecological validity (but see: Bayer & Schacht, 2014). Finally, heterogeneous findings might be based on comorbid depression in participants which is known to reduce attentional effects by decelerating response speed (McDermott & Ebmeier, 2009) or via an associated hypervigilance towards negative emotional stimuli (Joormann & Gotlib, 2007).

With the present study, we aimed to control for these possible biases by (1) focusing on one subtype of OCD, (2) applying a sensitive measure on early information processing, (3) presenting pictorial stimuli with high ecological validity, and (4) excluding participants with comorbid depression.

1.2 Studies on attention in the washing subtype of OCD

We decided to study the washing subtype of OCD as a promising candidate for attentional biases or preferential processing of CFr stimuli because fear objects are very specific (e.g. dirty toilettes, contaminated door handles) in contrast to stimuli associated with, for example, symmetry and ordering. Note that, contamination fear differs from other subtypes (symmetry and ordering, hoarding, obsessions and checking; Mataix-Cols et al., 2005) concerning the elicited emotions. While intrusive thoughts of the other subtypes are clearly associated with fear, individuals with contamination fear additionally report disgust when confronted with CFr stimuli (McKay, 2006).

Even studies focusing on subclinical or clinical groups with a single subtype show equivocal results. Specifically, a number of earlier studies on contamination fear reported an early attentional/vigilance bias towards CFr stimuli (Najmi & Amir, 2010; Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996) or a disengagement/maintenance bias (Cisler & Olatunji, 2010) or both (Foa, Ilai, McCarthy, Shoyer, & Murdock, 1993)–but contemporary studies did not (Cludius, Külz, Landmann, Moritz, & Wittekind, 2017; Cludius, Wenzlaff, Briken, & Wittekind, 2017).

1.3 Response Priming and pictorial stimuli

In the present study, we employed a sensitive paradigm to further investigate the early attentional bias in individuals with contamination fear: the response priming paradigm taps into the earliest stages of observable behavior (Klotz & Neumann, 1999; Klotz & Wolff, 1995; Schmidt, Haberkamp, & Schmidt, 2011; Vorberg, Mattler, Heinecke, Schmidt, & Schwarzbach, 2003), has a high sensitivity to initial attentional biases and reflects preferential processing. Additionally, the paradigm yielded consistent and reliable findings in several previous studies on anxiety disorders (Haberkamp & Schmidt, 2014; Haberkamp & Schmidt, 2015; Haberkamp, Schmidt, & Schmidt, 2013). Since previous studies emphasized the influence of pictorial stimuli on emotion (Hinojosa et al., 2009; Lench et al., 2011), we used pictures from two standardized picture systems (DIRTI: *Disgust-RelaTed-Images Database*, Haberkamp, Glombiewski, Schmidt, & Barke, 2017; BOCD-PS: Berlin Obsessive Compulsive Disorder-Picture Set, Simon, Kischkel, Spielberg, & Kathmann, 2012). The DIRTI Database comprises images addressing various aspects of disgust–an emotion playing an important role in the washing subtype of OCD (Cisler, Olatunji, & Lohr, 2009). The BOCD Picture Set on the other hand comprises images specifically chosen to evoke responses in individuals with clinical and subclinical OC symptoms. Using standardized picture sets, compared to unstandardized lexical stimuli of previous studies, will further increase validity and reliability of our results. To conclude, the present study uses two independent samples of participants and two sets of standardized stimuli in an established experimental paradigm to contribute to a deeper understanding of information processing of CFr stimuli in subclinical OCD.

1.4 The present study

In the first of two experiments, a group of participants with high contamination fear (HCF) and a control group with low contamination fear (LCF) responded to natural images of CFr images (i.e. pictures of blood and injuries, dirty bathrooms, disgust-related animals such as rats and pigeons, rotten food; cf. Fig. 1) drawn from the DIRTI Database (Haberkamp et al., 2017) and neutral images of household aids (e.g. vacuum cleaner, cutlery). They rated the images on the dimensions of valence, arousal, and disgust (*emotional rating task*) and performed speeded responses in a response priming experiment (*priming task*). In response priming, participants classify target stimuli into different response categories (e.g. CFr versus neutral images) by performing a speeded motor response. The target stimulus (e.g. a dirty trashcan) is preceded by a prime stimulus triggering either the same response as the target (*consistent prime*; e.g. dirty feet) or the opposite response (*inconsistent prime*; e.g. a neutral household aid). Consistent primes speed responses to the target, inconsistent primes slow down responses and increase error rates. This response priming effect increases with increasing stimulus-onset asynchrony (SOA) between prime and target for SOAs up to approximately 100 ms (Vorberg et al., 2003). We used an additional set of fear-related images drawn from IAPS Database (*International Affective Picture System*; Lang, Bradley, & Cuthbert, 2008) as aversive control stimuli, complemented by second set of neutral images of household aids. The DIRTI images were assumed to be *aversive* for LCF participants, but specifically *contamination-fear-related* for HCF participants. Fear-related IAPS images were assumed to be *fear-related* for both groups. Neutral images of household aids were assumed to be *neutral* for both groups.

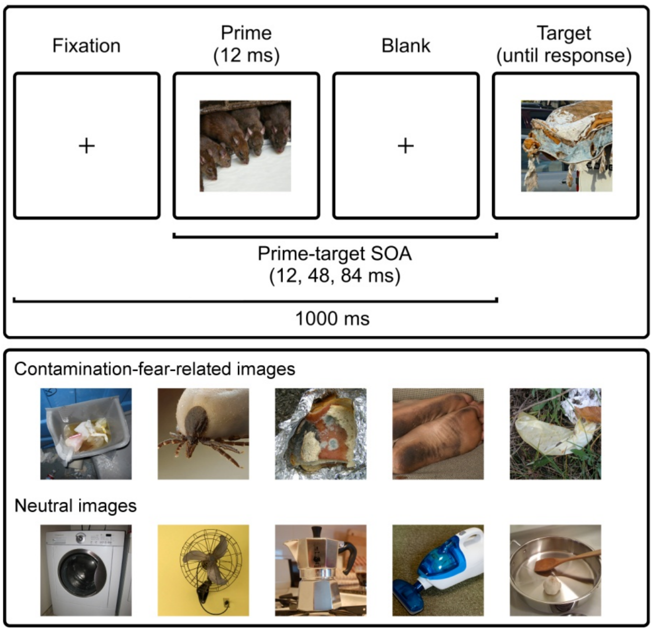

Figure 1. *Procedure and Example Stimuli.* Primes and targets were presented in the sequence displayed in the upper panel. Targets acted as backward masks for preceding primes. In each trial, the required response was either response-consistent (e.g. CFr prime and CFr target) or response-inconsistent (e.g. CFr prime and neutral target). Example stimuli for the CFr and neutral categories are displayed in the lower panel.

Based on studies demonstrating an attentional bias or preferential processing of OCD-related stimuli (Amir et al., 2009; Cisler & Olatunji, 2010; Lavy et al., 1994; Moritz et al., 2009; Najmi & Amir, 2010; Tata et al., 1996) and findings of preferential processing of fear-related stimuli in anxiety disorders (Fox et al., 2000; Haberkamp et al., 2013; Haberkamp & Schmidt, 2014; Lipp & Waters, 2007; Öhman et al., 2001), we formulated the following hypotheses: (1) CFr images will be rated as being more unpleasant, arousing, and disgusting by participants with HCF–in contrast to the neutral images of household aids and compared to the LCF group (*emotional rating task*). (2) Response priming effects will occur in both groups for CFr stimuli and neutral images (*priming task*). Specifically, we expect that CFr pictures will be preferentially processed by participants with HCF in comparison to the processing of (a) neutral pictures (within-group comparison), and of (b) CFr pictures in the LCF group (between-groups comparison). Based on our previous research (Haberkamp et al., 2013; Haberkamp & Schmidt, 2014), this preferential processing should manifest in larger response priming effects for CFr compared to neutral primes and faster responses to CFr targets compared to neutral targets in the group with HCF (within-group-comparison). Also, we expect that priming effects elicited by CFr primes will be larger and responses towards CFr targets will be faster in the group with HCF compared to the LCF group (between-group-comparison).

2. Study 1

2.1 Methods 1

2.2 Participants

Before the start of the study, we invited individuals describing themselves as highly afraid of dirt and germs or not afraid of dirt and germs at all. These participants were recruited via university-related e-mail and bulletin boards. Sixty-nine of these potential participants were screened with objective tests to confirm (or refute) their subjective appreciations. The participants were eligible for the *HCF group* if they scored < 11 on the BDI-II (German version of the "Beck Depression Inventory II" BDI; Hautzinger, Keller, & Kühner, 2006; original version by Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), to exclude participants with depressions, and above the OCD patient mean (≥ 14) on the Padua Inventory (PI) contamination fear subscale (Burns, Keortge, Formea, & Sternberger, 1996). The participants were eligible for the LCF group if they scored < 11 on the BDI-II and below the nonclinical mean (≤ 6) on the PI contamination fear subscale. 26 participants did not meet the predefined criteria and were not included. Later, a single participant of the HCF group did not complete the second experimental session and was excluded. Participants also filled in a German questionnaire that measures disgust sensitivity ('Fragebogen zur Erfassung der Ekelempfindlichkeit' FEE; Schienle, Walter, Stark, & Vaitl, 2002) and the Contamination Cognition Scale (CCS; Obsessive Compulsive Cognition Working Group, 2001) which lists 13 common objects associated with germs (e.g. door handles) and rates the likelihood and severity of contamination if they were touched. Likelihood ratings were given on a 0-100 scale from 0 = "not at all likely" to 50 = "moderately likely" to 100 = "extremely likely" and severity ratings from 0 = "not at all bad" to 50 = "moderately bad" to 100 = "extremely bad". In general likelihood and severity ratings highly correlate (Deacon & Maack, 2008; Deacon & Olatunji, 2007). Thus, we calculated a total sore on this measure averaging all 26 items (Table 1).

The final sample consisted of forty-two female participants, all students from the local university, with either low (*n* = 23; age range 18-36 years) or high (*n* = 19; age range 19-41 years) levels of contamination fear. All participants were naïve to the purpose of the study. They had normal or corrected-to-normal visual acuity and received course credit for participation. The study was approved by the local Ethical Committee of the Faculty of Psychology. All of them gave informed consent and were treated in accordance with the ethical guidelines of the American Psychological Association.

2.3 Apparatus

The participants were seated in a dimly lit room in front of a 17"-CRT-Monitor (1280 × 1024 pixels, retrace rate 85 Hz) at a viewing distance of approximately 60 cm.

2.4 Stimuli and Procedure

Four categories of colored images (CFr, fear-related, and two neutral control image sets) each containing 40 different pictures (8.83° of visual angle; 1 cm ≈ 0.95° of visual angle), were presented against a light gray background. Each trial started with the appearance of the central fixation cross (Fig. 1). After a varying delay (between 916 to 988 ms), the central fixation cross was replaced by a prime displayed for 12 ms. Subsequently, the target was presented at the same position at prime–target SOAs (time interval of stimulus onset of the prime and stimulus onset of the target) of 12, 48, or 82 ms and remained on screen until the participant's response. Prime and target pictures were pseudo-randomly drawn from one of the four different categories and a data base of 40 pictures for each category. All stimulus combinations of prime

Table 1. Means (SDs) and t-Tests for difference scores of eligible participants with HCF versus LCF in the four questionnaires (BDI-II; Padua Inventory; FEE, and CSS) and for age (Experiment 1).

Measures	HCF	LCF	t (40)	*p*
Age	24.05 (4.97)	23.13 (4.31)	0.64	*ns*
BDI-II	5.42 (4.17)	4.96 (4.22)	0.36	*ns*
Padua	21.47 (7.57)	3.83 (1.80)	9.94*	*p* < .001
FEE	105.37 (21.13)	56.43 (22.83)	7.15	*p* < .001
CCS	54.80 (16.44)	20.97 (13.90)	7.23	*p* < .001

Note: BDI = Beck Depression Inventory; Padua = Padua Inventory; FEE = 'Fragebogen zur Erfassung der Ekelempfindlichkeit'; CCS = Contamination Cognitions Scale; *ns* = non significant; bold letters indicate responses to phobic stimuli. *degrees of freedom adjusted due to unequal variance.

and target picture categories and prime–target SOA occurred equiprobably and pseudo-randomly in a repeated measures design. The participants' task was to discriminate as fast and as accurately as possible CFr and fear-related images from neutral control stimuli of household aids. Thus, participants categorized the targets as quickly as possible by pressing the left button for neutral household aids and the right button for CFr and fear-related images (or vice versa). Primes and targets were classified as "consistent" when mapped to the same response (i.e., pictures were from the same image category), and "inconsistent" when mapped to opposite responses (i.e., pictures were from different image categories).

Each participant performed two 1-hour sessions with 1,152 trials each, composed of one practice block followed by 24 blocks of 48 trials. The assignment of left and right response keys was counterbalanced across participants. They received summary feedback on the average response speed and accuracy after each block.

At the end of the final session, participants were asked to evaluate the images used in the study. The rating involved three dimensions (valence, arousal, and disgust). All dimensions were rated on a six-point rating scale. Scales were coded so that high scores reflected high arousal and disgust, respectively. Positive scores in the valence ratings represent positive emotions towards the image, a score of zero means that neither positive nor negative emotions are involved, and negative scores reflect negative emotions (for results see Fig. 2).

2.5 Data treatment and statistical methods

Practice blocks were not analyzed. 126 trials of one participant were lost due to technical failure (0.13% of total trials) and trials were eliminated if response times were shorter than 100 ms or longer than 1,000 ms (2.64% of trials). The overall error rate in the remaining trials was 3.58%, with no significant difference between error rates in LCF (3.51%) and HCF groups (3.88%) [$T(40) = 0.59$, $p = .558$].

Repeated-measures analyses of variance (rmANOVAs) were performed separately for response times and error rates with Huynh-Feldt-corrected *degrees of freedom* and *p* values. Error trials were not included in the response time analyses. Error rates were arcsine transformed to comply with ANOVA requirements. We report *F* values with subscripts indicating the respective effect (e.g. F_{PxT} for the interaction of prime and target, i.e., the priming effect). We report the effect size η^2 (Levine & Hullett, 2002) in which 0.01 reflects a small, 0.059 reflects a medium, and 0.138 reflects a large effect (Cohen, 1988). We report tests only for significant results.

For the critical differences between the priming effects and response times of both groups, we also report binomial tests plus the Scaled JZS Bayes factor (BF10), using a Jeffrey-Zellner-Siow Prior (Cauchy distribution on effect size) with default scale factor of 0.707 (Rouder, Speckman, Sun, Morey, & Iverson, 2009). BF10 expresses the probability of the data given H1 relative to H0 (i.e., BF10 >1 is considered in favor of H1). BF10 >3 can be considered as 'some evidence', BF10 >10 as 'strong evidence', and BF10 >30 as 'very strong evidence' for H1, whereas BF10<0.33 can be considered as 'some evidence', BF10 <0.1 as 'strong evidence', and BF10 <0.03 as 'very strong evidence' for H0 (Jeffreys, 1961).

3. Results 1

3.1 Emotional rating task

Due to problems in the data collection process, ratings of 2 out of twenty-three LCF participants and 3 out of nineteen participants of the HCF group were not collected. To compare emotional rating scores between the LCF and HCF group, we calculated T-Tests for each picture category (contamination fear, fear, control1, control2) and rating (disgust, arousal, valence). We hypothesized that CFr images will be rated as being more unpleasant, arousing, and disgusting by participants with HCF – in contrast to the neutral images of household aids and compared to the LCF group. Indeed, the HCF group rated CFr images higher in disgust [$T(34) = -4.99$, $p < .001$] and arousal [$T(34) = -2.55$, $p = .016$], and lower in valence [$T(34) = -4.02$, $p < .001$]. Also, they rated fear images lower in valence [$T(34) = 3.03$, $p = .005$]. No other tests reached significance (Figure 2).

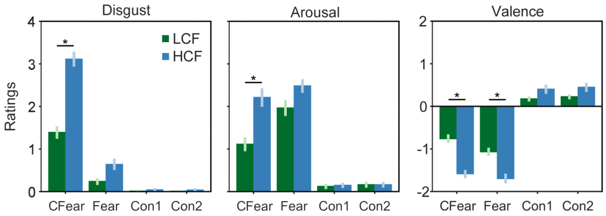

Figure 2. Results of the emotional rating task of Experiment 1. The three panels show disgust, arousal, and valence ratings of the LCF (green) and HCF group (blue) for the four picture categories (contamination fear images, *CFear*; fear images, *Fear*; control 1 images, *Con1*; control 2 images, *Con2*).

3.2 Priming task

We performed a fully-factorial rmANOVA with the between-factor of group (*G*; LCF, HCF), and within-factors of block (*B*; contamination fear, fear), target (*T;* neutral, contamination fear/fear), prime (*P;* neutral, contamination fear/fear), and SOA (*S;* 12, 48, 82 ms). We hypothesized that response priming effects will occur in both groups for CFr stimuli and neutral images. Indeed, we observed an articulated response priming effect across blocks and groups: responses were faster [$F_{TxP}(1,40) = 283.15$, $p < .001$, $\eta^2 = 0.131$] and more accurate [$F_{TxP}(1,40) = 162.53$, $p < .001$, $\eta^2 = 0.372$] in consistent compared to inconsistent trials. This priming effect increased with SOA in response times [$F_{TxPxS}(1.90,75.89) = 217.86$, $p < .001$, $\eta^2 = 0.056$] and error rates [$F_{TxPxS}(1.74,69.50) = 62.78$, $p < .001$, $\eta^2 = 0.149$] (cf. Schmidt et al., 2011; Vorberg et al., 2003). Specifically, we expect that CFr pictures will be preferentially processed by participants with HCF in comparison to the processing of (a) neutral pictures (within-group comparison), and of (b) CFr pictures in the LCF group (between-groups comparison). We expected that this preferential processing should manifest in larger response priming effects for CFr compared to neutral primes and faster responses to CFr targets compared to neutral targets in the group with HCF (within-group-comparison). Also, we expect that priming effects elicited by CFr primes will be larger and responses towards CFr targets will be faster in the group with HCF compared to the LCF group (between-group-comparison). However, the priming effect was not modulated by factors block or group, that is, not different for CFr vs. fear-related stimuli and not different for participants with HCF vs. LCF. In other words, the differences between groups in the emotional ratings of the stimuli did not translate to differences in priming effects. When calculating the Bayes factor for the differences in priming effects between both groups, they are in favour of H0 (< 1), indicating that mean priming effects of the two groups were the same (BF10 = 0.34 and BF10 = 0.36 for CFr and fear trials, respectively). Results of the priming task of CFr and neutral primes are shown in Figure 3. Results of fear-related and neutral primes look similar and, therefore, are not depicted here. Also, response times in the groups were not different for neutral vs. contamination fear/fear targets; however, participants of both groups made more errors when responding to contamination fear/fear targets compared to neutral targets [$F_T(1,40) = 38.13$, $p < .001$, η^2

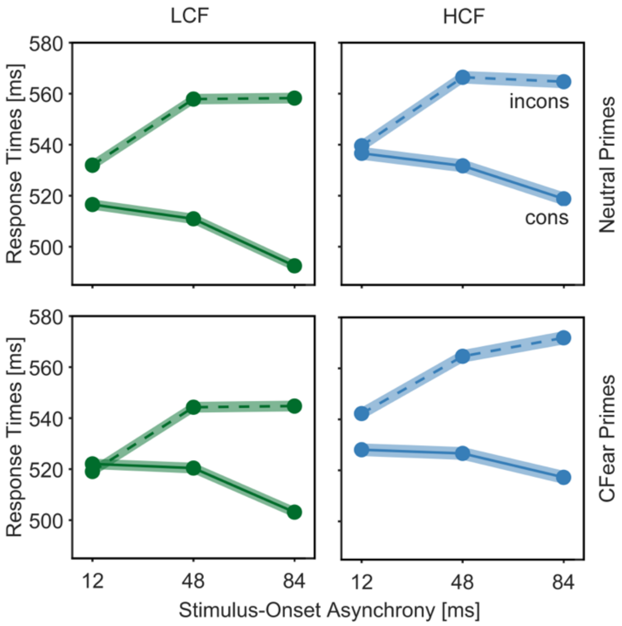

Figure 3. Results of the priming task of Experiment 1. The panels show response times in consistent (solid lines) and inconsistent trials (dashed lines) as a function of prime-target SOA, separately for LCF (left panels) and HCF (right panels) and for neutral primes (upper panels) and contamination fear primes (lower panels). In all panels, transparent regions denote standard errors of the mean with pure inter-subject variance removed (Cousineau, 2005).

= 0.065]. When calculating the Bayes factor for the differences in response times to the targets between both groups, they are generally in favour of H0 (< 1), indicating that mean response times to targets were the same for both groups. The evidence in favor of H0 is somewhat stronger for CFr and fear targets (BF10 = 0.37 and BF10 = 0.35, respectively) compared to neutral targets (BF10 = 0.88 and BF10 = 0.58, respectively).

Participants were slower [$F_B(1,40) = 18.43$, $p < .001$, $\eta^2 = 0.010$] and made more errors [$F_B(1,40) = 26.50$, $p < .001$, $\eta^2 = 0.032$] in blocks with fear-related images compared to blocks with CFr images. Finally, responses were faster [$F_S(1.41,56.45) = 28.89$, $p < .001$, $\eta^2 = 0.012$] and more accurate [$F_S(2,80) = 62.78$, $p < .001$, $\eta^2 = 0.078$] with shorter SOAs.

All other significant effects were numerically small and of marginal effect size ($\eta^2 < 0.01$) so that we will not interpret them; in response times: main effect of prime [$F_P(1,40) = 6.62$, $p = .014$, $\eta^2 = 0.001$] and interactions of prime and SOA [$F_{PxS}(2,80) = 3.19$, $p = .046$, $\eta^2 = 0.001$] and block, SOA, and group [$F_{PxS}(2,80) = 3.47$, $p = .036$, $\eta^2 = 0.001$]; in error rates: an interaction of block and group [$F_{BxG}(1,40) = 6.54$, $p = .014$, $\eta^2 = 0.008$], and an interaction of block, target, and group [$F_{BxTxG}(1,40) = 4.25$, $p = .046$, $\eta^2 = 0.007$].

Finally, as we measured priming effects in two separate experimental sessions, we could also determine test-retest reliabilities (cf. Rodebaugh et al., 2016). To this aim, we calculated correlations for individual priming effects between the two sessions, separately for the two blocks (CFr vs. fear-related stimuli). Then we applied the Spearman-Brown prophecy formula to estimate reliabilities for the full dataset. We obtained acceptable Spearman-Brown corrected split-half reliabilities of $r' = 0.69$ (CFr stimuli) and $r' = 0.61$ (fear-related stimuli).

4. Discussion 1

As expected, participants with HCF rated the CFr images as being more unpleasant, arousing, and disgusting in contrast to the group of low contamination fear and compared to the neutral images (*emotional rating task*). In contrast to our hypotheses, the differences in the emotional evaluation of the presented images did not transfer to the visuomotor processing of those images. As expected, we observed response priming effects in the two groups for CFr stimuli as well as neutral images (*priming task*). Thus, the briefly presented prime images affected the subsequent response to the target, resulting in speeded responses to targets in consistent trials and slower responses to targets in inconsistent trials. However, the emotional valence of the CFr images did not modulate the observed priming effects in the way expected. Specifically, responses to CFr images were not faster compared to neutral images or compared to responses in the group of low contamination fear participants. Furthermore, priming effects of CFr primes were neither larger compared to priming effects elicited by neutral primes, nor compared to priming effects of CFr primes in the LCF group.

Additionally, we did not find enhanced visuomotor processing of fear-related IAPS images, although participants in both groups rated those images as being more unpleasant and arousing compared to the neutral images of household aids. These results are inconsistent with studies reporting preferential processing of fear-related stimuli in the general population (Fox et al., 2000; Lipp & Waters, 2007; Öhman et al., 2001; Williams, Moss, Bradshaw, & Mattingley, 2005). However, they are in line with our previous response priming studies (Haberkamp et al., 2013; Haberkamp & Schmidt, 2014; Haberkamp & Schmidt, 2015) in which only phobic but not merely fear-related stimuli modulated priming effects (also see Tipples et al., 2002).

In Experiment 1, we used as CFr images pictures sampled from the DIRTI database. Although, pictures of dirty bathrooms, of blood and injuries, rats and pigeons have a high face validity to trigger CFr apprehensions and corresponding feelings of disgust, unpleasantness and arousal as reported in the emotional rating task, the database was not explicitly created to test contamination fear. Due to the novelty of the database, the presented images were not tested in previous studies with participants having HCF. Thus,

Table 2. Means (SDs) and t-Tests for difference scores of eligible participants with HCF versus LCF in the four questionnaires (BDI-II; Padua Inventory; FEE, and CSS) and for age (Experiment 2).

Measures	HCF	LCF	t (40)	*p*
Age	21.95 (2.93)	24.04 (3.96)	-1.91	*ns*
BDI-II	5.42 (2.78)	3.61 (3.14)	1.96	*ns*
Padua	22.68 (5.70)	2.78 (1.98)	14.52*	*p* < .001
FEE	94.47 (18.52)	56.91 (18.90)	6.47	*p* < .001
CCS	53.14 (17.89)	23.21 (14.56)	6.00	*p* < .001

Note: BDI = Beck Depression Inventory; Padua = Padua Inventory; FEE = 'Fragebogen zur Erfassung der Ekelempfindlichkeit'; CCS = Contamination Cognitions Scale; *ns* = non significant; bold letters indicate responses to phobic stimuli. *degrees of freedom adjusted due to unequal variance.

we decided to conduct a second experiment (Experiment 2) in which we used the same paradigm as in Experiment 1, however, using a different set of stimuli. In Experiment 2, the CFr stimuli were images from the Berlin Obsessive Compulsive Disorder-Picture Set (Simon et al., 2012) that were specifically chosen to provoke symptoms in participants with OCD. In their study, Simon and colleagues validated pictures through a two-staged process. First, three psychotherapists specialized on OCD preselected possible OCD triggers from a large pool of images. Those images were rated by OCD patients according to their anxiety, aversiveness and arousal. From this set, we chose those images that were validated for patients of the contamination-fear subtype of OCD. Neutral and fear-related images were those from Experiment 1. Equivalently to Experiment 1, images from the Berlin OCD picture set were assumed to be *aversive* to LCF participants, but specifically contamination-fear related to HCF participants. Fear-related IAPS images were again assumed to be *fear-related* for the two groups and neutral images of household aids were assumed to be *neutral* for the two groups. Assuming that the CFr images should be more efficient in modulating response priming effects compared to Experiment 1, we keep the same hypotheses as in Experiment 1: (1) CFr images will be rated as being more unpleasant, arousing, and disgusting by participants with HCF – in contrast to the neutral images of household aids and compared to the LCF group (*emotional rating task*). (2) Response priming effects will occur in the both groups for CFr stimuli and neutral images (*priming task*) with preferential processing of CFr pictures by participants with HCF (a) compared to neutral pictures (within-group comparison), and (b) compared to the processing of CFr pictures in the LCF group (between-groups comparison).

5. Study 2

5.1 Methods 2

5.2 Participants

Participants were recruited as described in *Methods 1*. 80 participants were screened for eligibility; 38 were excluded for not meeting the predefined criteria. This resulted in a sample consisting of forty-two participants, all students from the local university, with either low ($n = 23$; age range 19-36 years) or high ($n = 19$; age range 19-28 years) levels of contamination fear. They were naïve to the purpose of the study, had normal or corrected-to-normal visual acuity and received course credit for participation. The study was approved by the local Ethical Committee of the Faculty of Psychology. All of them gave informed consent and were treated in accordance with the ethical guidelines of the American Psychological Association.

5.3 Apparatus, Stimulus and Procedure

Experimental details were the same as in Experiment 1, except that CFr stimuli were images from the Berlin OCD picture set (Simon et al., 2012) and each participant performed one 1-hour session with 1,152 trials.

5.4 Data treatment and statistical methods

Practice blocks were not analyzed. Again, trials were eliminated if response times were shorter than 100 ms or longer than 1,000 ms (3.11% of trials). The overall error rate in the remaining trials was 3.69%, with no significant difference between error rates in LCF (4.14%) and HCF groups (3.15%) [*T* (40) = -0.98, *p* = .332]. Repeated-measures analyses of variance were performed as described in Experiment 1.

6. Results 2

6.1 Emotional rating task

Again, we hypothesized that CFr images will be rated as being more unpleasant, arousing, and disgusting by participants with HCF – in contrast to the neutral images of household aids and compared to the LCF group. To compare emotional rating scores between the LCF and HCF group, we calculated T-Tests for each picture category (contamination fear, fear, control1, control2) and rating (disgust, arousal, valence). Even though the overall pattern of results was qualitatively similar to that of Experiment 1, there were major differences: First, the HCF group showed generally higher disgust and arousal ratings compared to the LCF group, even for fear and control images. Second, the HCF group showed generally higher (i.e., more *positive*) valence ratings compared to the HCF group in Experiment 1 [for all images, *T*(32) > 8.51, *p* < .001], abolishing negative valence effects for contamination fear and fear images, and yielding positive valence effects for control images (Figure 4). Specifically, the HCF group rated contamination fear images higher in disgust [*T*(39) = -5.03, *p* < .001] and arousal [*T*(39) = -4.10, *p* < .001], but they did not rate them lower in valence. Also, they rated fear images somewhat higher in disgust [*T*(39) = -2.59, *p* = .014] and arousal [*T*(39) = -2.55, *p* = .015], but not lower in valence. Finally, the HCF group also rated control picture categories higher in disgust [*T*(39) < -2.87, *p* < .008] and arousal [*T*(39) < -2.74, *p* < .010], and somewhat *higher* in valence [*T*(39) < -2.73, *p* < .010] (Figure 4).

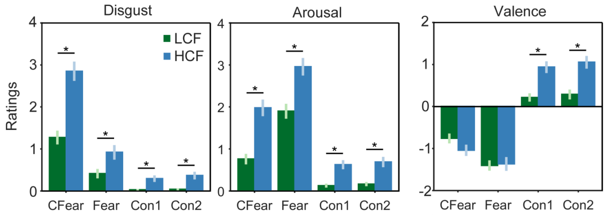

Figure 4. Results of the emotional rating task of Experiment 2. The three panels show disgust, arousal, and valence ratings of the LCF (green) and HCF group (blue) for the four picture categories (contamination fear images, CFear; fear images, Fear; control 1 images, Con1; control 2 images, Con2).

6.2 Priming task

We performed a fully-factorial rmANOVA with the between-factor of group (*G*; LCF, HCF), and within-factors of block (*B*; contamination fear, fear), target (*T;* neutral, contamination fear/fear), prime (*P;* neutral, contamination fear/fear), and SOA (*S;* 12, 48, 82 ms) to test whether CFr pictures will be preferentially processed by participants with HCF in comparison to the processing of neutral pictures, and of CFr pictures in the LCF group. The general pattern of priming effects in Experiment 2 replicated those of Experiment 1. We observed an articulated response priming effect across blocks and groups: responses were faster [$F_{TxP}(1,40) = 322.33$, $p < .001$, $\eta^2 = 0.160$] and more accurate [$F_{TxP}(1,40) = 99.60$, $p < .001$, $\eta^2 = 0.219$] in consistent compared to inconsistent trials. This priming effect increased with SOA in response times [$F_{TxPxS}(1.96,78.30) = 78.60$, $p < .001$, $\eta^2 = 0.030$] and error rates [$F_{TxPxS}(1.75,69.98) = 25.55$, $p < .001$, $\eta^2 = 0.054$] (cf. Schmidt et al., 2011; Vorberg et al., 2003). However, the response time priming effect was not modulated by factors block or group, that is, not different for CFr vs. fear-related stimuli and not different for participants with HCF vs. LCF. When calculating the Bayes factor for the differences in priming effects between both groups, they are in favour of H0 (< 1), indicating that mean priming effects of the two groups were the same (BF10 = 0.31 and BF10 = 0.39 for CFr and fear trials, respectively). However, priming effects in error rates were different between the blocks [$F_{BxTxP}(1,40) = 11.06$, $p = .002$, $\eta^2 = 0.029$]: priming effects were larger for neutral images compared to CFr images, but smaller for neutral images compared to fear images. Again, this is not what would be expected from the emotional ratings, where neutral images were always lower in disgust and arousal and more positive compared to CFr as well as fear images. Thus, differences in the emotional ratings between groups and image categories did not translate to differences in priming effects. Results of the priming task of CFr and neutral primes are shown in Figure 5 (results of fear-related and neutral primes look similar and, therefore, are not depicted here). Finally, neither response times nor error rates were different for neutral vs. contamination fear/fear targets. When calculating the Bayes factor for the differences in response times to the targets between both groups, they are generally in favour of H0 (< 1), indicating that mean response times to targets were the same for both groups (CFr targets: BF10 = 0.30; fear targets: BF10 = 0.32; control images 1: BF10 = 0.35; control images 2: BF10 = 0.31).

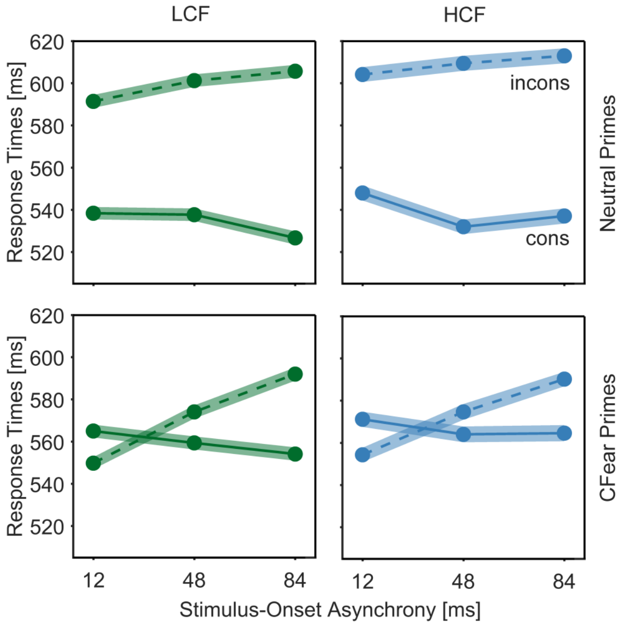

Figure 5. Results of the priming task of Experiment 2. The panels show response times in consistent (solid lines) and inconsistent trials (dashed lines) as a function of prime-target SOA, separately for LCF (left panels) and HCF (right panels) and for neutral primes (upper panels) and contamination fear primes (lower panels). In all panels, transparent regions denote standard errors of the mean with pure inter-subject variance removed (Cousineau, 2005).

In contrast to Experiment 1, participants were generally faster [$F_B(1,40) = 50.57$, $p < .001$, $\eta^2 = 0.039$] and more accurate [$F_B(1,40) = 4.48$, $p = .041$, $\eta^2 = 0.042$] in blocks with fear-related images compared to blocks with CFr images. We also found slower and less accurate responses in trials with contamination fear/fear primes compared to neutral primes – this effect was specifically driven by much slower responses in trials with CFr primes [response times: $F_P(1,40) = 26.08$, $p < .001$, $\eta^2 = 0.027$; $F_{BxP}(1,40) = 86.65$, $p < .001$, $\eta^2 = 0.025$; error rates: $F_{BxP}(1,40) = 10.24$, $p = .003$, $\eta^2 = 0.040$].

Finally, we again found that responses were faster [$F_S(2,80) = 9.69$, $p < .001$, $\eta^2 = 0.005$] and more accurate [$F_S(1.97,78.84) = 14.43$, $p < .001$, $\eta^2 = 0.031$] with shorter SOAs.

All other significant effects were numerically small and of marginal effect size ($\eta^2 < 0.01$) so that we will not interpret them; in response times: interactions of target and SOA [$F_{TxS}(2,80) = 3.28$, $p = .043$, $\eta^2 = 0.001$], of block, target, and SOA [$F_{BxTxS}(2,80) = 6.96$, $p = .002$, $\eta^2 = 0.002$] as well as block, prime, and SOA [$F_{BxPxS}(2,80) = 4.53$, $p = .014$, $\eta^2 = 0.001$]; in error rates: an interaction of target and SOA [$F_{TxS}(2,80) = 4.54$, $p = .014$, $\eta^2 = 0.006$], prime and SOA [$F_{PxS}(2,80) = 3.96$, $p = .023$, $\eta^2 = 0.006$].

7. Discussion 2

As expected, participants with HCF rated the CFr images as being more unpleasant, arousing, and disgusting compared to the neutral images, and as more arousing and disgusting compared to the group of LCF (*emotional rating task*). As in Experiment 1, the differences in the emotional evaluation of the presented images did not transfer to the visuomotor processing of those images. Even though we observed response priming effects in the two groups for CFr images as well as for neutral images (*priming task*), the emotional valence of the CFr images did not modulate the observed priming effects. Replicating Experiment 1, responses to CFr images were not faster compared to neutral images or compared to responses in the group of LCF participants. Furthermore, priming effects of CFr primes were neither larger compared to priming effects elicited by neutral primes, nor compared to priming effects of CFr primes in the LCF group.

In contrast to Experiment 1, we find some evidence for enhanced visuomotor processing of fear-related IAPS images: priming effects in the error rates are somewhat larger for IAPS images compared to the neutral images of household aids. However, there is no difference in overall response times or response time priming effects; there is no difference between groups even though participants with HCF rated the IAPS images as more disgusting and arousing. Therefore, we would rather not think of these findings as unequivocal evidence for preferential processing of fear-related stimuli in the general population (Fox et al., 2000; Lipp & Waters, 2007; Öhman et al., 2001; Williams et al., 2005).

To conclude, we replicated all of our main findings of Experiment 1 with a different set of CFr stimuli (Berlin OCD picture set; Simon et al., 2012) which were specifically chosen to provoke symptoms in participants with OCD.

8. General Discussion

In the present paper, we studied the evaluation and visuomotor processing of CFr stimuli in participants with HCF and LCF participants. Contrary to our expectations, we found no preferred information processing of CFr stimuli in our HCF groups (Experiment 1 and 2), although these stimuli were rated as being more negative, disgusting, and arousing (cf. emotional rating task) compared to neutral stimuli (within-group comparison) and ratings of the LCF groups (between group-comparison). Thus, participants with HCF did neither respond faster to CFr targets nor were priming effects different for CFr primes. In the following, we will discuss different aspects of the present study and relate it to previous findings.

8.1 Sampling

Our lack of finding a visual processing bias for CFr stimuli might be explained by testing a subclinical sample rather than patients suffering from OCD. In this sample, obsessions and compulsions elicited by the CFr stimulus material might have been insufficient to provoke attentional biases or behavioural avoidance responses strong enough to be measurable in response times. We do not think this likely for several reasons. First, Abramowitz and colleagues (2014) reviewed previous studies with analogues (i.e. non-clinical) samples and reasoned that results from subclinical samples are indeed relevant to understand OC symptoms in individuals with a clinical diagnosis of OCD. They base their conclusion on findings that OCD is rather a dimensional than a categorical phenomenon (i.e., individuals with OCD experience merely experience more frequent and intense symptoms and, thus, report more distress and impairment) and argue that a few studies even demonstrated OC symptoms in subclinical individuals and some degree of impairment and treatment seeking among them (Abramowitz et al., 2010; García-Soriano, Belloch, Morillo, & Clark, 2011; Watson & Wu, 2005). Also, taxometric studies (Haslam, Williams, Kyrios, McKay, & Taylor, 2005; Olatunji, Williams, Haslam, Abramowitz, & Tolin, 2008) found strong support for a dimensional latent structure. Other studies suggest that the contents of obsessions in clinical and non-clinical samples are similar (Julien, O'Connor, & Aardema, 2009; Rachman & Silva, 1978), and that the same is true for the type of compulsions (Flament et al., 1988; Henderson & Pollard, 1988). Studies on the heritability of OC symptoms (Taylor, 2011; Taylor, Jang, & Asmundson, 2010) suggest that OC symptoms of individuals with subclinical OCD are related to the diagnosis of OCD. However, we also know that obsessions and compulsions occur more frequently in patients with OCD compared to individuals with subclinical symptoms (Abramowitz et al., 2014). Thus, emotional and behavioural responses might be stronger in clinical samples. However, since response priming is a sensitive measure and attentional biases were also reported in subclinical samples (Amir et al., 2009; Cisler & Olatunji, 2010; Najmi & Amir, 2010), we doubt that the lack of finding preferential information processing of CFr stimuli in individuals with HCF is a result of choosing a subclinical sample. In both experiments, we assigned participants to the HCF group by using a rather conservative cut-off, that is, the patients mean (Burns et al., 1996; cf. Deacon & Olatunji, 2007)–resulting in an overall high drop-out rate of participants not meeting our contamination-fear criteria. Finally, we replicated our null finding in two different HCF groups in Experiments 1 and 2.

8.2 Stimulus material

Another explanation for finding no modulatory effect of CFr stimuli in the HCF groups might be the pictorial stimuli. The stimuli might have been insufficient to provoke strong emotional responses and associated behavioural responses. Again, we do not think this likely for several reasons. First, meta-analytic evidence suggests that picture presentation is especially effective in eliciting emotional responses (Lench et al., 2011; Moritz et al., 2008). Second, previous response priming studies successfully used pictorial stimuli to demonstrate preferential processing of fear-related stimuli in individuals suffering from anxiety disorders (Haberkamp et al., 2013; Haberkamp & Schmidt, 2014; Haberkamp & Schmidt, 2015).

Still, it might be argued that the picture set used in Experiment 1 (DIRTI-Database; Haberkamp et al., 2017) was not specifically tailored to elicit contamination fear in the HCF group because the database was recently developed and there is no validation yet for patients suffering from OCD. Rather, the database covers a broad range of disgust-related subcategories such as hygiene, death, food, and animals to study the discrete emotion of disgust in general. However, to address this point, we used as CFr stimuli in Experiment 2 images from a set that was explicitly developed to address individuals with clinical and subclinical OC symptoms (BOCD-PS; Simon et al., 2012). The findings are essentially the same: even though the results of the two emotional rating tasks suggest that the two picture sets of Experiment 1 and 2 elicited strong emotional responses in the two HCF groups (i.e. CFr stimuli were rated as being more negative, disgusting, and arousing compared to neutral stimuli and to ratings of the LCF group), their response times or priming effects were not modulated by the CFr stimuli.

Cludius and colleagues (2017) did also report no attentional effect in patients with CFr symptoms compared to patients with checking-related symptoms. They argue that the range of CFr symptoms is probably broader and less specific than those of checking-related symptoms. They follow that the stimulus set for investigating attentional biases in individuals with CFr symptoms should be chosen tailored to explicit fears (e.g. pictures of used syringes for individuals afraid of infectious diseases). In future studies, it might helpful to choose the stimuli individually for each participant. Another explanation for our lack of finding attentional biases for to CFr stimuli might lie in the complexity of the presented stimulus material. Speeded responses to targets might result from perceptual learning mechanisms, where individuals that are repeatedly confronted with a certain stimulus (e.g. a spider), acquire a “hardwired” binding of those stimulus' distinct features (e.g. eight black pins, one oval body) (VanRullen, 2009). This “hardwired” binding accelerates responses when confronted with the learned stimulus. Perceptual learning would occur especially for those stimuli that an individual is exposed to very frequently or to which an individual dedicates attentional resources (e.g. to spiders if he or she is afraid of spiders; Haberkamp et al., 2013). This theory explains why animals can be detected in the blink of an eye, although animals are extremely variable in their appearance (Kirchner & Thorpe, 2006; Thorpe, Fize, & Marlot, 1996). At the same time, subclasses of animals such as spiders have distinct features which make classification of these stimuli relatively easy. In contrast, the CFr images in the present study are very heterogeneous in content and image features (e.g. multiple objects, cluttered backgrounds, wide range of colours, textures, shapes, lighting conditions etc.) so that perceptual learning mechanisms are all but possible. This might explain why we did not find attentional biases to CFr stimuli even though they were rated as more unpleasant, disgusting and arousing compared to neutral images and compared to the ratings of the LCF group.

Amir and colleagues (2009) argue that previous studies probably found no attentional bias because the effect might dwindle over the course of the experiment. Thus, the temporal pattern has to be examined as well. We inspected our results according to possible habituation effects and found no changes in priming effects or response times over the course of the experiments.

8.3 Fear vs. disgust

As already mentioned in the introduction, the washing subtype of OCD differs with regard to the elicited emotions from other subtypes such as symmetry and ordering, hoarding, obsessions and checking. For example, while in obsessions and checking subtypes the dominant emotion is fear or anxiety, intrusive thoughts in the washing subtype of OCD not only elicit anxiety but also disgust (McKay, 2006). We know that fear helps to enable an individual to escape from danger (Foa & Kozak, 1986). Thus, rapid discrimination between perilous and harmless stimuli is a necessary requirement to enable an individual's fast response to threat in the immediate environment. However, CFr stimuli which also elicit disgust do not pose any immediate danger. Instead of a rapid behavioural response, CFr objects rather ask for a thorough examination. Thus, there is no necessity to immediately shift the attention (and produce an early attentional bias) towards these stimuli. Also, there is no need for ultra-rapid responses to these stimuli. On the contrary, disgust seems to interfere with orientation of attention towards disgust-related stimuli and cause difficulties in disengaging attention from these stimuli (Cisler, Olatunji, Lohr, & Williams, 2009; but see Cludius, Külz et al., 2017). This might explain the absence of preferential processing of those stimuli in our experiment which would be evident as a modulatory effect in the present data (also see Cludius, Külz et al., 2017).

8.4 Limitations

One limitation of the present study is the experimental paradigm: although response priming is a sensitive measure of enhancement in information processing, we can draw no conclusions about attentional effects causing attenuations of information processing (e.g. difficulties in disengagement). Cisler and Olatunji (2010) used a spatial cueing task in which individuals with subclinical contamination fear responded slower to trials showing disgust picture cues (but also fear picture cues) – indicating difficulties in disengagement of attention. However, the effect could not be replicated by Cludius and colleagues (2017) using eye tracking as a direct measure of attentional disengagement. These authors did neither find a vigilance bias nor a maintenance bias towards OCD-related stimulus material in the OCD group compared to the LCF group. Although, the present study replicates previous findings (Cludius, Külz et al., 2017; Cludius, Wenzlaff et al., 2017), showing no attentional biases in individuals with the subtype of contamination fear, the paradigm is only suitable to measure enhancement in early information processing.

Furthermore, we solely included measures on contamination fear but not on anxiety in general in our study. Thus, participants in the HCF group might have been more anxious per se which might bias the obtained results. Accordingly, participants in Experiment 2 rated all stimuli as being more negative, disgusting and arousing compared to the LCF group (but see results of the emotional rating task in Experiment 1). In case, the anxiety of the HCF group would generalize to all threatening stimuli, we would have expected enhanced information processing (i.e. larger priming effects and faster responses to targets) of threatening stimuli in this group–as repeatedly reported in the literature (cf. Fox et al., 2000; Haberkamp et al., 2013; Haberkamp & Schmidt, 2014; Öhman et al., 2001). However, we did not observe any modulation in the fear condition, rather suggesting no generalized anxiety in the HCF group.

8.5 Summary

Identifying and describing attentional biases and preferential processing of fear-related stimuli is potentially important for the diagnosis and therapy of psychiatric disorders. Here, we investigated preferential processing of contamination-fear related stimuli in participants with high contamination-fear, using two different sets of CFr stimuli and two independent groups of participants. By using an established paradigm with consistent and reliable findings in previous studies on anxiety disorders, as well as standardized stimulus material, we aimed to overcome methodological problems of previous studies on contamination fear which showed heterogeneous results of attentional bias and preferential processing of disorder-related stimuli. In line with contemporary studies, but in contrast to earlier work, we did not find any modulation of information processing in the two experiments. We assume that, at least in early visual processing of CFr stimuli, no preferential processing occurs. This finding suggests that the processing of disorder-related stimuli in OCD might be fundamentally different to that of fear-related stimuli in anxiety disorders (e.g. in specific phobia). Our study also highlights the difficulties that have to be faced when mapping out information processing in OCD, a multi-dimensional psychiatric disorder in which the individual experience is characterized not only by fear but also by intense feelings of disgust.

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