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Larger than life: Overestimation of object size is moderated by personal relevance in obsessive–compulsive disorder

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ABSTRACT

Background and Objectives: Along with other cognitive biases overestimation of threat (OET) has been implicated in the pathogenesis of obsessive–compulsive disorder (OCD). The present study investigated whether OET would not only manifest in *cognitive* distortions but, also in overestimations of the object size of disorder-related visual objects.

Methods: A total of 65 participants with OCD and 55 healthy controls who were recruited via OCD online forums underwent an incidental learning paradigm consisting of two blocks. In Block 1, participants were asked to rate the valence and the personal relevance for individual OCD concerns of 40 pictures which varied in size. Differences in size, however, were not explicitly communicated to the participants. Stimuli were selected from four categories: 1. neutral, 2. fear-related but OCD-unrelated, 3. washing (OCD-related), and 4. checking (OCD-related). In Block 2, participants were asked to recollect the original size of each stimulus (depicted as a small thumbnail) on a seven point scale.

Results: Whereas few group differences emerged for pre-defined OCD items, OCD-relevant items (individual judgments) were judged as significantly larger by patients with OCD relative to controls. The opposite pattern emerged for neutral items.

Limitations: The sample was recruited via online forums and had probable but not externally validated diagnoses of OCD. No psychiatric control group was recruited.

Conclusions: The present study indicates that OET may extend to neuropsychological tasks. Further research is needed to pinpoint whether OET occurs at the level of encoding suggesting a perceptual bias and/or occurs at the level of retrieval suggesting a memory bias.

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1. Introduction

Along with other cognitive biases and dysfunctional beliefs (e.g., inflated responsibility, intolerance of uncertainty or perfectionism) overestimation of threat (OET) has been implicated in the pathogenesis of obsessive–compulsive disorder (OCD; [Obsessive Compulsive Cognitions Working Group, 1997, 2001, 2003, 2005](#)). OET is a multi-faceted construct and subsumes different components, which are captured, for example, by the synonymous subscale of the Obsessive Beliefs Questionnaire (OBQ) long form (see

[Obsessive-Compulsive Cognitions Working Group, 1997](#)): 1. overestimation of base rates (e.g., “I believe that the world is a dangerous place”), 2. perceived enhanced personal vulnerability (e.g., “Bad things are more likely to happen to me than to other people”) and 3. overestimation of the consequences of a negative event (e.g., “Small problems seem to turn into big ones in my life”). Whereas patients with OCD display higher scores than healthy subjects on the OET subscale of the OBQ, differences to psychiatric controls are less well established ([Obsessive-Compulsive Cognitions Working Group, 2003](#); [Tolin, Worhunsky, & Maltby, 2006](#); however, see [Steketee, Frost, & Cohen, 1998](#)). However, as self-report questionnaires necessitate a certain degree of introspection and metacognitive awareness which is deficient in many psychiatric patients, questionnaires are perhaps not ideal measures to tap into OET.

Findings from our research group using experimental tests suggest that patients with OCD do not differ from controls on OET component 1 ([Moritz & Pohl, 2006](#)), but rather on components

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2 and 3. (Moritz & Jelinek, 2009; Moritz & Pohl, 2009). Whereas this line of research dealt with cognitive biases, the present study was concerned with the question whether OET also manifests in an overestimation of the size of OCD-related objects.

It is long known (Bruner & Goodman, 1947) that the perception of distance and size is modulated by personal relevance (Balcetis & Dunning, 2010; Witt, Linkenauger, Bakdash, & Proffitt, 2008). Perceptual distortions have been implicated in anxiety disorders, particularly specific phobias (Hofmann, Alpers, & Pauli, 2009), but seldom directly tested. One study found that emotionally relevant cues predominate perception when they are in direct competition with non-emotional cues (Alpers & Gerdes, 2007; Alpers & Pauli, 2006), but it is unclear whether anxiety-related cues also appear to be larger. Some evidence for distorted size perception in anxiety disorders has emerged for fear of heights: In two studies, persons afraid of heights overestimated the actual distance of a balcony to the ground, particularly when they were in a state of stress (Clerkin, Cody, Stefanucci, Proffitt, & Teachman, 2009; Teachman, Stefanucci, Clerkin, Cody, & Proffitt, 2008). In spider phobics, results are more equivocal. A recent pilot study demonstrated that persons with high ratings on a measure tapping spider phobia overestimated the size of spiders and at the same time underestimated the size of positive pictures relative to people low on spider phobia (Alpers & Gerdes, 2009). In an early study conducted by Rachman and Cuk (1992) snake-phobic and spider phobic participants showed distortions in the reported activity of the feared animal. However, no distortions of size were found when participants were asked to draw the phobia-related animals.

In OCD, visual cues can also be important triggers for OCD-related fears and compulsive behavior. To examine whether such stimuli are remembered differently by OCD patients, we adopted an incidental learning approach. Participants were first presented with OCD-related or neutral visual cues in different sizes ranging from small to big which was not pointed out to them as a relevant factor in the experiment until later. At this part of the experiment, they were just required to rate each picture according to valence and personal relevance. Later, thumbnails of the previously presented items were displayed with uniform size and the participants were asked to estimate the original size of individual objects with the help of a template. We expected that patients with OCD would overestimate the size of OCD-related material and that this bias would be more pronounced for items with personal OCD relevance.

The study was implemented via the Internet. Web-based research is increasingly adopted not only for economic reasons, but also to obtain larger samples and recruit patients who are difficult to recruit or not seen in health care related settings (Moritz, Jelinek, Hauschildt, & Naber, 2010). Self-report responses obtained from Internet studies are generally comparable in reliability and validity to paper-and-pencil administration (Chinman, Young, Schell, Hassell, & Mintz, 2004; Meyerson & Tryon, 2003; Moritz et al., 2010; Ritter, Lorig, Laurent, & Matthews, 2004). Validity of diagnosis and results are good if certain precautions are adopted (e.g. cookies, invitation from moderated forums only; for a discussion see Moritz et al., 2010).

2. Methods

2.1. Recruitment strategy

An invitation for a scientific study was posted on several German Internet discussion forums for OCD. We selected moderated Internet networks solely dedicated to OCD and requiring membership. Forums with a broader scope (e.g., mental illness in general) were thus not considered. In the advertisement, potential participants were informed that the study would require the

appraisal of visual items, some of which dealing with OCD themes. We announced that the survey would take approximately 20–30 min to complete. A link was provided connecting directly to the Internet questionnaire.

2.2. Internet based assessment

The electronic questionnaire was implemented via OPST[®]. Advancing from page to page was possible by pressing forward buttons, whereby the survey only proceeded if all mandatory items were answered. It was not possible to move back to previous pages once a page was completed (see below). “Cookies” were set to prevent multiple log-ons by the same participant. On the first page, participants were welcomed and reassured that the study was anonymous. If the participants had any questions, they were invited to contact the first author (postal and email address were provided). Participants were also instructed to calibrate the size of their monitor display to 100% (normal).

2.3. Background variables and medical history

The first part of the questionnaire consisted of the following sections: sociodemographic questions (age, gender, education) and medical history (e.g., prior therapies, whether a professional had previously determined a formal diagnosis). If a diagnosis of OCD was confirmed, the survey proceeded with the self-report scale of the Yale-Brown Obsessive–Compulsive Scale (Y-BOCS; Baer, Brown-Beasley, Sorce, & Henriques, 1993; for psychometric properties see below). The Y-BOCS was not administered to people who denied a diagnosis of OCD.

2.4. Size estimation experiment

2.4.1. Appraisal of visual images (Block 1)

In random order, 40 colour photographs were presented, ten items from each one of the following four categories: neutral, fear-related but OCD-unrelated, washing-related, and checking-related. The majority of the pictures was taken from the International Affective Picture System (IAPS) series and complemented by other images used in a prior OCD study (Moritz, Von Muhlenen, Randjbar, Fricke, & Jelinek, 2009). The fear-related pictures showed ferocious animals, predominantly predators, which frequently elicit fear (e.g., a snake) but are not common themes of OCD. The neutral pictures showed everyday objects (e.g., a chair or basket) which again are not common themes of OCD. The washing compulsion-related category depicted objects that commonly elicit unpleasant emotions in patients with contamination fears/washing compulsions (e.g., a dirty toilet, see Fig. 1 for an example). The checking-related pictures depicted objects that commonly elicit unpleasant emotions in patients with aggressive obsessions/checking compulsions (e.g., a burning house).

Each picture had to be categorized (see Fig. 1) as either 1. negative, 2. negative and relevant to one's own OCD, 3. neutral, 4. positive and relevant to one's OCD, 5. positive (options 2 and 4 only applied to participants who confirmed a diagnosis of OCD and were not presented to control participants). Response 4 could, for example, be chosen for the picture of a lock in case a subject with checking compulsions regarded this item as positive (from a theoretical viewpoint, this item is clearly negative as it is associated with compulsions and avoidance behavior; however, a person with, for example, low illness insight may still regard it as positive). Subsequently, all participants filled in the Obsessive–Compulsive Inventory-Revised (OCI-R; Foa et al., 2002; German version by Gönner, Leonhart, & Ecker, 2008) and the short form of the Beck Depression Inventory (BDI-SF; Beck & Steer, 1993; Furlanetto,

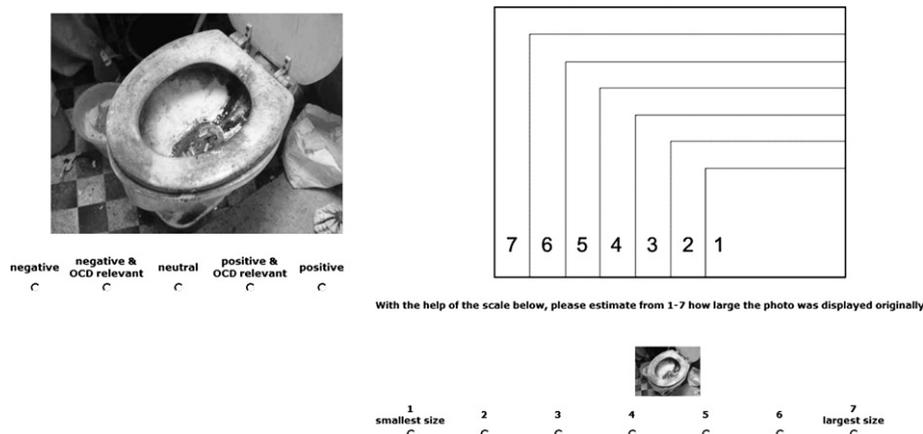


Fig. 1. In Block 1 (left panel), each ten items from four categories were displayed in five different sizes (corresponding to equidistant sizes 2 to 6 on the right panel). All items had to be categorized according to valence and personal OCD relevance. In Block 2 (right panel), all items were re-presented in thumbnail size. With the help of the scale the participant had to estimate the original size.

Mendlowicz, & Romildo Bueno, 2005; German version by Hautzinger, Bailer, Worall, & Keller, 1995). Items were worded in the respective original item format (for psychometric properties please see section below).

2.4.2. Size estimation task (Block 2)

Participants were then informed that they would be shown the previously displayed items as thumbnails (i.e., much smaller than originally presented). Their task was to estimate the original size by means of a scale showing seven different sizes, whereby the smallest and largest size were in fact never previously shown. As can be seen in Fig. 2, participants had to press “7” if they thought that the picture was filling the largest possible frame size. The procedure was practiced before this block started. Again, participants could neither go back to the original pictures nor log onto the survey again because of “cookies”.

On the final pages, participants were asked to confirm whether they had filled out the survey honestly. Participants were allowed to enter their email address if they wanted to be informed about the study's results. Shortly after the end of the study, feedback of the main results was posted on the OCD forums in which the invitation for the study had been originally posted.

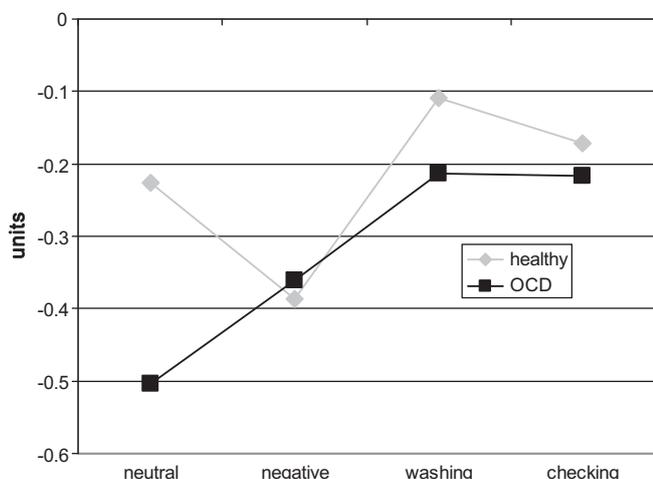


Fig. 2. All participants showed a tendency to underestimate the original size, which was less pronounced for OCD-related items, particularly in the OCD group where the evidence showed a significant interaction of Group × Category (see text).

2.5. Sample characteristics

A total of 272 persons entered the website and 180 of them completed the entire survey. Participants were allocated to the OCD group ($n = 65$) if they (1) connected from the OCD websites (these websites were solely devoted to OCD-related concerns and were most likely mainly accessed by participants with OCD), (2) reported a professionally confirmed diagnosis of OCD, (3) had an OCI-R total score of 21 or more points (see Foa et al., 2002), and (4) denied presence of schizophrenia or (5) bipolar disorder (the latter two diagnoses are commonly excluded in OCD research).

Control participants were recruited via an established participant pool (i.e., email addresses of participants from prior internet studies) and word-of-mouth. Participants were allocated to the healthy control group ($n = 55$) if they (1) denied presence of any psychiatric illness, (2) denied presence of checking or washing compulsions, (3) denied using the services of psychological or psychiatric institutions and (4) had a BDI-SF score of less than 10, and (5) had an OCI-R total score of less than 21. Participants who indicated that they had not answered the questions honestly were excluded.

A total of 60 potential participants were excluded for the following reasons: Participants sought prior psychiatric or psychological treatment but denied a diagnosis of OCD ($n = 31$), participants with a likely diagnosis of OCD according to the above criteria, but had an OCI-R total score below the cut-off of 21 ($n = 4$), participants with a likely diagnosis of OCD according to the above criteria but a Y-BOCS total score of below 8 ($n = 3$), psychiatric disorders other than OCD ($n = 3$), non-OCD participants with an OCI-R score above 21 ($n = 2$), participants who did not fill out the survey honestly according to self-report ($n = 3$), comorbid diagnosis of bipolar disorder ($n = 1$), comorbid diagnosis of schizophrenia ($n = 1$), non-OCD participant with a BDI-SF score above 10 ($n = 1$). The rest of the participants ($n = 11$) were excluded blind to experimental results, to make samples comparable regarding age, gender and school education. No incentive for participation was provided in this study.

2.6. Questionnaires

The self-report version of the Y-BOCS (Baer et al., 1993; Steketee, Frost, & Bogart, 1996) was applied in its German version (Schaible, Armbrust, & Nutzinger, 2001). The Y-BOCS measures the severity of obsessions and compulsions. Its psychometric properties and

sensitivity to treatment have been repeatedly asserted and also applies to the German version (Moritz et al., 2010). The self-report version of the scale has shown to have strong convergent validity with the original expert rating scale (Schaible et al., 2001; Steketee et al., 1996). To further improve the validity of the ratings, we provided definitions for obsessions and compulsions as patients sometimes confuse obsessions with others symptoms such as mental compulsions potentially compromising the validity of the self-rating (Federici et al., 2010).

The Obsessive–Compulsive Inventory-Revised (OCI-R; Foa et al., 2002; German version by Gönner et al., 2008) was administered to evaluate the frequency and distress experienced by OC symptoms across six subscales: washing, obsessing, hoarding, ordering, checking, and neutralizing. The OCI-R has good psychometric properties (Abramowitz & Deacon, 2006; Foa et al., 2002; Huppert et al., 2007) that also apply to the German Version (Gönner, Leonhart, & Ecker, 2007; Gönner et al., 2008). It is also sensitive to the effects of treatment (Abramowitz & Deacon, 2006). Internet administration of the OCI-R has been found to be equivalent to paper-and-pencil administration in previous studies (Coles, Cook, & Blake, 2007).

To tap depressive symptoms, the Beck Depression Inventory Short Form (BDI-SF; Beck & Steer, 1993; Furlanetto et al., 2005) was administered, which contains the cognitive-affective subscale of the long form. The BDI-SF is a widely used scale and the gold standard for the subjective assessment of depression. It contains good concurrent validity in medical patients (Furlanetto et al., 2005). In a recent internet study, the 4-week re-test reliability of all three scales was at least $r = 0.82$ (Moritz et al., 2010).

3. Results

3.1. Background and psychopathology

As can be seen in Table 1, patients with OCD were indistinguishable from control participants on all major background variables. In addition, no differences emerged regarding formal school education (the German school system has 3 levels: 9 years (“Hauptschule”), 10 years (“Realschule”) and 13 years (“Abitur”)), $\chi^2(1) = 3.60, p > .05$. However, as this difference approached trend level, education was considered as a moderator in the correlational analyses, which however did not influence results. As expected, patients displayed significantly elevated scores for the OCI-R and BDI-SF. The Y-BOCS mean scores were in the medium severity range.

Table 1
Background and psychopathological characteristics. Mean and standard deviations.

Variables	Control Group (<i>n</i> = 55)	OCD (<i>n</i> = 65)	Statistics
Background variables			
Sex (male/female)	15/40	20/45	$\chi^2(1) = 0.18,$ $p > .6$
Age	34.67 (10.35)	36.26 (9.56)	$t(118) = 0.87,$ $p > .3$
Psychopathology			
Y-BOCS obsessions	–	9.58 (3.65)	–
Y-BOCS compulsions	–	9.71 (5.01)	–
Y-BOCS total score	–	19.29 (6.48)	–
OCI-R total score	5.49 (4.29)	25.37 (10.70)	$t(118) = 4.37,$ $p < .001$
BDI-SF	1.87 (2.18)	12.51 (7.42)	$t(118) = 11.01,$ $p < .001$

Notes. BDI-SF = Beck Depression Inventory Short Form; OCI-R = Obsessive-Compulsive Inventory-Revised; Y-BOCS = Yale-Brown Obsessive–Compulsive Inventory.

3.2. Experimental variables

3.2.1. Strategy of data analysis

For the subsequent analyses, we subtracted the size estimates (Block 2) from the original size of the picture (Block 1), whereby positive values designate overestimations and negative values designate underestimations. The seven steps on the scale were equidistant (see Fig. 1). Whereas the original steps differed by 1 cm, they may have been displayed somewhat smaller or larger on the individual participant's monitor which, however, neither affects proportions nor equidistance. For the following analyses, the dependent variable will be referred to as a unit. A score of 1 for a particular item, for example, means that its size in Block 2 has been overestimated by 1 unit (e.g., a picture which was 2 or 4 units large but was memorized as 3 or 5 units large, respectively). A score 0 indicates perfect size estimation.

3.2.2. Accuracy

With regard to size, both groups made few exact estimates (healthy: $M = 8.31, SD = 2.30$; OCD: $M = 7.83, SD = 0.26$), which was not moderated by category subtype (i.e. neutral, fear-related, washing, checking). Neither the effect of Category, $F(3,354) = 0.57, p > .6$, Group, $F(3,354) = 1.09, p > .2$, nor the interaction, $F(3,354) = 0.26, p > .8$, achieved significance.

3.2.3. Deviance of estimate from correct size

A 4×2 mixed ANOVA was conducted with Category (neutral, fear-related, washing, checking) as within-subject factor and Group (OCD, Control Group) as between-subject factor. The deviance of the estimate from the original size in units served as dependent variable. The effect of Category, $F(3,354) = 7.94, p < .001$, and the Group \times Category interaction, $F(3,354) = 2.67, p = .05$, were significant but not the effect of Group, $F(1,118) = 0.31, p > .5$. Whereas there was a general tendency to underestimate size (see Fig. 2), this was less so for washing and checking-related items. To explore the nature of the significant interaction, follow-up analyses were carried out. We subtracted the three emotional conditions (fear-related, washing, checking) from the neutral condition (e.g. estimates for fear-related items minus estimates for neutral items etc.). Healthy participants underestimated the relative size of fear-related items compared to patients, who tended to overestimate these, $t(118) = 2.32, p = .02$. Healthy controls showed a greater bias to underestimate the size of checking-related items (with neutral items serving as a reference point) than patients, $t(118) = 2.62, p = .01$. For washing-related items a similar pattern emerged but only approached trend level, $t(118) = 1.56, p = .12$. Paired t -tests revealed that in healthy participants none of the emotional categories were different from the neutral condition ($p > .05$), whereas in OCD participants washing-related ($p = .001$) and checking-related ($p < .001$), but not the fear-related items ($p = .12$) were estimated much greater in size relative to neutral items.

3.2.4. Personal relevance

We then looked at the impact of personal relevance on size estimation, which relied upon individual categorizations of the pictures in Block 1 (Appraisal of Visual Images). Responses of 2 or 4 indicated relevance. To illustrate, if a participant deemed the picture of a snake as neutral, the corresponding value went into the neutral score even if the picture elicited a negative response (1 or 2) in most other participants. In Fig. 3, the descriptive statistics are provided for the mean estimates separated by categorization, whereby personal relevance ratings are only reported for OCD participants as healthy participants per definition, had no personally relevant OCD-related items. Visual inspection reveals an overestimation bias for personally relevant stimuli in patients with

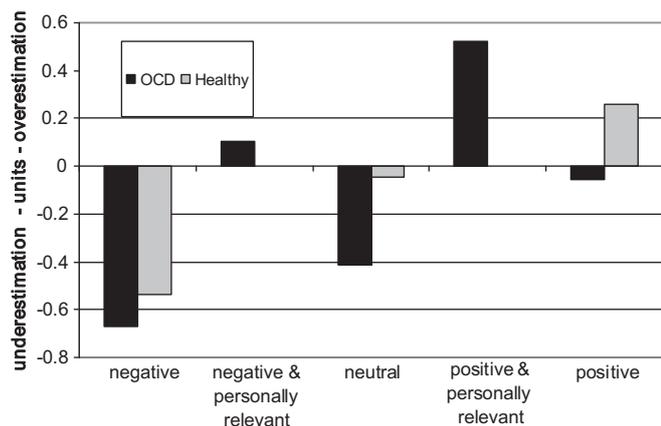


Fig. 3. Descriptive statistics separated for individual appraisal ratings. Note that relevance ratings are only displayed for OCD participants as healthy participants by definition had no personally relevant OCD-relevant items.

OCD, whereas non-relevant items were (slightly) underestimated. Healthy participants in turn underestimated negative items, overestimated positive items and displayed no strong bias for the neutral items.

To allow the computation of a comprehensive model, we collapsed the previously defined sub-categories into two general categories: a neutral category for all items judged as neutral (= 3) and an "OCD relevance" category which comprised all items the OCD group deemed personally relevant to their OCD symptoms (scores of 2 or 4). As healthy participants by definition did not have OCD-relevant symptoms, items which achieved a score of 1 or 5 (negative or positive) were taken as reference.

The 2 × 2 mixed ANOVA with Category (neutral, OCD relevance) and Group (healthy, OCD) revealed a significant effect of Category, $F(1,114) = 5.23, p = .02$, which was qualified by a significant interaction, $F(1,114) = 39.56, p < .001$. The effect of Group was again insignificant, $F(1,114) = 0.87, p > .3$. As can be seen in Fig. 4, OCD participants overestimated the size of personally relevant objects in comparison to healthy participants, $t(118) = 3.18, p = .002$. For neutral objects, the opposite response pattern emerged which slightly failed to reach significance, $t(118) = 1.93, p = .06$.

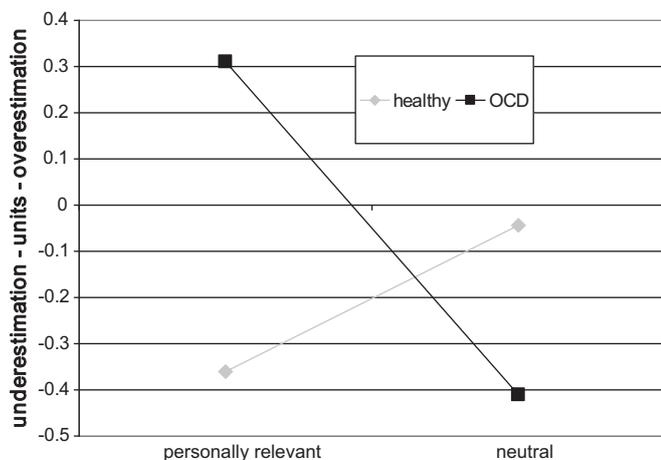


Fig. 4. OCD participants overestimated the size of personally relevant OCD objects and underestimated the size of neutral objects. The opposite response pattern occurred for healthy participants. As healthy participants by definition had no OCD, items which achieved a score of 1 or 5 (negative or positive) in healthy participants were taken as reference.

3.3. Correlations

None of the psychopathological and sociodemographic variables including school education significantly correlated with size estimations.

4. Discussion

Overestimation of threat (OET) has emerged as a fruitful concept in OCD research and together with other dysfunctional beliefs and cognitive biases such as inflated responsibility (Salkovskis & Forrester, 2002) is a core target of cognitive research in OCD (Obsessive-Compulsive Cognitions Working Group, 1997, 2001, 2003, 2005). Its main constituents are an enhanced subjective vulnerability for threat-related incidences and catastrophizing potential consequences (Moritz & Jelinek, 2009; Moritz & Pohl, 2006, 2009). The present study suggests that OET also manifests itself in distorted size perceptions in that patients overestimated the size of personally relevant OCD stimuli which was somewhat more marked for subjectively positive items. This is in accordance with findings gathered for acrophobics (Clerkin et al., 2009; Teachman et al., 2008) and spider phobics (Alpers & Gerdes, 2009).

The current study is the first investigation to examine OET in OCD using a neuropsychological paradigm. Therefore, the present results have to await replication. However, if confirmed, CBT interventions aiming to raise patients' metacognitive awareness about cognitive distortions, such as attention biases, may add this finding to psycho-education. Demonstrating to patients that obsessive thoughts and fears not only play tricks on cognitions but also memory and perhaps perceptions may foster a re-appraisal about the respective object and decrease its subjective potential to bring harm. The correct calibration of perceptions and memories could also be trained via bias modification procedures where a small sample has to be changed in size until it matches the target. Overestimation of size along with rumination and perhaps a lowered perceptual threshold for disorder-related material likely contributes to an over-representation of fearful objects in the patient's consciousness and may serve as maintenance factor of compulsive behavior. Conveying such a model to patients may not only enhance an understanding of their illness, but could also promote the urge to alter such biases as well as self-efficacy, as these processes are amenable to change - unlike biological models that at times induce treatment fatalism.

Interestingly, group effects were less convincing when looking at the pre-defined OCD categories. This emphasizes our hypothesis that biases are most strongly elicited in OCD when the idiosyncratic nature of the underlying fear is triggered (e.g., Moritz, Voigt, Arzola, & Otte, 2008). To illustrate, patients of the same subtype (e.g., checkers) may have very different obsessions (e.g., concerns about burglary, fire, aggressive acts towards beloved ones) and thus, will react very differently to objects commonly assumed to be checking-related (such as locks, an oven, or a knife). In contrast, in phobias the pattern of results is more consistent which could reflect the fact that in phobias the common denominator of feared objects is usually more homogeneous and restricted: Spider phobic patients are all preoccupied with spiders and webs, many social phobic patients are preoccupied with negative facial expressions as this is a general cue of social evaluation. The conclusion that personal relevance is perhaps more important than valence, has also been drawn for other populations. For example, we found a mood-congruent memory effect in depressed patients only when looking at items that patients deemed personally relevant (Moritz et al., 2008).

Overestimation of size in OCD is likely a bias rather than a perceptual or memory deficit for two major reasons: First, it is

apparently not ubiquitous (i.e., it occurs only for specific (personally relevant) material) while a deficit would manifest across item types. Second, overestimation of size is not an expression of pathology per se because it has also been found in non-psychiatric controls as well. Social psychology studies found that participants overestimate the size of coins relative to discs of the same diameter, which was moderated by socioeconomic status (i.e., poorer people had the tendency to overestimate the size of coins, see for example Bruner & Goodman, 1947; Munroe, Munroe, & Daniels, 1969). In sports, successful golf players tend to overestimate the size of golf holes relative to golfers who did not play as well (Witt et al., 2008). Two experiments revealed that the number of darts thrown in order to hit a target correlated negatively with memory estimates of the size of the target (Wesp, Cichello, Gracia, & Davis, 2004). Finally, patients with chronic pain perceive target distances as farther away when compared with a control group (Witt et al., 2009), which is in accordance with a previous finding observed for people wearing heavy backpacks (Proffitt, Stefanucci, Banton, & Epstein, 2003).

Participants had a general bias to underestimate the original size, which is in need of explanation. We attribute this finding to an anchor-effect: The thumbnails in Block 2, which were used to remind the participants of the previously shown picture, were much smaller than the original pictures. A considerable literature on the subject confirms that estimates are biased by intermediate information, so-called anchors. This effect is robust and can be elicited with meaningful, random, and even absurd anchors (for an overview see Mussweiler, Englich, & Strack, 2004). To provide an example, if one group of participants is first asked whether the temperature in the Antarctic is lower or higher than -17° Celsius and or lower or higher than -35° Celsius, subsequent temperature estimates for the absolute temperature will be substantially lower in the second case.

Our study faces some methodological limitations. Whereas a sizable sample was recruited, larger than comparable studies in this area of research, concerns about the reliability of the group allocation have to be taken seriously. However, although a formal interview was not made to ensure a diagnosis of OCD, multiple criteria were used to secure diagnostic status (i.e., invitation over moderated OCD forums, cut-off Y-BOCS and OCI-R scores, questions on medical history and prior treatment, absence of certain diagnoses, honesty rating at the end, only complete responders included). Moreover, duration of the survey probably discouraged people intending to sabotage the study. Further, 33% of the recruited participants were excluded due to our conservative inclusion criteria (i.e. below cut-off values of the Y-BOCS, OCI-R, BDI-SF or other psychiatric diagnoses). Notwithstanding that online studies should be confirmed with clinical studies, they possess certain advantages beyond economy. Particularly, online studies can reach patients which refuse to participate conventional clinical studies or who are not currently in treatment. In fact, only 40% of patients with OCD seek treatment (Kohn, Saxena, Levav, & Saraceno, 2004) and non-help seeking individuals differ on important respects from help seeking ones (Besiroglu, Cilli, & Askin, 2004). Moreover, responses on the Internet may sometimes be less guarded than responses derived from face-to-face interaction (e.g. Winzelberg et al., 2003). Thus, Internet and conventional studies should not be played out against each other, but regarded as complementary approaches with inherent advantages and disadvantages. In future studies, we would like to replicate the present study involving a psychiatric control group and extending the presently narrow scope of OCD related items (washing, checking) to other subtypes (e.g., symmetry, religion). As overestimations were not correlated with any clinical variable, it unlikely represents a state-factor. Longitudinal studies will have to elucidate whether overestimation is a trait-factor resistant to change or depends on

other, perhaps OCD-unrelated factors. Finally, future studies should try to tease apart the relative contribution of memory and perceptual biases since it is unclear whether the effects were driven by processes at the stage of perception and/or memory. In addition to an experimental procedure like the one used in the present study, subjects could be asked to change the display size of a target picture so that its size matches a cue item. Moreover, vividness and over-attention during perception as well as subsequent rumination and overall anxiety may also play a yet unknown role and should be controlled for.

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Conflict of interest

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