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Seeking Proxies for Internal States in Obsessive–Compulsive Disorder

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Pervasive doubts are a central feature of obsessive–compulsive disorder (OCD). We have theorized that obsessive doubts can arise in relation to any internal state and lead to compensatory reliance on more discernible substitutes (proxies), including rules and rituals. Previous findings corroborated this hypothesis, but were based on students with high and low OCD tendencies and did not control for anxiety. The present study tested our hypothesis in OCD participants using both anxiety disorders and nonclinical controls. Twenty OCD participants, 20 anxiety disorders participants, and 20 nonclinical participants underwent 2 experimental procedures. In the first, participants had to produce specific levels of muscle tension with and without the aid of biofeedback. In the second, participants were asked to subjectively assess their own muscle tension after viewing preprogrammed false feedback showing either increasing or decreasing levels of muscle tension. As predicted, OCD participants were less accurate than anxiety disorder and nonclinical participants in producing designated levels of muscle tension when biofeedback was not available and more likely to request the biofeedback when given the opportunity to do so. In the false feedback procedure, OCD participants were more influenced by the false biofeedback when judging their own level of muscle tension compared with the 2 controls groups. In both procedures, anxiety disorder participants did not differ from the nonclinical controls. These results support the hypothesis that individuals with OCD have attenuated access to and reduced confidence in their internal states, and that this deficit is specific to OCD and not attributable to anxiety.

Keywords: obsessive–compulsive disorder, anxiety, doubt, biofeedback, proxies

Pervasive and relentless doubts are among the central features of obsessive–compulsive disorder (OCD) and may trigger a variety of OCD symptoms, such as repeating and checking, elaborate hand-washing, reassurance seeking, excessive self-monitoring and mental reconstruction (American Psychiatric Association, 2000). Recent models of OCD assign a central role for doubt and uncertainty in regard to specific obsessive–compulsive (OC) concerns such as safety (e.g., Boyer & Liénard, 2006; Szechtman & Woody, 2004), task-completion (e.g., Summerfeldt, 2004, 2007), the self-concept (e.g., Aardema & O'Connor, 2007; Doron, Kyrios, & Moulding, 2007) and intimate relationships (e.g., Doron, Szepsenwol, Karp, & Gal, 2013). In addition, OC doubt and uncertainty have been widely demonstrated experimentally with regard to memory abilities (e.g., Tolin et al., 2001), decision-making and concentration (e.g., Nedeljkovic, Moulding, Kyrios, & Doron, 2009), attention and perception (e.g., O'Connor, Aardema, & Pélissier, 2005; van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout et al., 2009), and even general knowledge (Dar, Rish, Hermesh, Fux, & Taub, 2000).

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Recently, we have outlined a general hypothesis to account for OC doubt and ensuing rituals, which we termed Seeking Proxies for Internal States (SPIS; Lazarov, Dar, Liberman, & Oded, 2012a, 2012b; Lazarov, Dar, Oded, & Liberman, 2010; Liberman & Dar, 2009). We suggested that OC uncertainty is not limited to typical concerns such as cleanliness, morality, or safety but can be relevant to any internal state, be it cognitive (e.g., perception, memory, comprehension), affective (e.g., attraction, specific emotions), or bodily (e.g., muscle tension, proprioception). Moreover, according to the SPIS hypothesis, doubting one's internal state is associated with attenuated access to that state. Although our model does not specify whether doubt or reduced access is the initial cause in OCD, it builds on extant theories of OCD (e.g., van den Hout et al., 2008, 2009; van den Hout & Kindt, 2003a, 2003b) and of goal pursuit (Liberman & Dar, 2009; Shapira, Gundar-Goshen, Liberman & Dar, 2013) in postulating that they are likely to reinforce each other. For example, we would predict that doubting one's feelings toward one's partner would reduce the ability to accurately introspect on that feeling. The SPIS model further postulates that OC individuals attempt to compensate for their deficient conviction regarding internal states by developing and relying on *proxies*. Proxies are defined as substitutes for the internal state that the individual perceives as more easily discernible or less ambiguous, such as rules, procedures, behaviors, or environmental stimuli (Liberman & Dar, 2009). For example, to find out whether s/he loves her/his partner, a person might attempt to monitor the number of times s/he calls him/her, or the amount of money s/he spends on buying him/her a present.

Although the SPIS model is similar to other theories in emphasizing the central role of doubt and uncertainty in OCD, it diverges from each of these models on a number of important points. First,

in contrast to content-specific models of OCD (e.g., Boyer & Liénard, 2006; Doron et al., 2013; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004), which suggest that OCD is characterized by increased uncertainty about OCD-related contents such as safety, contamination, responsibility, morality, or self-integrity, SPIS suggests that OC doubt and uncertainty are not content-bound and might concern any internal state. Second, in SPIS doubting an internal state is accompanied by reduced knowledge about that same state, whereas other models only postulate uncertainty (e.g., O'Connor et al., 2005; Tolin, Abramowitz, Brigidi, Amire, & Foa, 2003), or an elevated need for certainty (e.g., Wahl, Salkovskis, & Cotter, 2008) and are silent with respect to whether or not uncertainty is accompanied with actual deficiency in knowledge. A third point of divergence is that SPIS emphasizes the functional aspect of some rituals as subjectively informative proxies that substitute and thereby compensate for a deficient knowledge of one's internal states. In contrast, other models of OCD tend to view rituals as by-products of a dysfunctional system, for example, as manifestations of a futile attempt to gain a sense of completion (e.g., Summerfeldt, 2004, 2007), safety (Boyer & Lienard, 2006; Szechtman & Woody, 2004), or certainty (e.g., O'Connor et al., 2005; Tolin et al., 2003).

Support for the SPIS hypothesis was provided by a series of studies in our laboratory in which biofeedback served as an external proxy for the internal states of relaxation and muscle tension. Participants in these studies were students with high and low scores on a measure of OC symptoms (Obsessive-Compulsive Inventory—Revised, see Measures below). In one of these studies (Lazarov et al., 2012b) we asked participants to achieve different levels of forearm muscle tension with and without the aid of biofeedback (the magnitude production task, see Procedure below). We reasoned that muscle tension is not related to any typical OCD concerns, rendering this task a particularly strong test of SPIS. As predicted, high OC participants were less accurate than low OC participants in producing the designated muscle tension levels without biofeedback, but performed equally well when biofeedback was available. In addition, when given the opportunity, and despite a potential cost in performance, high OC participants were more inclined to request access to the biofeedback. Similar results were obtained when relaxation rather than muscle tension was the target internal state (Lazarov et al., 2010). In another study (Lazarov et al., 2012a) we examined whether OC tendencies would predict the extent to which participants would rely on relevant but false feedback in judging their own internal state. High and low OC participants were instructed to relax their forearm muscles while viewing false preprogrammed "feedback" on their muscle tension. Each participant underwent two successive phases of putative feedback, one indicating gradual increase in muscle tension and one indicating gradual decrease in muscle tension. Following each phase, participants rated their perceived muscle tension. As predicted, high OC participants, as compared with low OC participants, were significantly more influenced by the false biofeedback in evaluating their own muscle tension, indicating that they relied more on the (false) biofeedback proxy for this particular internal state. In addition, high OC participants were less confident in their assessment of their own muscle tension, as rated at the end of the procedure. Similar results were obtained in another study with relaxation as the target state (Lazarov et al., 2010).

Our previous findings (Lazarov et al., 2012a, 2012b, 2010) corroborate the SPIS hypothesis in demonstrating that OC tendencies are associated with reduced confidence in internal states and with increased reliance on proxies for these states. Our results to date also demonstrate that high OC individuals are less accurate in evaluating and perceiving these states. Our previous studies had two major limitations, however, both of which we aimed to rectify in the present study. First, those results were based on nonclinical, highly functioning, largely female student samples, which restricts their generalizability to clinical OCD. Second, it is impossible to determine the extent to which our previous results were specific to OCD, as individuals with high and low OC tendencies are very likely to differ also on trait anxiety. The present study addressed these limitations by administering the magnitude production task and the false feedback procedure to OCD participants and to matched anxiety disorder participants and nonclinical controls. We predicted that OCD participants, compared with both anxiety disorder and nonclinical participants, would show deficient access to their own level of muscle tension, would exhibit elevate levels of doubt and uncertainty as to their muscle tension, and would rely more on the biofeedback in assessing this internal state.

Method

Participants

Participants were 20 individuals with a diagnosis of OCD, 20 individuals with a diagnosis of an anxiety disorder (AD), and 20 nonclinical (NC) control participants with no psychiatric history. Prior results with the same paradigm comparing participants high and low in OC tendencies yielded effects of D = .76 and larger (Lazarov et al., 2012b). As we did not know in advance whether the effects in a clinical sample would be larger or smaller, we used this effect size as an anchor for calculating the required sample size. A sample of 20 participants in each group has a power of 77% to detect a difference of .76 between any two groups and was therefore chosen as the target sample size in the present study. The anxiety and control groups were matched in terms of age and years of education to the OCD group (see Table 1) and had the same proportion of men (70%). Of the 20 AD participants 16 met criteria

Table 1
Psychopathological and Demographic Characteristics of the Three Groups

	OCD group		Anxiety group		Nonclinical group	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
OCI-R	32.95[a]	10.46	9.8[b]	5.72	10.3[b]	7.09
Trait-STAI	51.15[a]	10.04	48.25[a]	10.8	31.3[b]	7.46
BDI-II	16.5[a]	9.48	13.65[a]	10.73	4.35[b]	5.29
Age	39.57[a]	11.02	36.7[a]	8.69	38.25[a]	6.05
Years of education	13.2[a]	2.09	13.8[a]	1.82	13.45[a]	1.88

Note. Different superscripts signify differences between groups at $p < .001$. Same superscripts signify differences between groups at $p > .3$. $n = 20$ in each group. OCI-R = Obsessive-Compulsive Inventory–Revised; STAI = State-Trait Anxiety Inventory; BDI-II = Beck Depression Inventory; OCD = obsessive–compulsive disorder.

for social phobia (SP), six for generalized anxiety disorder (GAD), three for panic disorder (PD), and two for a specific phobia.

OCD and AD participants were recruited from a community mental health center in Israel. Initial diagnoses were based on a formal intake interview conducted by a psychiatrist or a trained clinical psychologist using the *Diagnostic and Statistical Manual of Mental Disorders* criteria (*DSM–IV–TR*; American Psychiatric Association, 2000) as part of the regular admission process to the mental health center. Primary and comorbid diagnoses were assessed a second time prior to participation in the study by individual clinical interviews using the Mini-International Neuropsychiatric Interview (MINI; Sheehan et al., 1998; see Measures). Only candidates whose diagnoses in the second interview were the same as their prior diagnoses were approved for participation in the study. In practice all of the participants met this requirement. We invited individuals with OCD and anxiety disorders to participate in the study according to the following exclusion criteria: Present or past psychotic episodes, comorbid posttraumatic stress disorder (PTSD), tic disorder or Tourette's syndrome, neurologic condition (e.g., epilepsy, brain injury), substantial present usage of drugs or alcohol, as defined by the MINI, or use of neuroleptic medication. We also planned on excluding candidates who had a spinal cord or muscle injury in the past or present time, although in practice none of the candidates met these criteria. All participants in the OCD group had a current primary diagnosis of OCD. NC participants were also assessed by individual clinical interviews using the MINI. We excluded participants with current or past OCD, anxiety disorder, or any other form of psychopathology, as well past or present spinal cord or muscle injury. All participants signed an informed consent and received 100 NIS (~25 U.S. dollars) as compensation for their time.

Of the 20 participants with OCD included in the study, 10 also met criteria for a past or present depressive episode, one met criteria for dysthymia, three met criteria for GAD, four met criteria for PD, four met criteria for SP and one met criteria for an eating disorder. Of the 20 participants with anxiety disorders included in the study, 10 also met criteria for past or present depressive episode, seven met criteria for dysthymia, and one met criteria for an eating disorder. Sixteen OCD participants and 12 AD participants were receiving pharmacological treatment, most of which consisted of selective serotonin reuptake inhibitors (SSRIs).

Apparatus

Physiological data on muscle activity was measured with the Procomp Infiniti hardware and Biograph Infinity software from Thought Technologies, Montreal, Canada. This biofeedback apparatus provides a reliable measure of muscle activity in a wide range of clinical contexts and at different muscle sites (e.g., Jantos, 2008; Mandryk & Atkins, 2007; Mandryk, Inkpen, & Calvert, 2006; Noé, Amarantini, & Paillard, 2009). A single triode electrode was applied to the skin over the flexor carpi ulnaris muscle of the participant's dominant arm. The electrode was connected to an electromyography (EMG) sensor and data were transmitted to a laptop computer via a biofeedback encoder.

In the magnitude production task, EMG changes were reflected on the computer screen as an upward–downward movement of a horizontal line along a vertical numerical axis ranging from 0 at the bottom to 5 at the top, with intervals of 1 (corresponding to EMG values of 0 to 20 microvolts, with intervals of 4). In the false feedback procedure, prerecorded EMG changes were displayed as a moving white dot on a black screen, the trajectory of which created a continuous line graph. In both procedures, a downward movement signaled a decrease in muscle tension.

Measures

Primary and comorbid diagnoses. Primary and comorbid diagnoses were assessed in individual clinical interviews using the MINI (Sheehan et al., 1998), a structured diagnostic interview for *DSM-IV* and ICD-10 psychiatric disorders, which takes approximately 20 min to administer and is a valid and time-efficient alternative to the SCID-P and CIDI (Lecrubier et al., 1997; Sheehan et al., 1997).

OC tendencies. OC tendencies were measured with the Obsessive-Compulsive Inventory–Revised (OCI–R; Foa et al., 2002). The OCI-R lists 18 characteristic symptoms of OCD followed by a 4-point scale ranging from 0 (*not at all*) to 4 (*extremely*), on which participants indicate the symptom's prevalence during the last month. The OCI–R has been shown to have good validity, test–retest reliability and internal consistency in both clinical (Foa et al., 2002) and nonclinical samples (Hajack, Huppert, Simons, & Foa, 2004).

OCD symptoms. The severity of OCD symptoms was assessed with the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Goodman et al., 1989). The Y-BOCS is a semistructured, clinician-rated 10-item scale, with each item rated from 0 (*no symptoms*) to 4 (*extreme symptoms*), resulting in a total score of 0–40 with separate subtotals for severity of obsessions and compulsions. Interjudge reliability of the Y-BOCS was reported as .85 and Cronbach's alpha as .89 (Woody, Steketee, & Chambless, 1995).

Trait anxiety. Trait anxiety was measured with the trait subscale from the State–Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). This subscale includes 20 items that are rated on a 4-point scale, with a possible total score of 20–80. The STAI-trait subscale has been found to have excellent internal consistency (ranging from .86 to .92) and high levels of test–retest stability (ranging from .73 to .86). In addition, the STAI has also demonstrated both convergent and discriminant validity (Spielberger et al., 1983).

Depression levels. Depression was assessed with the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II assesses the presence of 21 symptoms that are associated with depression, each based on a severity rating ranging from 0 to 3, with a possible total score of 0–63. The BDI-II has demonstrated high internal consistency in clinical (coefficient alpha of .92) and nonclinical samples (coefficient alpha of .93), as well as good test–retest reliability after a 1-week period (Beck et al., 1996). In addition, scores on the BDI-II were positively correlated with clinician-administered assessments of depression (Beck et al., 1996).

Muscle tension. Muscle tension was measured by averaging the EMG readings (in microvolts) of each participant during each experimental trial, such that a higher score indicated higher muscle tension. EMG has been widely used in previous clinical and experimental studies as a reliable and valid measure of muscle activity or tension. Previous studies have utilized EMG as a

measure to help individuals decrease muscle tension (e.g., Schwartz & Adrasik, 2003; Schwartz & Sedlacek, 2003), increase muscle tension (e.g., Fogel, 2003; Krebs & Fagerson, 2003) and, more relevant to the present study, to help individuals improve muscle control and awareness (e.g., Bayles & Cleary, 1986; Glaros & Hanson, 1990; Lehrer, Batey, Woolfolk, Remde, & Garlick, 1988; Segreto, 1995). As in our previous studies (Lazarov et al., 2012a) subjective perception of muscle tension was assessed on a 100-mm Visual Analog Scale (VAS), anchored with "really tense" on the left side and "completely loose" on the right. Participants were to place a mark that best described how their muscle felt during the last minute of each phase. The VAS score was measured in millimeters from the left anchor of the scale to the subject's pen mark (e.g., Di-Benedetto, Kent, & Linder, 2008; Leung, Chan, Lee, & Lam, 2004) and scores ranged between 0 and 100 with a higher score indicating lower muscle tension.

Procedure

Baseline assessment. Participants were tested individually in a quiet room. Upon arriving, the experimenter attached the electrode to the forearm of the participant's dominant arm. Participants were instructed to sit comfortably and refrain from talking or moving as much as possible while viewing a landscape presentation on the computer for 11 min. Resting baseline EMG was recorded during the last 3 min of this period.

The magnitude production task. Participants were told that in the first part of the experiment they will be asked to produce four target levels of forearm muscle tension that ranged from 1 (*lowest*) to 4 (*highest*). The experimenter guided the participant to produce two anchor tension levels, the level that was labeled 1 (four microvolt) and the level that was labeled 4 (16 microvolt). These anchors were attained by instructing participants to contract their forearm muscle until they have achieved the designated muscle tension target. The experiment resumed when participants were able to produce each of the two anchor levels twice, following a 2-min break.

In Phase 1 of the task participants were asked to produce different muscle tension levels, ranging from 1 to 4, and to hold the tension at that level until they were told to stop. Trials were 5-s long, with a 15-s rest period between trials in order to reduce fatigue. The different levels were presented in pseudorandom order, which was the same for all participants and across phases. Phase 1 consisted of 12 trials, during which participants could not view the biofeedback monitor.

Next, participants received a brief explanation as to the general nature and function of the biofeedback apparatus. This explanation was followed by a 2-min "self-discovery" period during which participants familiarized themselves with the apparatus with no specific instructions. Phases 2 and 3 replicated Phase 1, again requiring participants to produce different muscle tension levels ranging from 1 to 4, first while viewing the biofeedback monitor (Phase 2) and again without viewing the monitor (Phase 3).

Before the final phase (Phase 4) participants were told that during the next phase they will not be able to view the biofeedback monitor but that at several trials during this phase the experimenter will offer them a chance to view the biofeedback monitor for a few seconds, so that they will be able to see their progress and current state. They were told that at these trials the experimenter will ask "Would you like to see the monitor?" and that they were to nod if they chose to view the monitor and not to respond if they chose not to. Finally, they were informed that the rotation of the monitor may cause noise, which might be distracting and might affect their performance on the task (the allusion to the potential cost of requesting to see the monitor was designed to avoid a ceiling effect, whereby everybody would request to see the monitor as many times as possible). Participants' additional questions as for the reason why feedback might affect performance were answered by repeating the above. Each time a participant chose to view the monitor, the experimenter rotated the biofeedback monitor toward him/her briefly and then turned it back again. Participants were offered the choice of whether or not to view the monitor during Trials 2, 4, 6, 8, 10, and 12. Each of the first three phases of the experiment was followed by a 5-min interval of watching a screen saver in order to permit the participant's muscle tension level to return to baseline level before proceeding to the next phase, as well as to minimize fatigue.

During Phases 1–3 average EMG was measured as defined above. We derived a mean deviation score for each participant by computing the absolute difference between the target and the actual physiological response in each trial and averaging it across trials for each phase. The dependent measure in Phase 4 was the number of times the participant requested to view the biofeedback monitor. We predicted that compared with both AD and NC participants, OCD participants would be less accurate in producing the designated muscle tension levels in the absence of biofeedback, but not when the biofeedback was available. We also predicted that in Phase 4, OCD participants would request the biofeedback more frequently than would AD and NC participants.

False feedback on muscle tension. Following the magnitude production task there was a 10-min break in which participants were free to move about. Upon returning to their seats, the experimenter attached a new electrode to the forearm of the participant's dominant arm. Participants were then introduced to a putatively new biofeedback software. They were told that an upward movement of the white dot across the screen in this software signaled an increase in muscle tension, whereas a downward movement of the white dot signaled a decrease in muscle tension. In addition, they were told that "usually this new biofeedback software functions quite well, although its reliability is not a hundred percent, so that sometimes the feedback given in regard to muscle tension is not accurate." This explanation was followed by a 3-min interval of watching a screen saver in order to permit the participant's muscle tension to return to baseline levels.

The false feedback procedure comprised two 5-min phases, during which participants viewed preprogrammed "biofeedback" of their muscle tension. During one phase, the putative biofeedback showed a descending line graph indicating a decrease in muscle tension, and during the other, an ascending line graph indicating an increase in muscle tension. The order of the two phases was counterbalanced across participants. Following each phase participants were instructed to rate their perceived muscle tension on the VAS. Between phases, participants watched a 3-min screen saver in order to permit their muscle tension to return to baseline levels. While participants viewed the false biofeedback monitor, their actual EMG was recorded as described above in order to rule out any effects of the false feedback on actual muscle tension. At the end of the experiment participants were asked to

rate how confident they were about their subjective muscle tension estimates on a scale of 0%–100%. We predicted that OCD participants, compared with AD and NC participants, would be more influenced by the false feedback in rating their own muscle tension and would feel less confident about these ratings.

At the end of the entire procedure participants completed the OCI-R, the BDI-II, and the trait subscale of the STAI. OCD participants were also administered the Y-BOCS to assess the severity of their OCD. We chose to administer the questionnaires at the end of the procedure to eliminate any effect they might have on performance during the tasks, such as raising doubts, anxiety, or depressive thoughts. After completing these measures, participants were debriefed and paid.

Results

Psychopathological Characteristics

Table 1 presents participants' scores on the OCI-R, the trait subscale of the STAI and the BDI-II. OCD participants had significantly higher scores on the OCI-R in comparison to AD and NC participants, which did not differ on this measure. With regard to trait anxiety and depression, both OCD and AD participants had significantly higher scores in comparison with the NC participants and did not differ between them. The mean Y-BOCS score of the OCD participants was 21.55 (range of 11–32), which is at the moderate severity level (Steketee & Neziroglu, 2003).

Magnitude Production Task

A one-way analysis of variance (ANOVA) of baseline EMG indicated no significant differences between OCD (M = 1.49, SD = 0.4), AD (M = 1.74, SD = 1.06), and NC participants (M = 1.5, SD = 0.35), $F(2, 57) = .83$, $p = .44$. Figure 1 displays the deviation score of the three groups in the first three phases of the experiment. We used two planned interaction contrasts to examine the differential effect of viewing the monitor (Phase 2 vs. Phase 1 and Phase 3) on accuracy in producing the designated muscle tension, one with OCD versus AD and the second with OCD versus NC. The first interaction contrast was significant, $F(1, 57) = 22.46$, $p < .001$, $\eta^2 = 0.28$, as was the second, $F(1, 57) = 15.20$, $p < .001$, $\eta^2 = 0.21$. Confirming our prediction, viewing the biofeedback monitor had a different effect on OCD participants as compared with both AD and NC participants. Simple contrasts indicated that as predicted, during Phase 1 OCD participants had significantly higher mean deviation scores than both the AD participants, $F(1, 57) = 18.44$, $p < .001$, $\eta^2 = 0.24$, and the NC participants, $F(1, 57) = 13.85$, $p < .001$, $\eta^2 = 0.20$, which did not differ between them, $F(1, 57) = 0.33$, $p = .57$. A similar pattern emerged regarding Phase 3: OCD participants had a significantly higher mean deviation score than AD participants, $F(1, 57) = 12.2$, $p < .001$, $\eta^2 = 0.18$, and NC participants, $F(1, 57) = 8.64$, $p = .004$, $\eta^2 = 0.13$, which again did not differ between them, $F(1, 57) = 0.3$, $p = .58$. As predicted, introducing the biofeedback in Phase 2 eliminated the relatively poor performance of the OCD participants in comparison with the other two groups, as indicated by a lack of difference between the OCD and NC participants, $F(1, 57) = 1.04$, $p = .30$. Surprisingly, a weak but significant difference between the OCD and AD participants, $F(1, 57) = 4.26$, $p = .04$, $\eta^2 = 0.07$, indicated that with biofeedback OCD participants performed slightly better than AD participants. There was no significant difference between the AD and the NC control groups, $F(1, 57) = 1.09$, $p = .30$.

Finally, we performed three planned comparisons to examine whether OCD participants would be more inclined than AD and NC participants to request the biofeedback monitor during Phase 4. As predicted, OCD participants asked to see the monitor more times (M = 4.95, SD = 1.15) than did AD participants (M = 1.05, SD = 1.15), $F(1, 57) = 111.58$, $p < .001$, $\eta^2 = 0.66$, or NC participants (M = 1.1, SD = 1.21), $F(1, 57) = 108.74$, $p < .001$, $\eta^2 = 0.66$, who did not differ between them, $F(1, 57) = 0.02$, $p = .89$.

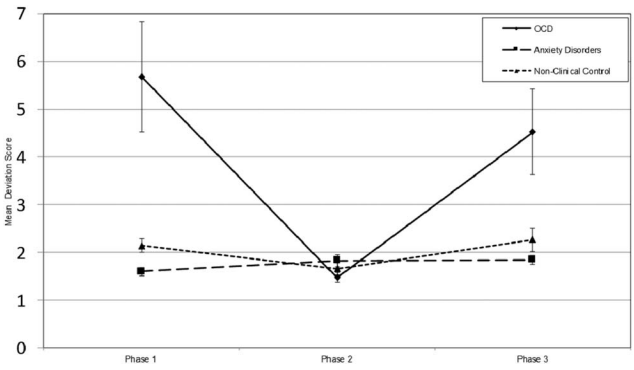

Figure 1. Mean absolute deviations from target muscle tension by phase and group. Higher values indicate higher deviations from target muscle tension in microvolts. Error bars denote standard error. Obsessive–compulsive disorder (OCD) participants were significantly less accurate during Phase 1 and Phase 3, when the biofeedback was not available, in comparison with anxiety disorder (AD) and nonclinical control (NC) participants. There were no differences in accuracy during Phase 2, when the biofeedback was available.

False Feedback on Muscle Tension

Figure 2 displays the perceived muscle tension of the three groups on the VAS following the two false feedback phases. Order of presentation of upward versus downward false feedback did not affect the results and will not be discussed further.

The predicted differential effect of the false feedback (upward vs. downward) on the three groups were confirmed by three planned interaction contrasts: OCD versus AD, $F(1, 57) = 67.08$, $p < .001$, $\eta^2 = 0.54$, OCD versus NC, $F(1, 57) = 67.74$, $p < .001$, $\eta^2 = 0.54$, and AD versus NC, $F(1, 57) = 0.002$, $p = .97$. These results indicate that, as predicted, OCD participants were significantly more affected by the false biofeedback in judging their own level of muscle tension as compared with the two other groups, which did not differ between them.

In order to rule out an interaction between false biofeedback and group in affecting actual muscle tension, we conducted a 3 (Group: OCD, AD and NC) × 2 (Trend: Upward vs. Downward) mixed-model ANOVA with mean EMG readings as the dependent measure. Consistent with our prediction, there was no interaction between trend and group, $F(2, 57) = .37$, $p = .69$, indicating that false biofeedback did not have a differential effect on real muscle

tension in the three groups (see Figure 3). There were no other significant effects of the independent variables on EMG readings.

Finally, we conducted three planned comparisons to examine participants' reported confidence with regard to their subjective muscle tension estimates. Consistent with our prediction, OCD participants were less confident in their judgments ($M = 76$, $SD = 16.98$) as compared with AD participants ($M = 92.5$, $SD = 7.16$), $F(1, 57) = 17.4$, $p < .001$, $\eta^2 = 0.23$, and to NC participants ($M = 91.5$, $SD = 13.37$), $F(1, 57) = 15.37$, $p < .001$, $\eta^2 = 0.21$, which did not differ between them, $F(1, 57) = 0.064$, $p = .80$.[1]

Discussion

The results of the present study were fully in line of our predictions. OCD participants were less accurate than both anxiety disorder and nonclinical participants in producing designated muscle tension levels in the absence of external feedback; in other words, they were less accurate in consistently mapping that particular internal state on a scale. When an objective proxy for muscle tension was provided via the biofeedback monitor, the performance of the OCD participants equaled that of the control participants. In addition, OCD participants were more likely to request the biofeedback proxy, as compared with both AD and NC participants. Thus, when choosing between relying on their own perception of their own muscle tension and relying on the proxy, OCD participants preferred the proxy despite its cost.

In the false feedback procedure, OCD participants relied more on (i.e., were more deceived by) the false biofeedback in judging their own muscle tension levels as compared with the two control groups. Our interpretation of this finding is that due to their doubt about (and probably attenuated access to) their own muscle tension, OCD participants more readily believed the information provided from the outside. This effect could not be accounted for by any actual effects of the false feedback on muscle tension. As expected, OCD participants, compared with both AD and NC participants, were also less confident in their subjective muscle tension estimates.

These findings provide strong support to the SPIS hypothesis, which postulates that OCD is related to reduced accuracy in evaluating internal states, reduced confidence in judging these states, and increased compensatory reliance on proxies for these states. Moreover, the present study demonstrates that our previous findings not only generalize to clinical OCD but are in fact much more prominent in this population compared with what we observed in our analogue samples of high and low OC participants. For example, the effect of viewing the false feedback, which can be calculated by subtracting the VAS score of the downward phase from that of the upward phase, was 41.85 for the OCD participants in the present study as compared with 17.1 for high OC participants in our previous studies (Lazarov et al., 2012a).

Just as importantly, the results of the present study strongly indicate that the processes implicated by the SPIS hypothesis are specific to OCD and cannot be accounted for by anxiety or depression. Regarding depression, the two clinical groups had the same proportion of participants (50%) who met criteria for past or present depressive episode and nevertheless showed a markedly different performance on the biofeedback task. The fact that the two clinical groups did not differ on BDI-II scores (see Table 1) also excludes depression as a likely explanation for our results. The same is true for anxiety: In both tasks, the performance of OCD participants was strikingly different from that of anxiety disorder participants, whose performance was essentially identical to NC participants. Such clear differentiation in task performance between OCD and anxiety disorders participants is rarely observed in the experimental literature. This being said, future studies can examine whether similar processes may also typify other forms of psychopathology, including obsessive–compulsive spectrum disorders and perhaps also other disorders which are characterized by rules and rituals, such as autistic spectrum disorders (e.g., American Psychiatric Association, 2013; McDougle et al., 1995; Zandt, Prior, & Kyrios, 2007).

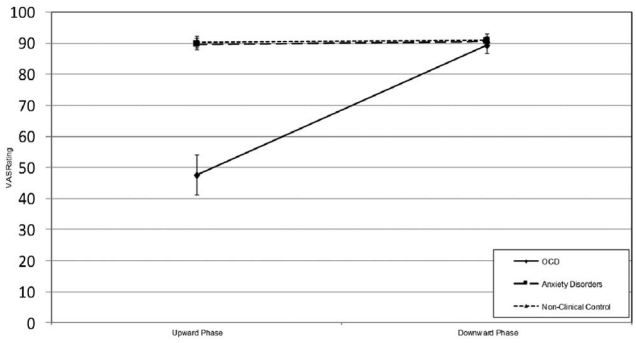

Figure 2. VAS ratings of subjective muscle tension by trend and group. Higher values indicate lower levels of reported muscle tension. Error bars denote standard error. Obsessive–compulsive disorder (OCD) participants were significantly more influenced by the false feedback in subjectively assessing their own level of muscle tension in comparison with anxiety disorder (AD) and nonclinical control (NC) participants.

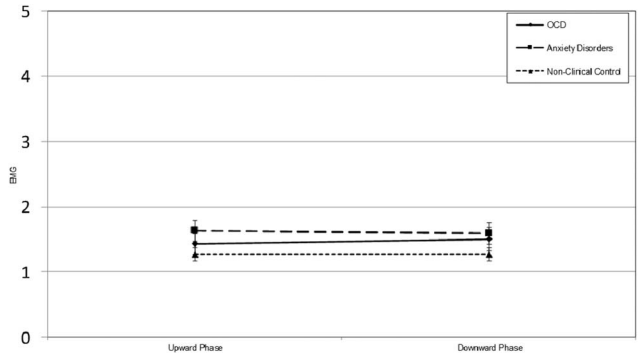

Figure 3. EMG readings of muscle tension by trend and group. Higher values indicate higher levels of muscle tension in microvolts. Error bars denote standard error. False feedback did not have a differential effect on actual muscle tension levels among the three groups.

[1] To further examine the specificity of our findings to OCD, we reconducted all the analyses pertaining to the differences between the OCD and the AD participants while controlling for anxiety (STAI) and depression (BDI-II) scores using analysis of covariance. Supporting the specificity argument, all the statistically significant differences between the groups in both procedures remained highly significant ($p < .005$) after controlling for these covariates.

The present findings, as well as some of our previous ones (Lazarov et al., 2012a, 2012b, 2010), corroborate our hypothesis that OC individuals not only doubt their subjective experience but may actually have attenuated access to their own internal states. This possibility is in line with recent models that postulate a deficiency in internal signals, cues, or feelings in OCD, which leads to repetitious behaviors and compulsions (Boyer & Liénard, 2006; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004). It is also consistent with studies showing real deficits in memory among OCD patients rather than merely reduced confidence in memory (e.g., Abramovitch, Dar, Schweiger, & Hermesh, 2011; Christensen, Kim, Dyksen, & Hoover, 1992; Savage et al., 2000; Tuna, Tekcan, & Topçuoğlu, 2005; Woods, Vevea, Chambless, & Bayen, 2002; Zitterl et al., 2001) and with findings suggesting a dysfunctional biological-somatic marker in OCD participants, affecting learning and decision-making processes (Cavedini et al., 2012; Joel & Avisar, 2001; Starcke, Tuschen-Caffier, Markowitsch, & Brand, 2009).

It is presently unknown whether such attenuation of internal signals in OCD is caused by obsessional doubts or is the cause of these doubts. A likely scenario is that both processes are at work. Repeated doubting and checking has been shown to degrade subjective experience (e.g., van den Hout et al., 2008, 2009; van den Hout & Kindt, 2003a, 2003b), and similar effects have been recently demonstrated with excessive monitoring of a subjective state (Shapira et al., 2013). Conversely, attenuated access to, or degraded clarity of internal states may lead to "justified" doubt in one's experience, leading to further doubting and monitoring, and subsequently to further attenuation. Whatever is the nature of the relation between doubt and deficient access to internal states, the implication for conceptualizing compulsive behavior are intriguing. Specifically, these relationships suggest that OC rules and rituals may sometimes be a reasonable response to decreased ability to accurately assess one's internal states. Future studies should examine the causal relationship between doubt regarding internal states, accurate perception of these states, and seeking proxies for those states. For example, we have shown in a previous study that undermining normal participants' confidence in their ability to perceive a specific internal state made them more susceptible to false feedback and led to enhanced reliance on proxies as means to evaluate this state (Lazarov et al., 2012a). To examine the effect of reduced confidence on accuracy, we are presently replicating the magnitude production task among a nonclinical, nonselected sample of students, half of which will undergo an experimental manipulation that would reduce their confidence in the ability to accurately access their own muscle tension.

The finding that biofeedback, when used as a proxy, improved the performance of OCD participants during Phase 2 of the magnitude production task supports the notion that proxies may at times be an adaptive strategy when more direct information is lacking. However, important caveats should be noted in relation to this possibility. First, in everyday life proxies are seldom as valid as biofeedback, and it would be important to examine the SPIS hypotheses with other proxies, both informative and useless. Second, although in the short run some proxies might be beneficial in reducing doubt and uncertainty and even improving performance, in the long run these same proxies might have a detrimental effect both on the ability to access the internal state and on confidence in such assessment. This is because continuous reliance on proxies and the tendency to monitor and question one's experiences oftentimes reduces confidence in these experiences and dissipates the experience itself. For example, checking behavior, which SPIS conceptualizes as a proxy for reduced conviction regarding memory and perception, has the ironic effect of reducing confidence and increasing doubt in one's own memory (e.g., Ashbaugh & Radomsky, 2007; Radomsky, Gilchrist, & Dussault, 2006; Tolin et al., 2001; van den Hout & Kindt, 2003a, 2003b), perception (van den Hout et al., 2008, 2009), and even general knowledge (Dar et al., 2000). Delineating the factors that determine the usefulness of proxies in the short and the long run is an important avenue for future theorizing and research. Finally, we should stress that the SPIS hypothesis does not maintain that all OCD rituals can be conceptualized as proxies for internal states. Many rituals, such as those conducted to magically avert disaster, may be better understood in terms of other theoretical constructs, such as need for and illusion of control (e.g., Reuven-Magril et al., 2008).

There are several limitations of the present study, which should be addressed in future research. First, 16 of the 20 participants in the anxiety disorders group were diagnosed with social phobia, yet the other anxiety disorders were not as well represented. Future studies should try and replicate our findings using a more heterogeneous anxiety group in order to broaden the specificity of the current results. Second, it might have been beneficial to include some additional measures in our questionnaire battery, such as the Intolerance of Uncertainty Scale (Freeston, Rhéaume, Letarte, Dugas, & Ladoceur, 1994) or the Obsessive Beliefs Questionnaire (OCCWG, 1997, 2001), to assess empirically whether some of these cognitive variables might have contributed to the differences in performance found in the present study. Third, 16 of the OCD participants and 12 of the AD participants were receiving pharmacotherapy, although all the NC participants were medication free. However, the fact that the OCD and AD groups exhibited widely different performance in all tasks, combined with the fact that the AD group and the NC group exhibited no significant differences in any of the tasks seems to rule out medications as a possible mediating factor in this study. Finally, the magnitude production task requires participants to accurately detect their own level of muscle tension and then to accurately produce the requested level. It is possible that the production rather than the detection was harder for OCD participants. Future studies should try to differentiate perception and performance in order to identify the hypothesized deficit more precisely.

Future research is also needed to elucidate several aspects the SPIS hypothesis. For example, although SPIS postulates a general doubt in and attenuation of internal states in OCD, OC symptoms typically concern specific realms or worlds of content. We know very little about why and how this hypothesized deficiency expresses itself in specific OC domains such as safety, cleanliness, or morality. The answer may be related to the subjective importance of the relevant domain or the sense of responsibility the individual feels in regard to that domain (Salkovskis, 1999; Wahl et al., 2008). Future research can examine how OC doubt and reliance on proxies varies with the relevance of the domain, the perceived seriousness of making a mistake, or the presence of threat. Finally, as noted in the beginning of the article, other theories of OCD have focused on difficulties with regard to specific internal states, such as achieving a sense of completeness or closure (e.g., Coles, Frost, Heimberg, & Rhéaume, 2003; Coles, Heimberg, Frost, & Steketee,

2005) or a sense of safety (e.g., Boyer & Liénard, 2006; Szechtman & Woody, 2004). We agree with these models in viewing these problems as stemming from a deficient access to an internal state, but we suggest that the difficulty experienced by people with OCD is broader, in that it concerns any internal state, not only the "just right" feeling. Future studies should examine the applicability of the SPIS model to additional internal states, ranging from basic sensations, such as hunger or pain, to more complex subjective experiences, such as affective states.

Finally, we believe that the SPIS hypothesis can be fruitfully integrated into cognitive and metacognitive therapy for OCD. Therapists can use this framework to discuss with patients the difficulties they have in trusting their own subjective experiences. Targeting doubt as a means to achieving beneficial treatment outcome has been suggested in previous approaches to OCD (e.g., Aardema & O'Connor, 2012; Tolin et al., 2003). For example, treatment trials examining the Inference Based Therapy (IBT; Aardema & O'Connor, 2012) have shown that improvements in the ability the resolve doubt were positively related to treatment outcomes (e.g., Aardema & O'Connor, 2012; Aardema, Wu, Careau, O'Connor, & Dennie, 2010). We believe that equivalent emphasis should be given to the detrimental effects that using and relying on proxies may have for confidence in and access to one's own internal states. OC rules and rituals can be reframed in therapy as less ambiguous substitutes for vague internal state, and the potential ramifications inherent in relying on proxies as a compensation strategy can be discussed. Potentially, therapists may be able to use biofeedback-aided procedures to help OCD patients improve their perception and labeling of their own subjective experiences. Future research can examine the viability of acquiring a general skill of identifying and relying on internal states, which may help to counter the self-doubt that is so pervasive in OC individuals.

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