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Can doubt attenuate access to internal states? Implications for obsessive-compulsive disorder

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ABSTRACT

Background and objectives: We have previously reported that obsessive-compulsive individuals perform more poorly on tasks that require accurate perception of internal states. As these individuals are also characterized by elevated levels of doubt regarding internal states, the causal relationship between doubt and accurate perception remained unclear. The presented study examines whether undermining participants' confidence in their ability to accurately produce a specific internal state would affect their performance on a task that requires accurate perception of this state.
Methods: Participants were trained to produce specific levels of forearm muscle tension and then required to produce various tension levels in four experimental phases. The first three alternated in terms of whether the participants viewed a biofeedback monitor while the fourth offered participants several times the choice to view the monitor. Prior to the task, half of the participants received instructions that undermined their confidence in their ability to accurately assess their own muscle tension. We measured participants' accuracy in producing the required muscle tension levels and the number of times they requested to view the monitor in the final phase.
Results: Undermined confidence participants were less accurate in producing the required muscle tension levels in the absence of biofeedback, and were also more likely to request the monitor in the final phase.
Conclusions: Doubt can affect performance on tasks that require perceiving and experiencing internal states. This finding supports the possibility that access to internal states in OCD is attenuated due to elevated levels of doubt regarding these states.

1. Introduction

Obsessive and relentless doubts are considered to be one of the primary features of obsessive-compulsive disorder (OCD; American Psychiatric Association, 2013). These doubts typically trigger a variety of OCD related pathological behaviors such as repeated checking, excessive hand washing, persistent mental reconstructions, enhanced self-monitoring and exhausting validation and reassurances seeking from one's immediate environment (e.g., Dar, Hermesh, Fux, Rish, &Taub, 2000). Obsessive-compulsive (OC) doubt has been demonstrated in relation to many cognitive functions ranging from memory (e.g., Dar, 2004; Tolin et al., 2001) to attention and perception (e.g., Hermans et al., 2008; Hermans, Martens, De Cort, Pieters, & Eelen, 2003; van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout, Engelhard, Smeets, Dek, Tuksma, & Saric, 2009) and its central role in OCD has been acknowledged in both early theories (e.g., Janet, 1903; Rapoport, 1989; Rasmussen & Eisen, 1989; Reed, 1985; Shapiro, 1965) and more recent ones (e.g., Boyer & Liénard, 2006; Hinds, Woody, Van Ameringen, Schmidt, & Szechtman, 2012; O'Connor, Aardema, & Pélissier, 2005; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004; Tolin, Abramowitz, Brigidi, & Foa, 2003; Wahl, Salkovskis, & Cotter, 2008; Woody & Szechtman, 2005, 2011; Zor, Szechtman, Hermesh, Fineberg, & Eilam, 2011).

Recently we have outlined a new model of OCD, which we termed Seeking Proxies for Internal States (SPIS; Lazarov, Dar, Oded, & Liberman, 2010; Lazarov, Dar, Liberman, & Oded, 2012a, 2012b; Lazarov, Liberman, Hermesh, & Dar, 2014; Liberman & Dar, 2009). SPIS joins earlier models in considering OC doubt as a main component in the phenomenology and etiology of OCD. According to the SPIS model OC doubt is relevant to and can be manifested in

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any internal state, be it cognitive (e.g., perception, memory, comprehension), affective (e.g., attraction, specific emotions) or bodily (e.g., muscle tension, proprioception), and thus is not limited to typical OC concerns such as safety, task-completion, the self-concept or intimate relationships (e.g., Aardema & O'Connor, 2007; Boyer & Liénard, 2006; Doron, Kyrios, & Moulding, 2007; Doron, Szepsenwol, Karp, & Gal, 2013; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004). Furthermore, we proposed that doubting one's internal state is accompanied by attenuated access to that state, resulting in difficulties in experiencing and perceiving it accurately. In addition, the SPIS model delineates a compensation strategy through which OC individuals attempt to defend against OC doubt regarding internal states, namely the development and reliance on *proxies*. Proxies are defined as substitutes for the internal state that the individual subjectively perceives as more easily discernible or less ambiguous, such as rules, procedures, behaviors or environmental stimuli (Liberman & Dar, 2009). For example, an OCD patient was asked during a therapy session how she knew that her hands were clean. Her reply was: “I never really *know* whether they are clean or not. What I do know is that I have completed my ritual.” In terms of the SPIS model, the washing ritual serves as a proxy signaling to that patient that her hands are clean, thus compensating for her missing internal feeling of cleanness.

The present study follows two previous studies in which we used an electromyography biofeedback apparatus as a proxy for the internal states of muscle tension (Lazarov et al., 2012b, 2014). We chose muscle tension as the designated internal state to be examined as it is not obviously related to any specific or typical OC concern, rendering this task as a particularly strong test of the SPIS model. Participants in the first study (Lazarov et al., 2012b) were students with high and low OC tendencies scores, as measured by the Obsessive-Compulsive Inventory-Revised (OCI-R; Foa et al., 2002). In the first three phases of the experiment (the magnitude production task; for details, see Procedure below) we asked participants to achieve different levels of forearm muscle tension either with or without the aid of the biofeedback monitor. During the fourth phase we offered participants the chance to view the biofeedback monitor at several trials, after warning them that choosing to see the biofeedback monitor might impair their performance on the task. As predicted, high OC participants were less accurate than low OC participants in producing the designated muscle tension levels without the biofeedback, but performed equally well when biofeedback was available. In addition, when given the opportunity, and despite the potential cost in performance, high OC participants were more inclined to request access to the biofeedback compared with the low OC participants. Similar findings were obtained in a more recent study using the same magnitude production task with OCD participants compared to anxiety disorder (AD) and non-clinical (NC) control participants (Lazarov et al., 2014). Importantly, the AD and NA groups did not differ in their accuracy in producing the different muscle tension levels or the number of requests to view the biofeedback monitor, thus eliminating anxiety as a possible alternative explanation of the results.

The results of our studies with the magnitude production task, combined with previous findings from our lab using other paradigms (Lazarov et al., 2010, 2012a, 2012b, 2014), lend preliminary support to the SPIS postulation that OC individuals are characterized by attenuated access to their own internal states. However, because OC participants are also characterized by elevated levels of doubt, our studies to date could not elucidate the relationship between doubt regarding internal states and accurate perception of these states. Attenuated access could naturally give rise to elevated levels of doubt regarding internal states – a person who cannot determine whether s/he feels tense or not, would naturally doubt that any specific level of tension applies to her/him. Alternatively, it is also possible that attenuated access is the result rather than the cause of elevated levels of doubt regarding these states. In other words doubt, in and of itself, may be sufficient to weaken access to internal states. In a previous study we examined the effects of undermining participants' confidence on their susceptibility to false pre-programmed feedback which served as a proxy for the feeling of relaxation (Lazarov et al., 2012a). Specifically, we presented non-selected participants, half of whom received instructions that undermined their confidence in their ability to assess their own level of relaxation, with pre-programmed false feedback showing either increasing or decreasing levels of relaxation. We found that undermined confidence participants were more affected by the false biofeedback when judging their own level of relaxation as compared to control participants. Thus, inducing doubts regarding internal states was causally related to relying on and using proxies. Nevertheless, that study did not allow us to determine whether experimentally induced doubt regarding internal states is sufficient to also impair perception of these states.

The present study was the first to experimentally examine whether doubt regarding internal states can interfere with accurate perception of these states. We administered the magnitude production task to a non-clinical non-selected sample of students, half of which underwent an experimental manipulation designed to undermine their confidence in their ability to accurately produce their own level of muscle tension. Based on the reasoning explained above, we predicted that in the absence of biofeedback, participants whose confidence was undermined, as compared with the control participants, would perform more poorly on Phase 1 of the magnitude production task, which relies solely on subjective internal cues. We also predicted that viewing the biofeedback monitor during Phase 2 would improve the performance of participants whose confidence was undermined more than that of control participants. Finally, we predicted that when given the opportunity, participants whose confidence was undermined would be more inclined than the control participants to seek the biofeedback monitor.

2. Method

2.1. Participants

Thirty seven psychology students at Tel-Aviv University participated in the study. One participant was excluded from the analysis due to technical problems with the biofeedback apparatus during the experiment. The final sample included 36 participants, 27 women and 9 men (M age = 23, SD = 2.12, range = 19–28). This sample size is similar to our previous study with the same experimental procedure (Lazarov et al., 2012b). Participants signed an informed consent and received course credit for participation. None of the participants had prior experience with biofeedback.

2.2. Apparatus

Physiological data regarding muscle activity was measured with the Procomp Infiniti hardware and Biograph Infinity software from Thought Technologies, Montreal, Canada, used by Lazarov et al. (2012a, 2012b, 2014) in their previous work examining the ability to accurately produce different levels of muscle tension. This biofeedback apparatus, as well as other versions of it, were shown in previous studies to provide a reliable measure of muscle activity in a wide range of clinical contexts and at different muscle sites (e.g., Bravo, Coffin, & Murphey, 2005; Jantos, 2008; Mandryk & Atkins, 2007; Mandryk, Inkpen, & Calvert, 2006; Noe, Amarantini, & Paillard, 2009; Reissing, Binik, Khalife, Cohen, & Amsel, 2004).

For each participant a single triode electrode was applied to the skin over the flexor carpi ulnaris muscle of the participant's dominant arm (i.e., the muscle that contracts in the forearm when you are asked to make a fist). The sensor measured electromyography (EMG) – electrical signals generated during muscle activity (Peek, 2003). The electrode was connected to an EMG sensor and data were transmitted to a laptop computer via a biofeedback encoder. 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 0–20 μV, with intervals of 4).

2.3. Measures

2.3.1. Obsessive-compulsive tendencies

Obsessive compulsive tendencies were measured by the OCI-R (Foa et al., 2002). The OCI-R lists 18 characteristic symptoms of OCD. Each symptom is 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 non-clinical samples (Hajack, Huppert, Simons, & Foa, 2004). Cronbach's alpha of the OCI-R in our sample was .88, which is identical to the figure reported in previous studies with college samples (Hajack et al., 2004; Lazarov et al., 2010, 2012a, 2012b).

2.3.2. Depression, anxiety and stress symptoms

Depression anxiety and stress symptoms were measured using the Depression, Anxiety and Stress Scales-21 (DASS-21; Lovibond & Lovibond, 1995a). The DASS-21 is a 21 item self-report questionnaire yielding three sub-scales of seven items each, assessing dimensional components of depression, anxiety and physiological stress. Each individual statement reflects a negative emotional symptom and is followed by a 4-point scale ranging from 0 (*the item does not apply to me at all*) to 3 (*the item applies to me very much or most of the time*), on which participants indicate how much the statement applied to him/her experience over the past week. The DASS-21 has been shown to have high reliability, validity and internal consistency in both clinical and non-clinical groups (Antony, Bieling, Cox, Enns, & Swinson, 1998; Henry & Crawford, 2005; Lovibond, 1998; Lovibond & Lovibond, 1995b).

2.3.3. Muscle tension

Muscle tension was measured as in our previous muscle tension studies (Lazarov et al., 2012a, 2012b, 2014), by averaging the EMG readings (in microvolts) of each participant during each experimental trial, such that a high EMG score indicated higher muscle tension and a low EMG score indicated lower muscle tension. EMG measures muscle activity by detecting surface voltage that occurs when a muscle is being contracted (Peek, 2003). EMG has been widely used in previous clinical and experimental studies as a reliable and valid measure of muscle activity or tension. Some studies have utilized EMG as a measure to help individuals decrease muscle tension (e.g., Ince, Leon, & Christidis, 1987; McGrady & Linden, 2003; Neblett, Gatchel, & Mayer, 2003; Schwartz & Adrasik, 2003; Schwartz & Sedlacek, 2003), some for training individuals to increase muscle tension (e.g., Cohen, Richardson, Klebez, Febbo, & Tucker, 2001; Croce, 1986; Fogel, 2003; Ince et al., 1987; Krebs & Fagerson, 2003; Middaugh & Miller, 1980; Moreland, Thomson, & Fuoco, 1998) and more relevant to the present study, some have utilized EMG as a measure to help individuals increase muscle control and awareness (Bayles & Cleary, 1986; Glaros & Hanson, 1990; Kinsman, O'Brien, Robinson, & Staudenmater, 1975; Lehrer, Batey, Woolfolk, Remde, & Garlick, 1988; Segreto, 1995; Sime & DeGood, 1977; Staudenmayer & Kinsman, 1976; Stilson, Matus, & Ball, 1980).

2.4. Procedure

The procedure closely followed the one used in Lazarov et al. (2012b, 2014). Participants were tested individually in a small and 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. This period served as an adaptation period, and resting baseline EMG was recorded during the last 3 min. Next, participants were told that during the experiment they will be asked to produce four target levels of forearm muscle tension that ranged from 1 to 4, with 1 being the lowest and 4 being the highest. The experimenter then guided the participant to produce two anchor tension levels, specifically the level that was labeled 1 (4 μV) and the level that was labeled 4 (16 μV). These anchors were attained by verbally instructing participants to contract their forearm muscle until they achieved the designated response, at which point they were told "OK, this level is a one/four". During this anchoring process participants did not receive any feedback other than the experimenter's instructions. The experiment did not resume until participants were able to produce each of the two anchor levels twice. There was a 2-min break before proceeding with the experiment.

Next, participants were told that they are going to participate in a study examining people's ability to accurately produce designated levels of muscle tension. They were randomly assigned to an undermined confidence group and to a control group. The allocation of participants was predetermined randomly before the beginning of the experiment. Participants in the undermined confidence group were then told that "feeling control over one's own muscle tension may be misleading. People often feel that they are accurate in producing a certain degree of muscle tension though in fact they are off-target, so their confidence in their ability to control muscle tension is actually false. Therefore, throughout the experiment, you should ask yourself whether you are really and genuinely convinced that you are accurate in producing the designated levels of muscle tension and whether you are confident in the control you feel over your own muscle tension". Participants in the control group were not given any additional instructions before proceeding to Phase 1 of the experiment.

During the first phase participants were asked to produce different muscle tension levels, ranging from 1 to 4, and to hold it 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 pseudo-random order, with the same order of presentation for all participants and across phases. The first phase consisted of 12 trials, during which participants were unable to view the biofeedback monitor. After Phase 1 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 were able to familiarize themselves with the apparatus, with no specific instructions. Phases 2 and 3 replicated Phase 1, again instructing participants to produce different muscle tension levels ranging from 1 to 4, first while viewing the biofeedback monitor (phase 2) and then again without viewing the monitor (phase 3). Each of the first three phases was followed by a 5-min interval of watching a screen saver on the monitor, in order to permit the participant's muscle tension to return to its baseline level before proceeding to the next phase, as well as to reduce fatigue effects as much as possible.

Before the final phase (Phase 4) the experimental manipulation was "refreshed." Participants in the undermined confidence group were reminded of the explanation they received in the beginning of the experiment, namely, that feeling control over one's own muscle tension may be misleading. They were requested again to ask themselves throughout the next phase whether they are convinced of their accuracy in producing the designated muscle tension levels. Participants in the control group were not given any additional information. Next, all the 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 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.

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.

After Phase 4 we conducted a manipulation check of the confidence undermining manipulation. We asked participants in both groups to rate how confident they were in their performances on the experimental task. Ratings were measured with a 100-mm Visual Analogue Scale (VAS) anchored with "I am not confident at all" at one side (i.e., the left anchor) and "I am completely confident" at the other (i.e., the right anchor). Participants were asked to place a pen mark that best describes how confident they were in their accuracy upon the production of the designated levels of muscle tension during the experiment. 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 higher confidence levels. At the end of the procedure participants completed the OCI-R and DASS-21 (see Measures above), were debriefed and given their course credit for participation.

3. Results

3.1. Psychopathological characteristics

Table 1 presents participants' scores on the OCI-R, the total DASS-21 score and the depression, anxiety and stress subscales. Two-tailed independent samples *t*-tests indicated that there were no significant differences between the two groups on any of these measures.

Table 1
Psychopathological characteristics of the two groups.

Measure	Manipulation group		Control group		$t(34)$	p
	M	*SD*	*M*	*SD*		
OCI-R	17.00	9.55	21.39	13.16	−1.14	.20
DASS-21	11.11	7.19	14.22	10.30	−1.05	.30
Depression subscale	3.11	2.95	3.78	3.49	−.62	.49
Anxiety subscale	2.78	1.99	2.89	3.10	−.70	.08
Stress subscale	5.72	3.95	7.56	4.84	−1.24	.41

Note. OCI-R, Obsessive-Compulsive Inventory-Revised; DASS-21, Depression, Anxiety and Stress Scales-21.

3.2. Manipulation check

In order to check whether our manipulation created a significant difference between the two groups regarding their confidence in their accuracy in producing the designated muscle tension levels we conducted a two-tailed independent samples Mann–Whitney *U* test with confidence rating as the dependent measure. This non-parametric test was chosen because confidence ratings were non-normally distributed, as determined by the Shapiro–Wilk normality test (Shapiro & Wilk, 1965), $W = .78$, $p < .001$. As expected, undermined confidence participants were less confident ($Mdn = 76.75$) regarding their performance accuracy than were control participants ($Mdn = 64.50$), $U = 2.26$, $p = .007$.

3.3. Hypothesis tests

Table 2 presents the means and standard deviations for EMG readings during the different phases of the procedure. A two-tailed independent samples *t*-test on baseline EMG level indicated that there were no significant differences between the two groups, $t(34) = .41$, $p = .68$. Fig. 1 displays the deviation score of the two groups in the three phases of the experiment. We tested our hypotheses within a 2 (group: manipulation vs. control) × 3 (phase: P1–P3) mixed-model analysis of variance (ANOVA) with deviation score as the dependent measure. As predicted, the undermined confidence group had a significantly higher mean deviation score than the control group during phase 1, $F(1,34) = 5.09$, $p = .03$, reflecting poorer performance on the novel task (without the biofeedback monitor). To examine our prediction regarding the differential effect of biofeedback on the two groups, we performed the interaction contrast of undermined confidence group vs. control and Phase 1 vs. Phase 2. As predicted, this interaction contrast was significant, $F(1,34) = 4.02$, $p = .05$, indicating that the performance of undermined confidence participants improved more than that of control participants when the biofeedback monitor was introduced.

Finally, we conducted a two-tailed independent samples *t*-test to examine the prediction that undermined confidence participants would be more inclined than control participants to request the biofeedback monitor during phase 4. Consistent with this prediction, undermined confidence participants asked to see the monitor more times ($M = 3.00$, $SD = 1.41$) than did the control participants ($M = 1.56$, $SD = 1.14$), $t(34) = 3.36$, $p = .002$, reflecting their

Table 2
EMG readings during the different phases of the procedure.

Measure	Manipulation group		Control group	
	M	*SD*	*M*	*SD*
Baseline	1.22	1.39	1.03	1.25
Phase 1	5.11	2.62	3.54	1.32
Phase 2	2.28	1.02	2.33	.93
Phase 3	4.18	2.90	3.33	.94

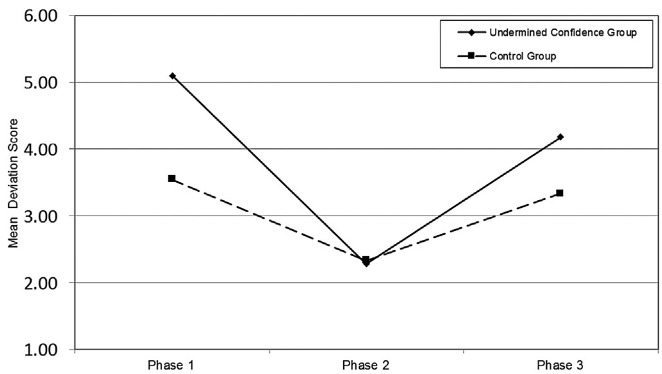

Fig. 1. Mean absolute deviations from target muscle tension by phase and group.

increased tendency to rely on the available proxy, and less confidence in their performance, as was also reflected by their subjective confidence rating.

4. Discussion

The present study examined the possibility that doubt regarding internal states may lead to attenuated access to these states, resulting in increased reliance on available proxies. We examined this hypothesis by using a magnitude production task, in which muscle tension was used as the internal state and a biofeedback monitor was used as the available proxy. Doubt in internal states was manipulated with instructions designed to undermine participants' confidence in their ability to accurately produce different levels of muscle tension.

As predicted, inducing doubt yielded performance patterns that resembled those previously observed in OCD and high OC participants (Lazarov et al., 2012b, 2014). In the absence of biofeedback, undermined confidence participants, compared to control participants, were less accurate in producing the designated levels of muscle tension. When a proxy for muscle tension was provided via the biofeedback monitor, the difference in performance between the two groups was eliminated. In addition, undermined confidence participants were more likely than control participants to request the biofeedback monitor when asked to achieve this particular internal state. These effects could not be accounted for by differences in baseline EMG levels or by OC tendencies.

Together with our previous results (Lazarov et al., 2010, 2012a, 2012b, 2014), the present findings corroborate the SPIS model, and specifically the hypothesis that OC individuals not only doubt their subjective experience but may actually have attenuated access to their own internal states. Additionally, the present findings suggest a possible causal relationship between doubt and accurate perception of these states. As accurate perception is necessary for accurate production of specific levels of muscle tension, the poorer performance of undermined confidence participants in the absence of biofeedback is consistent with the possibility that doubts can lead to attenuation in perceiving and experiencing internal states. In the present paradigm, this deficiency could be compensated for by relying on the biofeedback monitor during Phase 2, which eliminated the previous deficient performance in the undermined confidence group. Our findings also replicate previous ones regarding the effect doubt has on using and relying on proxies for internal states. In Lazarov et al. (2012a) undermining participants' confidence in their ability to accurately perceive their own level of relaxation made them more susceptible to false feedback, which they presumably used as a proxy for evaluating their own level of relaxation. In the present study we found a similar pattern in a different task using a different internal state, namely, muscle tension. Undermined confidence participants chose to rely on a previously-learned and useful proxy as an aid to achieving the different muscle tension levels, whereas control participants, who were less doubtful and presumably had intact access their internal state, did not feel the need to rely on this proxy. However, we should emphasize that these results do not mean that attenuated access to internal states in OCD is necessarily the result of reduced confidence. It is entirely possible that in real life, both directions of causality operate, such that reduced confidence reduces access to internal states, and attenuated access further reduces confidence. Quite possibly, both reduced confidence and reduced access can serve as the initial instigators of this vicious cycle.

Altogether, our findings to date (Lazarov et al., 2010, 2012a, 2012b, 2014) accord with certain aspects of previous models and theories of OCD while elaborating others. First, our results are consistent with previous OCD accounts that postulate a real deficiency or malfunction in generating and experiencing internal signals, cues or feelings, such as a “feeling of knowing” (Summerfeldt, 2004, 2007; Szechtman & Woody, 2004) or “satiety feedback feelings” (Boyer & Liénard, 2006) in OC individuals. According to these models, intensified environmental monitoring and repetitive checking are fueled by attempts to achieve a missing internal state or feeling. The present findings expand these models by incorporating general internal states that are not restricted to typical OC concerns. Our findings are also in line with the results of Aardema et al. (2014), who investigated confabulatory introspection in relation to OC symptoms utilizing the Choice Blinded Paradigm (CBP). They reported evidence supporting a significant relationship between limited introspective access, leading to confabulatory introspection, and obsessions. Second, our results support OCD models that postulate reliance on external objective cues as possible indicators of an elusive internal “feeling of rightness.” For example, Wahl et al. (2008) found that instead of relying on subjectively doubted sensory input, compulsive washers evaluate multiple objective and subjective criteria (which in SPIS terminology would be considered proxies for a deficient feeling of cleanliness) for deciding when to terminate a wash, resulting in prolonged compulsive washing. However, SPIS postulates that individuals with OCD rely on proxies and use them not only as evidence for the appropriateness of stopping a compulsive act, but also more generally as relatively discernible or less ambiguous substitutes for internal states. For example, in order to be sure s/he understands the material learned in school a person might resort to memorizing by heart that material as an indicator of his/her feeling of understanding. Furthermore, SPIS postulates that doubting an internal state is accompanied by reduced knowledge about that same state, whereas other models only postulate doubt. Finally, our suggestion that doubt can result in attenuation of internal states is in line with previous studies demonstrating that repeated doubting and checking degrade subjective experiences. Numerous studies have shown that inducing OC-like monitoring and checking behaviors is sufficient to cause healthy participants to doubt their own cognitive operations, such as memory (e.g., Coles, Radomsky, & Horng, 2006; Radomsky, Gilchrist, & Dussault, 2006; van den Hout & Kindt, 2003a, 2003b, 2004), attention (Hermans et al., 2008) and visual perception (van den Hout et al., 2008; van den Hout et al., 2009). In a similar manner, Shapira, Gundar-Goshen, Liberman, and Dar (2013) have shown that intense monitoring of the level of closeness with one's partner interfered with experiencing the corresponding subjective feeling of closeness.

As a final note, we should indicate that although SPIS proposes that attenuated access to internal states and compensatory reliance on proxies can be manifested in any domain where doubt exists, it does not preclude other OCD-related concepts as relevant factors in the manifestation of SPIS. We still do not know why and how the general deficiency in accessing and experiencing internal states expresses itself in specific domains of doubt – why it is that one individual experiences doubt in regard to locking the door, while another with regard to the cleanness of her hands? It is plausible that SPIS processes might be enhanced as a function of the subjective importance of a relevant domain, the sense of responsibility the individual feels in regard to that domain (Salkovskis, 1999; Wahl et al., 2008) or other OCD-relevant concerns. In these specific areas doubt may be especially troubling, leading to enhanced deficiency in experiencing and perceiving internal states and to excessive reliance on proxies. Future research can examine how the predictions of SPIS vary with the relevance of the domain, the perceived seriousness of making a mistake or the presence of threat.

There are several limitations of the present study that should be noted and addressed in future research. First, the study employed a small sample of participants and as such requires replication and elaboration. Second, in the current study doubt was partly operationalized by asking participants to continually self-question and self-monitor their ability to accurately produce the required muscle tension levels. Hence, repeated checking might have been also manipulated alongside doubt. Future studies should address this issue by refining the current operationalization to better distinguish between these two constructs. For example, future studies can try and undermine confidence in the designated internal state by using false feedback procedures instead of verbal instructions. Third, the muscle production task requires not only accurate detection and perception of muscle tension but also accurate production. It is possible that the interference did not occur on the levels of perception but rather on the level of production. Future studies should attempt to exclude this possible confounding factor. In an attempt to address this limitation we are currently examining the effects of undermining confidence in one's ability to correctly recognize one's own feelings and emotions on a task not requiring production of any kind.

Finally, the effects doubt has on the clarity of subjective experiences and the ability to experience and perceive internal states has important implication for clinical interventions in OCD. Therapist can use SPIS terminology to delineate the vicious and endless cycle connecting doubt, reliance on proxies and attenuation of subjective experiences. Therapist should explore patients' difficulties in trusting their own subjective experiences and educate them as to the counterproductive effects that relying on proxies might have on their level of doubt, and as a later consequence on their ability to accurately perceive and experience their own internal states. Targeting doubt in therapy has been suggested in previous approaches to OCD (e.g., Aardema & O'Connor, 2012; Tolin et al., 2003). 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). However, SPIS suggests 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. The effects heightened self-monitoring has on clarity of subjective experiences can also be integrated into therapy of socially anxious individuals functioning in social settings. As mentioned earlier, Shapira et al. (2013) have demonstrated that monitoring closeness only serves to degrade that very experience. Thus, encouraging socially anxious individuals to relax their monitoring efforts might lead to a reduction in social anxiety and better social performance. From a therapeutic standpoint it might be interesting to investigate whether lowering checking and monitoring behavior would lead to an improvement in the ability to perceive internal signals. For example, future research can try and replicate the current experimental procedure among high OC individuals, while giving half of them instructions aimed at reducing monitoring and reliance on proxies. This might be achieved by explaining to participants that excessive monitoring of muscle tone is known to decrease performance accuracy and that in most cases an intuitive approach to this task yields the optimal results.

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