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Obsessive-compulsive tendencies and undermined confidence are related to reliance on proxies for internal states in a false feedback paradigm

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Background and objectives: We have previously hypothesized that obsessive-compulsive (OC) tendencies are associated with a general lack of subjective conviction regarding internal states, which leads to compensatory seeking of and reliance on more discernible substitutes (proxies) for these states (Lazarov, A., Dar, R., Oded, Y., & Liberman, N. (2010). *Behaviour Research and Therapy, 48,* 516–523). This article presents two studies designed to provide further support to this hypothesis by using false biofeedback as a proxy for internal states.

Methods: In Study 1 we presented high and low OC participants with pre-programmed false feedback showing either increasing or decreasing levels of muscle tension. In Study 2 we presented similar false feedback on level of relaxation to non-selected participants, half of which received instructions that undermined their confidence in their ability to assess their own level of relaxation.

Results: In Study 1, high OC participants were more affected by false biofeedback when judging their own level of muscle tension than were low OC participants. In Study 2, undermined confidence participants were more affected by false biofeedback when judging their own level of relaxation as compared to control participants.

Limitations: Our findings are based on a non-clinical, highly functioning, largely female student sample and their generalization to OCD requires replication with a sample of OCD patients.

Conclusions: These results provide converging evidence for our hypothesis by replicating and extending our previous findings. We discuss the implication of our hypothesis for the understanding and treatment of OCD and outline directions for future research.

1. Introduction

Relentless and tormenting doubt is very common in obsessive-compulsive disorder (OCD) and is considered an essential feature of this disorder (e.g., Boyer & Lienard, 2006; Janet, 1903; Rapoport, 1989; Reed, 1985; Shapiro, 1965; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004). These doubts are believed to trigger a variety of pathological behaviors typical of OCD, such as washing and cleaning, counting, requesting and demanding reassurance, excessive self-monitoring, mental reconstruction and especially repeating and checking (American Psychiatric Association, 2000; Dar, Rish, Hermesh, Fux, & Taub, 2000). Obsessive-compulsive (OC) doubts have been demonstrated in relation to a variety of cognitive functions including memory (e.g., Constans, Foa, Franklin, & Mathews, 1995; Cougle, Salkovskis, & Wahl, 2007; Dar, 2004; Dar et al., 2000; McNally & Kohlbeck, 1993; Sher, Frost, & Otto, 1983; Tolin et al., 2001), decision-making and concentration (Nedeljkovic & Kyrios, 2007; Nedeljkovic, Moulding, Kyrios, & Doron, 2009), as well as attention and perception (Hermans et al., 2008; Hermans, Martens, De Cort, Pieters, & Eelen, 2003; van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout et al., 2009).

Classic descriptions of OCD have observed that patients doubt not only their cognitive functions but also other internal states including feelings, preferences, comprehension, wishes and beliefs (Janet, 1903; Rapoport, 1989; Reed, 1985; Shapiro, 1965). In their descriptions of OCD, Shapiro (1965) and Reed (1985) have identified pathological doubt and uncertainty as principle characteristics of OCD. They have suggested that an inability to experience conviction is a central trait in individuals with OCD, which is not limited to particular obsessions or compulsions. They further suggested that individuals with OCD are able to function well despite this deficit by using various compensation strategies, such as relying on external indicators for internal states and

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adopting rules, norms and rituals to guide their behavior. More recent models of OCD have also hypothesized that the pervasive doubts and related symptoms in OCD stem from deficient "subjective conviction" or "feeling of knowing." Szechtman and Woody (2004) have used the term "feeling of knowing," defined as "a subjective conviction functionally separate from knowledge of objective reality (p. 115)" in their account of OCD. They suggested that in contrast to normal individuals, the behavioral output of individuals with OCD is unable to generate this inner feeling, living them in a continuous state of anxiety and doubt regarding their safety and ability to avoid potential harm. In a similar account, Boyer and Lienard (2006) postulated that OCD symptoms are related to missing "satiety feedback feelings," which leads to doubts and uncertainty regarding the proper performance of actions as a precaution in response to the detection of potential dangers. Finally, in her account of the OCD-related phenomenon of incompleteness, Summerfeldt (2004, 2007) also postulated a missing "feeling of knowing" in OC individuals, which specifically leads to a sense of incompleteness and to "not just right" experiences.

Building on the models reviewed above, we have recently outlined a general hypothesis of OCD, which we term Seeking Proxies for Internal States (SPIS), that adopts similar assumptions regarding a lack of subjective conviction or feeling of knowing in individuals with OCD (Lazarov, Dar, Oded, & Liberman, 2010; Liberman & Dar, 2009). We suggested that this lack of subjective conviction is not limited to harm avoidance (Boyer & Lienard, 2006; Szechtman & Woody, 2004) or task completion concerns (Summerfeldt, 2004, 2007), but can be relevant to any internal state. By internal states we mean subjective states that cannot be fully assessed by outside observers or objective measures. Internal states can be cognitive (e.g., perception, memory, comprehension), affective (e.g., attraction, specific emotions) or bodily (e.g., muscle tension, proprioception). In addition, we suggested that individuals with OCD attempt to compensate for their lack of subjective conviction regarding these internal states by developing and relying on proxies for subjective experiences. By "proxies" we mean a substitute for the internal state that the individual perceives as more easily discernible or less ambiguous, such as rules, procedures, behaviors or environmental stimuli.

The present formulation conceptualizes compulsive rituals as attempts to develop proxies for lacking or ambiguous internal experiences. An example might help to illustrate this notion. A young OCD patient began to worry that he did not fully understand the material he had learned in school. The more he questioned and attempted to monitor his own level of understanding, the more his uncertainty about his understanding grew. As a result of losing confidence in his understanding, he developed the rule that he should be able to recite the material by heart. In terms of our SPIS hypothesis, the patient compensated for a lacking subjective conviction as to his internal state of understanding by developing a more discernible substitute (i.e., a proxy).

Our conceptualization of compulsive rituals as proxies for internal states is also in line with previous theoretical perspectives suggesting a compensatory link between rituals and internal states. Wahl, Salkovskis, and Cotter (2008), building on Salkovskis' cognitive-behavioral model (Salkovskis, 1999), proposed that due to Elevated Evidence Requirements (EER), individuals with OCD consider multiple criteria, both internally referenced and objective sensory input, before deciding to terminate a compulsive act. According to the EER model, individuals with OCD experience difficulties in stopping compulsive actions as a result of an inflated sense of responsibility manifesting in specific OCD relevant situations. According to the SPIS hypothesis, individuals with OCD rely on proxies not only for stopping a compulsive act but also for inferring about their own internal states. Moreover, the SPIS hypothesis postulates that OC tendencies are associated with reliance on proxies for internal states in any area of human functioning where doubt and uncertainty emerge (though this might be particularly manifested in situations which trigger responsibility or other OC-relevant concerns).

In a recent study (Lazarov et al., 2010) we tested the SPIS hypothesis by comparing high and low OC participants on their tendency to rely on self perception in assessing their internal states. Self perception theory (Bem, 1972) asserts that people may learn about their attitudes, personal characteristics and dispositions, preferences, emotions and other internal states from their own behavior, in much the same way as do external observers. Bem (1972) speculated that such inferences would be more likely when "internal cues are weak, ambiguous or uninterpretable" (p. 2), a prediction that was later corroborated by Chaiken and Baldwin (1981); (see also Detwiler & Zanna, 1976; Holland, Verplanken, & Van Knippenberg, 2002; Wood, 1982). As OC tendencies, according to our proposal, are associated with uncertainty and doubt regarding internal cues, it follows that individuals high in OC tendencies would tend to rely on self perception processes in inferring their own internal states. In other words, when asking themselves "how do I feel?" these individuals would tend to resort to more discernible or less ambiguous substitutes (i.e., proxies) that may inform them about their own feelings.

In the aforementioned study (Lazarov et al., 2010) we used a biofeedback-aided relaxation procedure to examine whether individuals high in OC tendencies would be more susceptible to self perception effects when assessing their own level of relaxation. A biofeedback apparatus provides an external representation of an internal physiological activity (Ince, Leon, & Christidis, 1987), a function that makes it well suited for examining our predictions. The biofeedback apparatus was used as a proxy for the participant's subjective state of relaxation. We asked participants high and low in OC tendencies (based on OCI-R scores; Foa et al., 2002; see Measures below) to achieve a state of relaxation while viewing a false pre-programmed feedback and then to subjectively evaluate their own level of relaxation. This was done twice, once with an arousal trend and once with a de-arousal trend. As predicted, high OC participants, compared to low OC participants, relied more on the false biofeedback in judging their state of relaxation, indicating that they were more susceptible to self perception effects. This effect could not be accounted for by the actual state of relaxation, which did not depend on the interaction between OC tendencies and type of false feedback.

The studies presented here were designed to provide further support to the SPIS hypothesis that OC tendencies are related to a lacking sense of subjective conviction, which leads individuals high in OC tendencies to rely on subjectively more discernible proxies in attempt to compensate for this lack of subjective conviction. Study 1 aimed to replicate our original self perception study (Lazarov et al., 2010; Study 2) using muscle tension instead of relaxation as the target internal state. We predicted that participants with high OC tendencies, compared to those with low OC tendencies, would be more strongly influenced by false feedback in assessing their own level of muscle tension. Study 2 was designed to directly examine the link between reduced confidence in internal states and reliance on proxies. We used the false feedback procedure from Lazarov et al. (2010) with non-selected participants, half of which received instructions designed to undermine their confidence in regard to their ability to assess their own feeling of relaxation. We predicted that participants whose confidence was undermined in this way would be more susceptible to self perception effects than participants who did not undergo the confidence-undermining manipulation.

2. Study 1 – self perception of muscle tension: high vs. low OC tendencies

Study 1 examined the prediction that individuals high in OC tendencies, as compared with individuals low in OC tendencies, would be more susceptible to self perception effects in relation to internal states. As mentioned above, this prediction was confirmed in a previous study (Lazarov et al., 2010) with general relaxation as the target internal state. However, as OC tendencies are strongly and inherently related to anxiety and therefore possibly to relaxation ability, these results may not generalize to other internal states. The aim of the present study was to test our prediction in the context of a different target internal state that would not be so directly related to OC tendencies, namely muscle tension. In addition, we wanted to examine possible differences in confidence regarding the reported internal state between high and low OC participants. The study employed a false physiological feedback procedure, similar to procedure used by Lazarov et al. (2010). Based on the reasoning elaborated above, we predicted that the high OC participants, as compared with the low OC participants, would rely more on the false biofeedback in judging their own level of muscle tension in comparison to the low OC participants. We predicted no effect of the false feedback on actual muscle tension in either group. Finally, we predicted that high OC participants, as compared to the low OC participants, would be less confident in their evaluations of their muscle tension ratings.

2.1. Method

2.1.1. Participants

Two hundred and one psychology students (152 women, 49 men) at Tel-Aviv University were screened using the Obsessive-Compulsive Inventory-Revised (OCI-R; Foa et al., 2002; see Measures below). We invited students who scored at the top and bottom of the distribution for participation in this study, with a cut-off score of 30 for high OC participants and a cut-off score of 5 for low OC participants. The final sample included 38 students (*M* age = 22.53 years, *SD* = 1.72, range = 20–29 years): Nineteen (15 women and 4 men) with high OC tendencies ($M = 36.37$, $SD = 6.84$) and 19 (14 women and 5 men) with low OC tendencies ($M = 2.63$, $SD = 1.86$), $t(36) = 20.74$, $p < .001$. The scores in the high OC group ranged between 30 and 58, and in the low OC group between 0 and 5. For comparison, the mean OCI-R for OCD patients in Foa et al. (2002) was 28.01 ($SD = 13.53$) with a cut-off score of 21 for differentiating OCD patients from non-anxious controls, and 18 for differentiation from anxious controls. In a previous study in our laboratory (Reuven-Magril, Dar, & Liberman, 2008) the mean OCI-R for OCD patients was 29.22 ($SD = 15.22$). The two groups differed significantly on all subscales of the OCI-R, $p < .001$. None of the participants had previous experience with biofeedback. Participants signed an informed consent and received course credit for participation.

2.1.2. Apparatus

Physiological data regarding muscle activity was measured using the Procomp Infiniti hardware and Biograph Infinity software from Thought Technologies, Montreal, Canada. This biofeedback apparatus was 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., Jantos, 2008; Mandryk & Atkins, 2007; Mandryk, Inkpen, & Calvert, 2006; Noe, Amarantini, & Paillard, 2009). For each participant a single triode electrode was applied on the skin over the flexor carpi ulnaris muscle (i.e. the muscle that contracts in the forearm when you are asked to make a fist) of the participant's dominant arm. The electrode was connected to a sensor and the data was transmitted to a laptop computer via a biofeedback encoder. The sensor measured electromyography (EMG) – electrical signals generated during muscle activity (Peek, 2003). EMG changes were reflected on the computer screen as a moving white dot along a black screen, which creates a continuous line graph. A downward movement of the dot signaled a decrease in muscle tension, whereas an upward movement of the dot signaled an increase in muscle tension.

2.1.3. Measures

2.1.3.1. 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 Likert 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; Soref, Dar, Argov, & Meiran, 2008).

2.1.3.2. Muscle tension. Muscle tension was measured by averaging the EMG readings (in microvolt) of each participant during the last minute of each experimental phase, such that a high score indicated higher muscle tension and a low score indicated lower muscle tension. EMG measures muscle activity by detecting surface voltage that occur 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. EMG has been used to help individuals decrease muscle tension (e.g., Ince et al., 1987; Neblett, Gatchel, & Mayer, 2003), for training individuals to increase muscle tension (e.g., Ince et al., 1987; Krebs & Fagerson, 2003) and to help individuals increase muscle control and awareness (Bayles & Cleary, 1986; Glaros & Hanson, 1990; Segreto, 1995).

2.1.3.3. Subjective muscle tension assessments. Subjective assessments of muscle tension were measured with a 100-mm Visual Analogue Scale (VAS) on which participants were asked to place a mark that best describes how their muscle felt during the last minute of each phase (Leung, Chan, Lee, & Lam, 2004). The VAS has been widely used to assess a variety of subjective feelings and states (for a review, see McCormack, Horne, & Sheather, 1988) including musculoskeletal fatigue (e.g., Farella, Bakke, Michelotti, & Martina, 2001; Krishnasamy, 2000; Leung et al., 2004) and has been shown to have good psychometric validity and reliability (e.g., Bijur, Silver, & Gallagher, 2001; Leung et al., 2004) and better sensitivity than Likert scales (e.g., Di-Benedetto, Kent, & Linder, 2008; Singer & Thode, 1998). In the present study, the VAS was anchored with "my muscle feels really intense" at the minimum state end (i.e., the left anchor) and "my muscle feels completely loose" at the maximum state end (i.e., the right anchor). The VAS score was measured in millimeters from the left anchor of the scale to the subject's pen mark (Di-Benedetto et al., 2008; Leung et al., 2004) so that subjective muscle tension scores ranged between 0 and 100 for each participant.

2.1.4. Procedure

Three weeks before starting with the experimental procedure we measured baseline resting EMG of each participant. Participants were instructed to sit comfortably and refrain from talking or moving as much as possible while viewing a landscape presentation on a computer monitor. Baseline resting EMG was taken during the last 3 min of an 11-min period.

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. At the beginning of the study participants received a brief explanation as to the general nature and function of the biofeedback apparatus, while viewing an example on the biofeedback monitor. Specifically, they were told that an upward movement of the white dot across the monitor screen signals an increase in muscle tension, whereas a downward movement of the white dot across the screen signals a decrease in muscle tension. In addition, they were told that "usually this biofeedback apparatus functions quite well, although its reliability is not a hundred percent, so that sometimes the feedback given as to levels of muscle tension is not accurate". This explanation was followed by a 3-min interval of watching a screen saver on the monitor, in order to permit the participant's muscle tension level to return to its baseline level before the start of the experiment, and more importantly, to eliminate as much as possible prior, pre-experiment sources of attribution as to participant's muscle tension status.

The study included two false pre-programmed biofeedback phases, 5 min each: One of a descending line graph signaling to participants decrease in muscle tension, and one of an ascending line graph signaling increase in muscle tension. The order of the two false pre-programmed biofeedback phases was counter-balanced across participants and did not affect the results. Before each phase participants were instructed to "let go of any tension in your forearm muscle" while being monitored by the biofeedback apparatus. They were told that they will be able to view the biofeedback monitor and were asked to refrain from talking or moving as much as possible. After each phase participants were instructed to subjectively evaluate their muscle tension using the VAS. Before the second phase participants again watched a 3-min screen saver on the monitor, in order to permit their muscle tension level to return to its baseline level before proceeding to the next phase. While participants viewed the false biofeedback monitor, we measured their actual EMG readings, as defined above, in order to rule out any real muscle tension level differences between the two biofeedback phases. At the end of the experiment participants were asked to rate how confident they were about their two subjective muscle tension estimates, using a scale of 0–100% with 10% intervals.

2.2. Results and discussion

A two-tail independent sample t-test on the baseline EMG level indicated that there were no significant differences between the two groups, $t(36) = 1.28$, $p = .21$.

We tested our hypotheses with a 2 (OC tendencies: high vs. low) $\times$ 2 (trend: upward vs. downward) mixed-model ANOVA with VAS score as the dependant measure. Consistent with our prediction, the interaction was significant, $F(1, 36) = 7.44$, $p < .001$, reflecting a differential effect of the false biofeedback on the two groups. As Fig. 1 shows, high OC participants were more affected by the false biofeedback in judging their level of muscle tension compared to low OC participants.

In order to rule out an interaction between false biofeedback and group in affecting actual muscle tension, we examined the same interaction with average EMG readings as the dependant measure. Consistent with our prediction, there was no interaction between trend and OC tendencies, $F(1, 36) = .09$, $p = .76$, indicating that false biofeedback did not have a differential effect on real muscle tension in the two groups. There no other significant effects of the independent variables on EMG readings.

Finally, we conducted a two-tail independent sample t-test to examine the hypothesis that high OC participants would be less

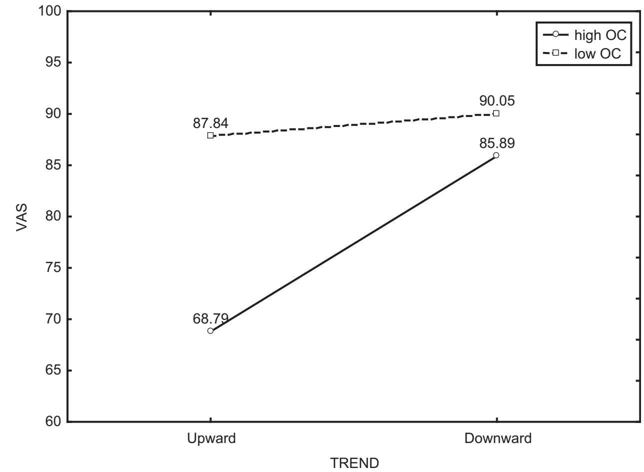

Fig. 1. VAS ratings of muscle tension by trend and OC tendencies.

confident than low OC participants with regard to their subjective muscle tension estimates. Consistent with this prediction, high OC participants were less confident in their estimates ($M = 69.47$, $SD = 18.70$) than the low OC participants ($M = 86.32$, $SD = 9.55$), $t(36) = -3.50$, $p < .001$.

In sum, as predicted, high OC participants, compared to low OC participants, relied more on the false biofeedback in judging their own muscle tension levels, indicating that they were more susceptible to self perception effects. This effect could not be accounted for by differences in baseline EMG levels or by the actual effects of the biofeedback on muscle tension, which did not interact with OC tendencies. In addition, as predicted, high OC participants, compared to low OC participants, were less confident in their subjective muscle tension estimates, indicating that reliance on external feedback did not eliminate their uncertainty regarding their internal state of muscle tension.

We believe that the inclination of high OC participants to rely on the false biofeedback in assessing their own muscle tension levels reflects their tendency to rely on proxies (in this case, the biofeedback monitor) to compensate for their reduced subjective conviction as to their own internal states (in this case, their sense of muscle relaxation). This proposition is consistent with Bem's (1972) suggestion that self perception effects would be especially strong in situations of weakened confidence regarding internal states, a condition we believe characterizes the experience of individuals high in OC tendencies. The lower confidence of the high OC participants, compared to low OC participants, despite the provision of external (though false) feedback, suggests that this strategy does not fully compensate for their hypothesized lack of subjective conviction.

3. Study 2 – self perception of relaxation: effects of undermining confidence

According to the SPIS hypothesis outlined above, OC symptoms are related to a reduced sense of subjective conviction, which leads them to a compensatory reliance on proxies. While our original study (Lazarov et al., 2010) as well as Study 1 showed that OC tendencies are related to reliance on proxies, they did not directly examine the causal relationship between feelings of doubt and uncertainty in internal states and increased reliance on proxies. In the present study we aimed to examine this causal link by experimentally undermining confidence in the relevant internal state in non-selected participants and examining the effect of this manipulation on the tendency to rely on proxies.

In this study we used the same false physiological feedback procedure as in Study 1 and predicted that undermining participants' confidence in their ability to judge their internal state of relaxation would mimic the effect of having high OC tendencies.[1] Specifically, we predicted that participants whose confidence in evaluating their state of relaxation would be undermined, as compared with control participants, would be more susceptible to the influences of self perception, as reflected in larger influence of the false biofeedback on judgments of relaxation. We predicted no effect of the false feedback on the actual relaxation measure in either group.

3.1. Method

3.1.1. Participants

Thirty eight psychology students (28 women, 10 men) at Tel-Aviv University participated in the study. Participants signed an informed consent form and received course credit for participation. None of the participants had prior experience with biofeedback procedures.

3.1.2. Apparatus

Autonomic arousal levels were measured by the same biofeedback apparatus (Prorelax interactive program, version 4.0, Mindlife, Jerusalem, Israel) used in our previous work examining relaxation abilities (Lazarov et al., 2010), earlier versions of which were shown in previous studies to provide reliable measures of autonomic arousal levels in various clinical contexts (Leahy, Clayman, Mason, Lloyd, & Epstein, 1998; Nagai, Goldstein, Fenwick, & Trimble, 2004; Shapiro, Melmed, Sgan-Cohen, Eli, & Parush, 2007; Yahav & Cohen, 2008). As in Lazarov et al. (2010), monitoring was done by two Velcro strapped electrodes applied to the fingertips of the second and forth digits of the right hand. Electrodes were connected to a sensor and the data was transmitted through infrared telemetry to a receiver, which was connected to a laptop computer. An isolated skin conductance coupler applied a constant 0.5 V potential across the electrode pair. The finger sensors measured the galvanic skin response (GSR) – electrical changes in the skin that are affected by sweat gland activity in response to physical, emotional and mental states (Leahy et al., 1998; Nagai et al., 2004; Shapiro et al., 2007; Yahav & Cohen, 2008).

3.1.3. Measures

3.1.3.1. Subjective anxiety levels. Subjective levels of current anxiety were measured using the short form of the State subscale of the State-Trait Anxiety Inventory (STAI-6; Marteau & Bekker, 1992). The STAI-6 is a 6 item measure that assesses subjective feelings of anxiety and tension at the particular moment during which the test is completed. Rating is done on a 4-point Likert-type scale ranging from 1 (not at all) to 4 (very much). The STAI-6 produces scores similar to those obtained using the full 20 item State subscale of the STAI (Spielberger, Gorsuch, & Lushene, 1970). It has been shown to have good validity, test-retest reliability and internal consistency across subject groups manifesting normal and raised levels of anxiety (e.g., Lazarov et al., 2010). The STAI-6 remains sensitive to different degrees of anxiety while offering a briefer and more acceptable scale for participants (Marteau & Bekker, 1992).

3.1.3.2. Level of relaxation. Galvanic skin response (GSR), which results from sympathetic modulation of skin sweat glands secretions (Andreassi, 2000), is an accessible and sensitive index of peripheral sympathetic nervous activity, reflecting peripheral autonomic change (Nagai et al., 2004), and thus can serve as a sensitive way of monitoring autonomic responses to external and/or internal stimuli (Shapiro et al., 2007). One measure of GSR autonomic response, which has been widely employed in previous studies as a physiological correlate of arousal or anxiety and relaxation levels, is GSR nonspecific activity or spontaneous GSR (e.g., Ashcroft, Guimaraes, Wang, & Deakin, 1991; Hensman, Guimaraes, Wang, & Deakin, 1991; Katkin, 1965, 1966; Katkin & McCubbin, 1969; Lazarov et al., 2010; Orme-Johnson, 1973). This measure gauges fluctuations in skin resistance that occurs in the absence of specific stimulation (Katkin, 1965, 1966; Orme-Johnson, 1973). As was done in Lazarov et al. (2010) and consistent with previous studies, level of relaxation in this study was measured by calculating the total number of spontaneous or nonspecific GSR fluctuations each participant exhibited during the relaxation task, so that lower scores indicate a more relaxed state. A spontaneous GSR was defined as a sudden decrease in skin resistance of at least 10 GSR units followed by a recovery of resistance. Only spontaneous GSR fluctuations which occurred independently of outside noise or participant's physical movement were scored. We also chose this measure because it enables more control over irrelevant interferences such as outside noise or physical movements, which greatly affect other biofeedback relaxation measures.

3.1.4. Procedure

Our procedure closely followed the one used in Lazarov et al. (2010, Study 2). Participants were tested individually in a small and quiet room. Upon arriving participants received a brief explanation as to the general nature and function of the biofeedback apparatus. They were told that a downward movement of the line signals an increase in relaxation, whereas an upward movement of the line signals a decrease in relaxation. In addition participants were told that "usually the biofeedback apparatus functions quite well, although its reliability is not a hundred percent, so that sometimes the feedback given as to levels of relaxation is not accurate." This explanation was followed by a 3-min interval of watching a screen saver on the monitor, in order to permit the participant's arousal level to return to its baseline level before the start of the experiment and to minimize as much as possible prior sources of attribution regarding participant's current relaxation levels.

Next, participants were told that they are going to participate in a study examining people's ability to relax. They were randomly assigned to an undermined confidence condition and a control condition. Participants in the undermined confidence group were then told that "feelings of relaxation can be misleading. People often feel that they are relaxed only to discover later on that they were not, thus realizing that their confidence about their own feeling of relaxation had been false. Therefore, you should ask yourself whether you are really and genuinely relaxed, and whether you are confident about what you are feeling." Participants in the control group were not given any additional information before proceeding to the first phase of the experiment.

The study included two false 5-min pre-programmed biofeedback phases, one of a descending line graph signaling to participants an increase in relaxation, and one of an ascending line graph signaling a decrease in relaxation. The order of the two false pre-programmed biofeedback phases was counterbalanced across participants and within each group. Before each relaxation phase participants were instructed to "try and relax deeply" while being monitored by the biofeedback apparatus. They were told that they will be able to view the biofeedback monitor and were asked to refrain from talking or moving as much as possible during the

[1] Note that relaxation ability is not a potential confound in this study as participants were not pre-selected based on OC tendencies and were randomly assigned to the two experimental conditions.

different phases. After each relaxation phase participants were instructed to complete the STAI-6 (Marteau & Bekker, 1992). Before the second relaxation phase participants again watched a 3-min screen saver on the monitor in order to permit the participant's arousal level to return to its baseline level before proceeding to the next phase. While participants viewed the false biofeedback monitor, we measured their actual spontaneous GSR fluctuations, as defined above, in order to rule out a real relaxation level differences between the two biofeedback phases. Finally, as a check on the confidence manipulation, we asked participants in both groups at the end of the procedure to rate how confident they were about their subjective relaxation/anxiety estimates, using a scale of 0–100% with 10% intervals. At the end of the session participants were asked to fill out the OCI-R (Foa et al., 2002; see Measures, Study 1).

3.2. Results and discussion

3.2.1. Manipulation check

In order to check whether our manipulation created a significant difference between the two groups in regard to their confidence in their estimates of relaxation/anxiety we conducted a two-tail independent sample *t*-test with confidence rating as the dependant measure. As expected, undermined confidence participants were less confident ($M = 76.32$, $SD = 17.7$) regarding their subjective relaxation/anxiety estimates than were control participants ($M = 86.32$, $SD = 7.61$), $t(36) = 2.26$, $p = .003$.

3.2.2. Hypothesis tests

We tested our hypotheses with a 2 (confidence: undermined vs. control) × 2 (trend: upward vs. downward) mixed-model ANOVA with STAI-6 score as the dependant measure. Consistent with our prediction, the interaction was significant, $F(1, 36) = 4.87$, $p = .03$, reflecting a differential effect of the false biofeedback on the two groups. As Fig. 2 shows, undermined confidence participants were more affected by the false biofeedback when judging their level of relaxation as compared to control participants.

In order to rule out real relaxation level differences between the two false biofeedback phases among the two groups, which might serve as an alternative explanation to the interaction we found, we repeated the same analysis with the number of spontaneous GSR fluctuations as the dependant measure. Consistent with our prediction, there was no interaction between trend and confidence, $F(1, 36) = .02$, $p = .86$, indicating that there were no differences between the two groups in terms of the effects of the false feedback on real relaxation levels. There were no other significant effects.

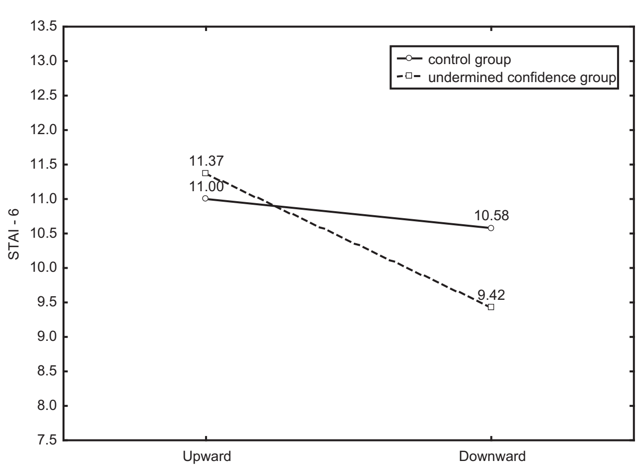

Fig. 2. STAI-6 scores by trend and group.

3.2.3. Correlation analysis

In order to examine the relationship between OC tendencies and self perception effects we calculated for each participant a self perception score by subtracting the STAI-6 score of the downward phase from that of the upward phase. We then calculated the correlation between that score and the OCI-R score of each participant and found this correlation to be significant in both the undermined confidence group, $r(19) = .62$, $p < .05$ and the control group, $r(19) = .50$, $p < .05$. The parallel score based on the difference in spontaneous GSR scores between phases did not correlate significantly with the OCI-R scores in either group: $r(19) = -.02$, $p > .05$ for the undermined confidence group and $r(19) = -.19$, $p > .05$ for the control group. Finally, we correlated the OCI-R scores with level of relaxation as assessed by the number of spontaneous GSR fluctuations for each group in each of the two experimental conditions. None of the correlations were significant (r's $= -.17$–$.23$).

In sum, as predicted, the undermined confidence participants, compared to control participants, relied more on the false biofeedback in judging their own state of relaxation, indicating that they were more susceptible to self perception effects. This effect could not be accounted for by the actual effects of the biofeedback on relaxation levels, which did not interact with experimental group. The fact that our confidence-undermining manipulation led to the same pattern previously obtained with high OC participants lends further support to the hypothesized causal relationship between uncertainty regarding internal states and inclination to rely on proxies as a compensation strategy.

In addition to supporting the prediction that lowered confidence would lead to reliance on external proxies, we found a significant relationship between OC tendencies and self perception effects. This finding corroborates the conclusion of Study 1 as well as of our previous studies (Lazarov et al., 2010) in showing that OC tendencies are related to the tendency to infer internal states from more verifiable indicators. Together, these findings provide further evidence for the SPIS hypothesis that OC tendencies are related to seeking and relying on proxies as compensation for reduced subjective conviction in internal states.

4. General discussion

The results of the two studies expand on previous findings that individuals with OCD tend to distrust their own cognitive functions, including memory, perception and attention (e.g., Aardema, O'Connor, & Emmelkamp, 2006; Brown, Kosslyn, Breitler, Baer, & Jenike, 1994; MacDonald, Antony, MacLeod, & Richter, 1997; Tuna, Tekcan, & Topçuoğlu, 2003; Woods, Vevea, Chambless, & Bayen, 2002; Zitterl et al., 2001) to encompass more basic sensations and internal states. While our findings are consistent with both classic (Janet, 1903; Rapoport, 1989; Reed, 1985; Shapiro, 1965) and more recent models of OCD that emphasize the role of doubt and uncertainty in OCD (Szechtman & Woody, 2004; Boyer & Lienard, 2006; Summerfeldt, 2004, 2007), they elaborate on these recent models in two important ways. First, they suggest that the proposed lacking of subjective conviction is not limited to concerns with security or incompleteness. Second, they corroborate the proposition that individuals high in OC tendencies rely on more discernible substitutes (i.e., proxies) as means to cope with this deficiency. Whereas previous models emphasize the repetitive nature of compulsive acts, which are understood as repetitive and prolonged attempts to generate the missing internal feelings of knowing or subjective conviction, our model emphasizes the functional aspect of rituals, which are conceptualized as informative proxies that substitute and thereby compensate for lacking subjective conviction regarding internal states.

It is important to note that proxies may vary in the extent to which they are valid indicators of subjective states. In our studies, biofeedback is a valid, objective proxy for relaxation or muscle tension. However, in many cases proxies are poor substitutes for the relevant internal state. For example, in the case of the young person with OCD mentioned above, his concentration on rehearsing sentences ironically resulted in poorer understanding of the material, leading to a vicious cycle of further losing confidence in his ability to understand and developing other compensatory proxies, such as counting lines and pages he has read. This notion is in line with the well established finding that repeated checking, which we conceptualize as a proxy for reduced conviction regarding memory and perception, can ironically increase doubts in the relevant memory (Ashbaugh & Radomsky, 2007; van den Hout & Kindt, 2003a, b; Radomsky & Alcolado, 2010; Radomsky, Gilchrist, & Dussault, 2006; Tolin et al., 2001) or perception (van den Hout et al., 2008; van den Hout et al., 2009). Another problem with proxies is that at close examination, they may lose their apparent clarity and engender further substitution. For example, an OCD patient could not feel convinced in her love for her partner, and attempted to use the proxy of how much she missed him when he was gone and happy to see him when they met. This proxy, however, proved just as tricky to detect with confidence, leading the patient to seek more "objective" but also more remote proxies for the evasive feeling of love, such as the number of phone calls she made to him each day.

While our findings corroborate and extend the previous findings of Lazarov et al. (2010), several questions require examination in future studies. First, the limits of our hypothesis should be explored by examining other internal states, from basic sensations like hunger and proprioception to more complex subjective experiences such as preferences, motivations and affective states. In regard to the former category, our studies to date indicate that biofeedback can profitably be used both to examine participants' ability to label correctly interoceptive or proprioceptive sensations as well as to examine the extent to which participants rely on it in assessing and achieving control over basic sensations. At the same time, future studies should examine other proxies, including ones that are less objective and valid than biofeedback. In the same vein, our findings are based on a non-clinical, highly functioning, largely female student sample and their generalization to OCD requires replication with a sample of OCD patients. Finally, individuals with high and low OC tendencies are very likely to differ also on trait anxiety and perhaps on other psychopathology as well, which constitutes a limitation and a possible alternative explanation for our results. We are presently conducting a large clinical study implementing the same procedures with a clinical population of OCD patients, anxiety patients with no OC symptoms and control participant in an attempt to address this potential confound as well as to examine the generalizability of our findings to clinical OCD.

Perhaps more importantly, we still know very little about the source of the OC lacking of subjective conviction regarding internal states. Our results suggest that the hypothesized lacking of subjective conviction and the resultant seeking and reliance on informative proxies are not restricted to OC concerns such as safety or completeness. If this is the case, then what might be the source of this general deficit in subjective conviction? There are at least two distinct possibilities: One is that individuals with OCD have intact access to their subjective states, but meta-cognitive processes such as excessive self-monitoring and self-questioning lead to doubts in regard to these states. This possibility is consistent with studies demonstrating the effects of checking behavior on memory and perception confidence (Ashbaugh & Radomsky, 2007; van den Hout & Kindt, 2003a, b; Radomsky & Alcolado, 2010; Radomsky et al., 2006; Tolin et al., 2001) and with studies that found no real memory deficits in OC individuals other than memory confidence (e.g., Abbruzzese, Bellodi, Ferri, & Scarone, 1993; Ceschi, Van der Linden, Dunker, Perroud, & Bredart, 2003; Foa, Amir, Gershuny, Molnar, & Kozak, 1997; Jelinek, Moritz, Heeren, & Nadar, 2006; Karadag, Oguzhanoglu, Ozdel, Atesci, & Amuk, 2005; Kim et al., 2006; Simpson et al., 2006). The alternative possibility is that inputs from internal states in OCD are attenuated, so that checking and self-questioning only serve to increase doubts that are grounded in a real deficiency in perceiving and experiencing internal states. This possibility is consistent with recent models that postulate a real deficiency in internal signals, cues or feelings in OCD which leads to repetitious behaviors and compulsions (e.g., Boyer & Lienard, 2006; Summerfeldt, 2004, 2007; Szechtman & Woody, 2004) and with memory studies showing real deficits in memory abilities among OCD patients (e.g., Boone, Ananth, Philpott, Kaur, & Djenderjian, 1991; Christensen, Kim, Dyksen, & Hoover, 1992; Ecker & Engelkamp, 1995; Rubenstein, Peynircioglu, Chambless, & Pigott, 1993; Savage et al., 2000; Sher, Frost, Kushner, Crews, & Alexander, 1989; Sher et al., 1983; Tallis, Pratt, & Jamani, 1999; Tuna et al., 2005; Woods et al., 2002; Zielinski, Taylor, & Juzwin, 1991; Zitterl et al., 2001). Further studies should attempt to differentiate empirically between these two alternatives.

We believe that the hypothesized reliance on proxies to compensate for doubts in regard to internal states and its potentially detrimental effects may be integrated into cognitive and meta-cognitive therapy for OCD. Therapists can use this framework to discuss with patients the difficulties they have in trusting their own internal states and feelings. SPIS conceptualization can be used to explain to patients how these doubts and uncertainties can lead to compensatory compulsive behaviors such as excessive reliance on norms, rules and rituals and to seeking external validation from others. Therapists can use SPIS terminology to explain the patients the ironic effect of using and relying on proxies for internal states, which may lead to vicious circles that end up further reducing their confidence in those states. More speculatively, biofeedback-aided procedures may be developed to help patients improve the accuracy of their perception and labeling of internal states, such as anxiety or muscle tension, and to gradually reduce their dependence on proxies for these states. Future research should 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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