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Distrust of the senses and its association with obsessive-compulsive symptoms

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ABSTRACT

Background and objectives: Leading cognitive theories of OCD suggests that despite prevalent and persistent doubt, individuals with OCD do not have perceptual deficits. An alternate cognitive theory, the Seeking Proxies for Internal States hypothesis (SPIS), proposes that sensory distrust in OCD stems from actual deficits in accessing internal states. Consistent with the SPIS, previous research has found that high-OC individuals were less accurate than low-OC individuals in producing target levels of muscle tension in a biofeedback task and that OC symptoms were positively associated with reliance on an external proxy.
Methods: The current study aimed to replicate and extend the SPIS hypothesis in two experiments using a modified version of the biofeedback-aided muscle tensing task using grip strength as the sensory input and a distance perception task. We contrasted the performance of undergraduate students self-reporting high- and low-OC symptoms.
Results: Overall, our findings failed to substantially support the SPIS hypothesis such that OC symptoms were not associated with deficient access to internal states of grip strength and distance perception or increased reliance on feedback.
Limitations: As this study was conducted in a non-clinical sample, we were unable to generalise our findings to a clinical population.
Conclusions: Findings are commensurate with the wider OCD literature suggesting the absence of cognitive and perceptual deficits in OCD individuals.

One of the primary features of obsessive-compulsive disorder (OCD) is the experience of pervasive and persistent doubt that does not reflect reality (e.g., 'I might be contaminated' or 'my door might be unlocked'; American Psychiatric Association, 2013). Individuals with OCD are compelled to alleviate the distress caused by these doubts by completing various compulsive behaviours such as repeated washing and checking. Obsessive-compulsive (OC) doubt is not only experienced in the context of typical OCD-relevant concerns such as contamination. Multiple studies have indicated that OC doubt can be about one's memory (Dar, 2004; Tolin et al., 2001), decision-making and concentration abilities (Nedeljkovic & Kyrios, 2007; Nedeljkovic, Moulding, Kyrios, & Doron, 2009), and sensory perception (Aardema, O'Connor, & Emmelkamp, 2006; Hermans et al., 2008; van den Hout, Engelhard, de Boer, du Bois, & Dek, 2008; van den Hout et al., 2009).

Recognising the centrality of doubt in OCD, recent cognitive theories have attempted to explain how obsessional doubts are maintained despite there being substantial contradictory evidence available in the environment (O'Connor, Ecker, Lahoud, & Roberts, 2012). Lazarov, Liberman, Hermesh, and Dar (2014) have recently presented one such cognitive model suggesting that distrust of sensory perception in OCD may stem from deficient access to all internal states, including cognitive (e.g., perception and memory), affective (e.g., attraction), or bodily (e.g., muscle tension). Deficient access to internal states is proposed to lead to difficulties in accurately experiencing and perceiving signals associated with these states. Consequently, the individual with OCD develops and relies on external proxies to compensate for this deficit by seeking

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externally verifiable and objective information. For example, an OCD patient with contamination concerns may develop washing rituals to serve as a proxy signalling to them that their hands are clean to compensate for deficient access to internal cleanliness cues.

This hypothesis, termed Seeking Proxies for Internal States (SPIS), is supported by data from a series of quasi-experimental studies utilising a magnitude production task involving varying levels of muscle tension, with biofeedback serving as the external proxy for muscle tension levels (Lazarov, Dar, Liberman, & Oded, 2012). Groups of undergraduate students reporting high and low levels of OC symptoms were asked to produce target levels of muscle tension. High-OC participants were found to be less accurate in producing the targets compared to low-OC participants during phases where biofeedback was initially unavailable. However, both groups performed equally well when biofeedback was introduced. Furthermore, high-OC participants were more likely to request biofeedback when viewing it was made optional. Similar findings have been found using muscle relaxation as the sensory input (Lazarov, Dar, Oded, & Liberman, 2010).

Most recently, these findings have been extended by comparing a clinical OCD group to a clinical control group diagnosed with non-OCD anxiety disorders and to a healthy control group (Lazarov et al., 2014). OCD patients were significantly less accurate than both the anxiety and healthy control groups when producing target levels of muscle tension without biofeedback. Introduction of the biofeedback eliminated this difference. OCD participants relied on this proxy more than the other groups as reflected by an increased tendency to request for the biofeedback. Based on these findings, proponents of the SPIS concluded that individuals with OCD not only have heightened distrust of their senses, but that this distrust may originate from and is maintained by a genuine deficiency in accurately perceiving their internal states.

However, this conclusion that individuals with OCD have deficient access to their internal states is in contrast to other popular cognitive theories of OCD. That is, these other theories assume that individuals with OCD are able to perceive reality correctly (Brown, Kosslyn, Breiter, Baer, & Jenike, 1994). For example, the cognitive appraisal model of OCD also posits that doubts play a central role in OCD pathology, but argue that these doubts are maintained due to maladaptive appraisals of doubts as revealing and threatening (Rachman, 2002; Salkovskis, 1989). Another cognitive model is the inference-based approach, which proposes that pathological doubts about reality are confused to be true via a state termed *inferential confusion* (Aardema et al., 2006; Aardema, O'Connor, Emmelkamp, Marchand, & Todorov, 2005; O'Connor & Robillard, 1995). Inferential confusion is characterised by maladaptive reasoning devices proposed to be exclusive to OCD that lend credibility to, or prevent disconfirmation of, the obsessional doubt. Proponents of this theory suggest that one such reasoning device is a tendency to distrust the senses, rather than an actual sensory deficit.

In sum, research testing out the predictions of the SPIS hypothesis is nascent and their key findings require replication, which is especially important given its differences with established cognitive models of OCD. Furthermore, as the SPIS hypothesis predicts that OCD is associated with deficient access to any internal state, their findings should be extended to sensory modalities and proxies beyond muscle tension and biofeedback. For example, we would expect that the formation of perceptual judgements, such as the individual's physical proximity to an object, would also require feedback from internal cues. As such, individuals with OCD would be expected to be poorer at judging their relative distance given a deficient access to these signals.

1. Study 1 – OC tendencies and access to internal states: grip strength production

The aim of Study 1 was to replicate and extend the results of Lazarov et al. (2014) using a paradigm similar to the biofeedback-aided muscle tensing task. That is, instead of instructing participants to produce target levels of muscle tension, we asked participants to produce target levels of grip strength. The choice of grip strength over muscle tension production was based on two important considerations. Firstly, Lazarov et al. (2014) had their participants tense their flexor carpi ulnaris muscle. This muscle contracts in the forearm when making a fist and would presumably be activated when gripping an object. As such, producing target levels of grip strength would be an extension of Lazarov and colleagues' (2014) existing paradigm that would allow us to test the robustness of their findings while still relying on similar physiological mechanisms.

Secondly, an alternative explanation of Lazarov and colleagues' (2014) results could be that individuals with higher levels of OC symptoms performed poorer on the task because of inherently elevated levels of doubt in OCD (Aardema, O'Connor, Pelissier, & Lavoie, 2009) that were exacerbated by their perceptions of the task as being difficult (given the unfamiliarity of isolating awareness to the flexor carpi ulnaris muscle). Experimentally increasing levels of doubt in healthy participants has been shown to produce a pattern of results on the muscle tensing task similar to OCD patients (Lazarov, Cohen, Liberman, & Dar, 2015). Therefore, we chose grip strength since participants would be presumably more familiar with and aware of their levels of grip strength and therefore experience less doubt regarding their performance.

In line with the SPIS hypothesis and consistent with previous research, we predicted that a group self-reporting more OC symptoms (high-OC) would be less accurate in estimating and producing target levels of grip strength compared to a group reporting less OC symptoms (low-OC) when feedback was initially unavailable. We also predicted that viewing the feedback would improve the performance of all participants, but that the performance of the high-OC group would improve more than the low-OC group. Furthermore, we expected that the high-OC group would be more likely to ask for feedback on their performance when given the opportunity to do so.

1.1. Method

1.1.1. Participants

Eighty-four undergraduate psychology students (females = 59, mean age = 19.35, SD = 3.34, range 17–43) at the University of New South Wales participated in exchange for course credit. Only participants scoring in the top and bottom quartiles of the Dimensional Obsessive-Compulsive Scale (DOCS; Abramowitz et al., 2010), a measure of OC symptom severity (outlined below), were included in our analyses. This use of non-clinical analogue samples in OCD research is appropriate for understanding OC-related phenomena (Abramowitz et al., 2014). The top and bottom quartiles of scorers were categorised as high- and low-OC, respectively. Our final sample consisted of 42 participants (31 females, mean age = 18.60, SD = 1.08, range 17–22): 22 high-OC and 20 low-OC participants. The mean score on the DOCS for the high-OC group (M = 25.32, SD = 8.25) approached the mean score for individuals diagnosed with OCD (M = 30.06, SD = 15.49) and was above the DOCS clinical cut-off score of 18 (Abramowitz et al., 2010). The mean score on the DOCS for the low-OC group (M = 3.60, SD = 1.93) was lower than the mean score for healthy individuals (M = 11.93, SD = 9.87; Abramowitz et al., 2010).

1.1.2. Materials and measures

1.1.2.1. Dimensional Obsessive-Compulsive Scale (DOCS). The DOCS is a 20-item self-report questionnaire that was used to measure four dimensions of OC symptoms (i.e., concerns regarding contamination, responsibility for harm, unacceptable obsessional thoughts, and symmetry and completeness) experienced during the past month (Abramowitz et al., 2010). The DOCS total and subscale scores has high internal consistencies across varying samples (0.83–0.94; Abramowitz et al., 2010) and was comparable to the current sample (0.81–0.92). The DOCS has also been shown to have significant positive correlations with total scores of other OCD measures ($r = 0.54–0.71$; Abramowitz et al., 2010).

1.1.2.2. Depression Anxiety and Stress Scales – 21 (DASS-21). The DASS-21 is a 21-item self-report questionnaire that was used to measure depression, anxiety, and stress levels experienced over the past week (Lovibond & Lovibond, 1995). The DASS-21 was included to assess whether general distress affected performance on the experimental tasks. The internal consistencies of the DASS-21 total score and subscales are excellent for a non-clinical sample (0.82–0.93; Henry & Crawford, 2005), and was comparable to the current sample (0.80–0.94).

1.1.2.3. Grip strength task. The grip strength task was designed for the current study. This task was similar to the biofeedback-aided muscle tensing task described by Lazarov et al. (2014) except that we asked participants to produce levels of grip strength (via a grip strength device held in their dominant hand) instead of muscle tension. Specifically, participants' accuracy in producing target grip strengths were assessed, based on their maximum grip strength (i.e., 25%, 50%, 75%, and 100% of maximum grip strength), when feedback was either available or unavailable. We also assessed participants' confidence in their performance by offering them an opportunity to view accurate feedback in the final phase. There were a total of 4 phases with 12 trials per phase and participants were asked to produce the target grip strengths in a pseudo-random order.

1.1.2.4. Apparatus. The Grip Force Transducer hardware from ADInstruments was the grip strength device held by participants. It was connected to the ML880 PowerLab system (ADInstruments) which received physiological data regarding grip strength from the Grip Force Transducer and recorded this data using the LabChart Version 8.0 software (ADInstruments).

1.1.3. Procedure

The experimenter tested participants individually in a quiet laboratory at the University of New South Wales. Participants first provided informed consent and answered a series of demographics questions on the computer. The experimenter then introduced participants to the grip strength device and informed them that they would be asked to produce 4 target grip strengths (based on their maximum grip strength) throughout the experiment. Next, the experimenter instructed participants to hold the device with their dominant hand and to provide their maximum grip strength, stating, "grip the device with a high level of strength that you can sustain for at least 10 s, and do not grip the device with so much strength that it causes your hand to hurt". This instruction was included so that participants produced a maximum grip strength that could easily be replicated since they would have to frequently do so throughout the experimental phases. In order to familiarise them with their maximum grip strength, the experimenter asked them to reproduce this twice.

For ease of interpretation, this maximum grip strength (measured in microvolts; μv) was entered into an algorithm on the LabChart software which converted subsequent measurements of grip strength into a percentage of the participants' maximum grip strength. The program also produced a window on the computer monitor which signalled when each of the target grip strengths were achieved (i.e., showed '25%' when 25% of the participants' maximum grip strength was produced). This window served as the feedback mechanism for the second and fourth experimental phases.

Participants were then guided by the experimenter to produce two anchor grip strengths (25% and 100% of maximum grip strength). Participants were instructed to grip the device until the anchors were achieved at which point they were told "OK, that is 25%/100%". No other feedback was given during this anchoring phase and the experiment did not proceed until participants successfully produced the anchors twice. We included a 2 min break before beginning the first experimental phase.

During the first experimental phase, participants were asked to produce different target grip strengths on each trial and to hold it at that level for 5 s. In order to reduce fatigue, we included a 15 s rest period between trials. No feedback was available during this phase. Prior to the second phase, the experimenter turned the monitor towards the participant so that they could see the feedback window. Following a brief explanation of the feedback mechanism, participants were given 2 min to familiarise themselves with the feedback. Phases 2 and 3 were similar to phase 1, with participants producing the different target grip strengths while either viewing the feedback window (phase 2) or again without feedback (phase 3).

The fourth phase again replicated phase 1, except that participants were offered a choice to view the feedback window on every second trial. However, the experimenter warned them prior to starting this phase that additional feedback may impair their performance. Consistent with Lazarov et al. (2014), participants were informed about this potential cost of seeing the feedback in order to avoid a ceiling effect, whereby participants would request to see the feedback as many times as possible. On trials where participants requested feedback, the experimenter would briefly turn the monitor showing the feedback towards the participant (for 5 s) before turning it back towards themselves. Each phase was followed by a 2 min rest period to reduce participant fatigue.

Following the grip strength task, participants completed computerised versions of the DOCS and DASS-21. These questionnaires were administered following the experimental task to reduce any potential demand characteristics (i.e., to avoid priming participants that the study was concerning obsessive-compulsive symptoms). Finally, the experimenter debriefed participants, thanked them, and credited them for their participation.

During the first three phases, we measured participants' average grip strength on each trial (given that each trial lasted 5 s) and this was calculated as a percentage of their maximum grip strength. Grip strength was not calculated for the fourth phase as it was not the variable of interest during this phase. For each participant, we calculated a deviation score for each trial by computing the absolute difference between the target grip strength and their actual grip strength. We then averaged the deviation scores across trials for each phase. Lower deviation scores indicated greater accuracy on the grip strength task. During the fourth phase, the number of times participants requested to view the feedback window was recorded. Greater number of requests was considered indicative of low confidence in perceived ability to produce the target grip strengths.

1.2. Results and discussion

1.2.1. Sample characteristics

Table 1 shows participant characteristics by group. A chi-square test confirmed that the high- and low-OC groups did not differ with regards to gender, $\chi^2(1, N = 42) = 0.03$, $p = 0.87$. Furthermore, a two-tail independent samples *t*-test confirmed that these groups did not significantly differ with regards to age, $t(40) = 0.26$, $p = 0.80$, Cohen's $d = 0.54$.

1.2.2. Manipulation check and questionnaire results

A multivariate analysis of variance (MANOVA) simultaneously compared groups on the DASS-21 and the DOCS. Using Pillai's trace, there was a significant effect of group, $F(2, 39) = 65.62$, $p < 0.001$, $\eta^2_p = 0.77$. See Table 2 for means, standard deviations, and test statistics for group comparisons on each measure. As expected, the high-OC group self-reported significantly more OC symptoms and significantly more general distress.

1.2.3. Grip strength task

Average deviation scores across trials on each of the three phases are displayed in Fig. 1. We tested our hypotheses within a 2 (Group: high- vs. low-OC) × 3 (Phase: P1, P2, P3) repeated measures analysis of variance (ANOVA) with group as the between-subjects variable and phase as the within-subjects variable. There was no significant main effect of group, $F(1, 39) = 0.34$, $p = 0.57$, $\eta^2_p = 0.01$, suggesting that (averaging across phases) groups did not differ on their average deviation scores (i.e., accuracy). Contrary to prediction, there were no significant differences in accuracy between the groups during phase 1 when feedback was initially unavailable, $t(40) = 1.20$, $p = 0.24$, Cohen's $d = 0.38$.

There was, however, a significant main effect of phase, $F(2, 38) = 22.62$, $p < 0.001$, $\eta^2_p = 0.54$, suggesting that (averaging across groups) participants differed in accuracy between phases. Predictions regarding the effect of feedback on participants' accuracy in phase 2 were tested by examining the quadratic contrast (P2 – viewing feedback vs. P1 and P3 – no feedback). Unsurprisingly, there was a main effect of phase for this contrast, $F(1, 39) = 41.03$, $p < 0.001$, $\eta^2_p = 0.51$, suggesting that viewing feedback during the second phase improved accuracy (i.e., lower deviation scores) across both groups. Contrary to prediction, however, the group × phase interaction was not significant, $F(1, 39) = 0.79$, $p = 0.38$, $\eta^2_p = 0.02$, suggesting that viewing feedback did not differentially improve accuracy across the groups.

Interestingly, the group × phase interaction effect approached significance when examining the linear contrast (P1 vs. P3), $F(1, 39) = 2.90$, $p = 0.10$, $\eta^2_p = 0.07$. The pattern of results suggests that the high-OC group, as opposed to the low-OC group, demonstrated improved accuracy in phase 3 after receiving feedback (compared to phase 1).

A two-tail independent samples *t*-test was conducted to test the prediction that high-OC participants, compared to low-OC participants, would be more likely to request for feedback on their performance when given the opportunity to do so during the fourth phase. Contrary to prediction, requests for feedback were not significantly different between the high-OC group ($M = 2.68$, $SD = 2.15$) and the low-OC group ($M = 2.20$, $SD = 1.51$), $t(40) = 0.83$, $p = 0.41$, Cohen's $d = 0.26$.

The predictions of the SPIS hypothesis were largely unsupported by the present findings. Specifically, we found no evidence that more self-reported levels of OC symptom severity was significantly associated with deficient access to an internal state and thus poorer accuracy in producing target grip strengths when feedback was initially unavailable (phase 1). Unsurprisingly then, greater OC symptom severity was not significantly associated with increased benefits to performance while viewing the feedback in phase 2. Furthermore, greater OC symptom severity in participants was not significantly associated with reliance on an external proxy (i.e., times requested for feedback in phase 4).

Study 1 had specific limitations that may have prevented us from confirming the SPIS hypothesis, one of which may be the important difference between perception and performance. In the current study and the study by Lazarov et al. (2014), participants' access to their internal states was represented by their performance on the magnitude production tasks. However, there may be an important distinction to be made between their ability to physically *produce* levels of grip strength and muscle tension and their ability

Table 1
Sample demographics for between-group analyses (N = 42) in study 1.

	High-OC ($n = 22$)	Low-OC ($n = 20$)
Gender	Male = 6 (27.3%)	Male = 5 (25%)
Age	18.64 years (1.00)	20.45 years (4.62)
Marital status		
Single	95.5%	95%
Married/de facto	4.5%	5%
Ethnicity		
Caucasian	31.8%	45%
Other	68.2%	55%
Employment		
Employed	81%	80%
Other [a]	19%	20%
Education		
Tertiary	18.2%	15%
Secondary	81.8%	85%

Note. [a] Includes individuals who are not working, retired, and unemployed. Standard deviations are presented in parentheses.

Table 2
Study 1 group means, standard deviations, and test statistics for questionnaire responses (N = 42).

Questionnaire	Group				$F(40)$	p	η^2_p
	High-OC ($n = 22$)		Low-OC ($n = 20$)				
	M	*SD*	*M*	*SD*			
DOCS	25.32	8.25	3.60	1.93	131.81	<0.001	0.77
DASS-21	38.09	25.01	15.50	16.18	11.81	0.001	0.23

Note. DOCS = Dimensional Obsessive-Compulsive Scale; DASS-21 = Depression Anxiety and Stress Scales – 21.

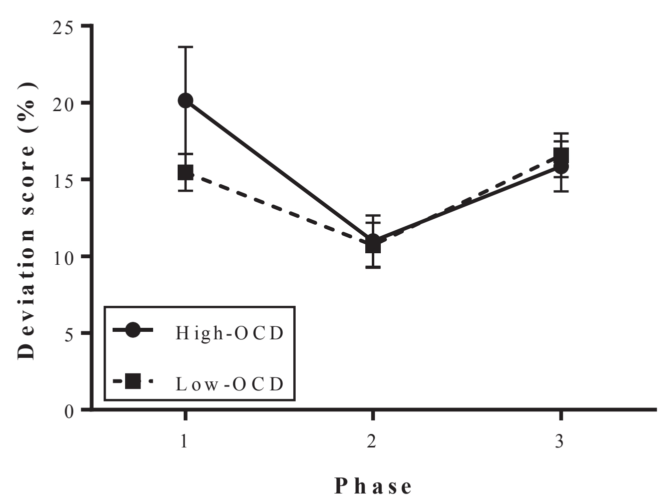

Fig. 1. Mean absolute deviations from target grip strength by phase and OC tendencies.

to *perceive* these internal states. As an analogy, an individual might be able to accurately perceive how far away an object is, but would fall short if asked to jump the distance to the object, perhaps due to a lack of practice or physical limitations. It is possible that participants on the grip strength task could accurately perceive 25% of their maximum grip strength but had difficulty producing this strength due to the novelty and difficulty of the task. Some support for this alternative explanation is provided by the finding that participants deviated from the target grip strength by at least 10% even while viewing the feedback in phase 2 (when reliance on their own perception was minimised). In the next study, we utilised a different study methodology in order to address this potential gap between perception and performance.

2. Study 2 – OC tendencies and access to internal states: distance perception

Lazarov et al. (2014) emphasised that the SPIS hypothesis needs to be further explored by examining its predictions with regard to other internal states and sensory domains, such as the basic sensations of hunger and pain. As such, we aimed to explore whether the SPIS hypothesis generalised to distance perception in Study 2 and to address the identified methodological limitations in Study 1, specifically the potential gap between perception and performance. As such, we investigated distance perception in the current study on a task designed to directly measure perception (or reported perception) without being confounded by participants' performance on this task. Distance perception was chosen as it was expected to be a familiar form of visual estimation and a form of perception that would be ecologically valid to an OCD population. For example, individuals with OCD commonly rely on their vision to detect threat such as in determining whether a surface is contaminated or whether a door appears to be locked.

In line with the SPIS hypothesis, we predicted that when feedback is unavailable, individuals who are high in OC symptoms would be less accurate in estimating target distances compared to those with low levels of OC symptoms. We also predicted that viewing feedback would improve the performance of all participants, but that the performance of the high-OC group would improve more than the low-OC group. Finally, we expected that the high-OC group would be more likely to ask for feedback on their performance when given the opportunity to do so.

2.1. Method

2.1.1. Participants

The current sample was recruited via the first year undergraduate psychology pool at the University of New South Wales who received course credit for their participation. As per course requirements, all enrolled students ($N = 1100$) completed a battery of pre-screening measures. Only individuals scoring in the top and bottom quartiles of the Obsessive-Compulsive Inventory – Revised (OCI-R; Foa et al., 2002) were eligible for participation. The top and bottom quartiles of scorers were categorised as high- and low-OC, respectively. The final sample consisted of 35 participants (22 females, mean age = 19.65, $SD = 3.79$, range 17–34): 16 high-OC and 19 low-OC participants. Both the experimenter and participants were blind to the participants' group status. The mean score on the DOCS for the high-OC group ($M = 21.93$, $SD = 9.97$) approached the mean score for individuals diagnosed with OCD ($M = 30.06$, $SD = 15.49$) and was above the DOCS clinical cut-off score of 18 (Abramowitz et al., 2010). The mean score on the DOCS for the low-OC group ($M = 7.11$, $SD = 4.96$) was lower than the mean score for healthy individuals ($M = 11.93$, $SD = 9.87$; Abramowitz et al., 2010).

2.1.2. Materials and measures

2.1.2.1. Self-report measures. The OCI-R is an 18-item self-report questionnaire that measured the severity of OC symptoms experienced during the past month. The OCI-R has high internal consistencies across varying samples, ranging from 0.81 to 0.93 (Foa et al., 2002). In addition to the OCI-R, the same set of self-report questionnaires used in Study 1 was used in the current study. The internal consistencies (Cronbach's alpha) of each of these measures in the current sample were as follows: OCI-R = 0.96, DOCS (total score) = 0.93, and DASS-21 (total and subscales score) = 0.81–0.94.

2.1.2.2. Distance judgement task. The development of this task was adapted from the biofeedback-aided muscle tensing task described by Lazarov et al. (2014) and the grip strength task used in Study 1. In this task, participants' accuracy in perceiving and producing target distances (i.e., 2.5, 5, 7.5, and 10 m) away from a large cut-out tree (relative to themselves) was assessed when feedback was either available or unavailable. Production of these distances presumably reflected actual perception as it simply required participants to physically place themselves away from the cut-out tree at the target distances, which was selected to be an easier task compared to producing target grip strengths. This reduction in overall task difficulty is evidenced from an inspection of Figs. 1 and 3. Specifically, initial target deviation on the grip strength task ranged from 15 to 20% and was relatively higher compared to the distance judgement task (8–12%). We also assessed participants' confidence in their estimates by offering them an opportunity to view accurate feedback on their performance in the final phase. Similar to the paradigm used in Study 1, there were a total of 4 phases and presentation of the target distances in each phase were in the same order for all participants. Due to time constraints, there were only 4

Fig. 2. Cardboard cut-out of tree.

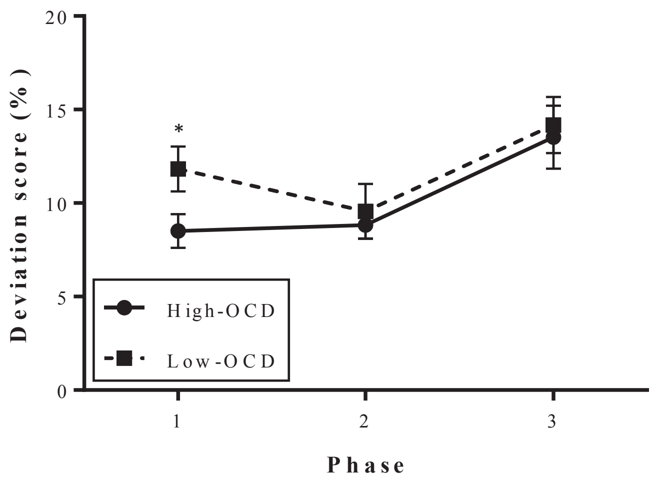

Fig. 3. Mean absolute deviations from target distance by phase and OC tendencies. $^*p < 0.05$.

trials in each phase, with participants producing each target distance once per phase.

A cardboard cut-out tree was used as the anchoring stimulus and was chosen to be emotionally neutral. The tree was printed in colour with its dimensions of 1.34 m × 0.54 m (height × width). The cut-out was attached with the Ryobi RLM30 laser tape measurer to determine the exact distance of participants from the cut-out. See Fig. 2 for an image of the tree.

2.1.3. Procedure

All undergraduate students first completed the battery of pre-screening measures, which included the OCI-R. Signups were processed via the SONA Experimental Management System which allowed the experimenter to restrict access to the current study based on students' OCI-R scores. Eligible participants (see above) were tested individually in a large rectangular room measuring 13m × 11m (length × width) and provided informed consent. The experimenter then introduced participants to the cut-out tree and informed them that they would be asked to produce the 4 target distances away from the cut-out throughout the experiment. Next, the experimenter placed the cut-out at one end of the room and instructed participants to stand directly in front of the cut-out while at the other end of the room. The experimenter then guided participants to produce two anchor distances away from the cut-out, specifically 4 and 7 m. These anchors were obtained by instructing participants to take normal steps towards the cut-out tree until they produced the specified distance, at which point they were told "OK, that is 4/7 m". No other feedback was provided during this anchoring process. Following this, participants were instructed to return to their starting position.

During the first experimental phase, participants were asked to produce each of the 4 target distances across 4 trials. They were instructed to return to their starting position between each trial and no feedback was available during this first phase. In the second phase, participants were again asked to provide the 4 target distances, however they were given accurate feedback on their performance for each trial. That is, following their production of the target distance on each trial, the words 'Too Close' or 'Too Far' would be presented on a monitor next to them. Participants were then given the option to change their distance from the cut-out based on the feedback. The third phase replicated the first phase (i.e., no feedback provided).

In the fourth phase, participants were offered a choice of whether or not to view accuracy feedback on their performance for each trial. Consistent with Lazarov et al. (2014) and Study 1, participants were warned about the potential cost of additional feedback on performance to prevent ceiling effects. On trials where participants requested feedback, the monitor would present the words 'Too Close' or 'Too Far' but would otherwise remain blacked out throughout this phase. The cut-out was placed on a different wall of the experiment room during each phase in order to minimise possible practice effects.

Following the distance judgement task, participants answered a series of demographics questions on the computer and completed computerised versions of the DOCS and DASS-21. Similar to Study 1, these questionnaires were administered following the experimental task to reduce any potential demand characteristics. Finally, participants were debriefed, thanked, and credited for their participation.

During the first three phases, the experimenter measured the distance of participants from the cut-out tree for each trial (in metres) using the Ryobi RLM30 laser tape measurer. For each participant, we calculated a deviation score for each trial by computing the absolute difference between the target distance and their actual distance. Deviation scores were not calculated for the fourth phase as it was not the variable of interest during this phase. For ease of interpretation, deviation scores were converted into a percentage by dividing them by the target distance. Deviation scores were then averaged across trials for each of the three phases. Lower deviation scores indicated greater accuracy on the distance judgement task. During the fourth phase, we recorded the number of times participants requested to view the feedback monitor. Greater number of requests by participants was indicative of low confidence in their own perceived ability to judge distances.

2.2. Results and discussion

2.2.1. Sample characteristics

Table 3 shows participant characteristics by group. A chi-square test confirmed that groups did not differ in regards to gender, $\chi^2(1, N = 35) = 1.86$, $p = 0.17$. Furthermore, a two-tail independent samples *t*-test confirmed that groups did not significantly differ in regards to age, $t(32) = -1.07$, $p = 0.29$, Cohen's $d = 0.41$.

2.2.2. Manipulation check and questionnaire results

A MANOVA simultaneously compared groups on all questionnaire scores. Using Pillai's trace, there was a significant effect of group, $F(3, 30) = 37.94$, $p < 0.001$, $\eta^2_p = 0.79$. See Table 4 for means, standard deviations, and test statistics for post-hoc comparisons.

Table 3
Baseline Sample Demographics for Study 2 (N = 35).

	High-OC (n = 16)	Low-OC (n = 19)
Gender	Male = 4 (25%)	Male = 9 (47.4%)
Age	18.81 years (1.11)	20.26 years (4.94)
Marital status		
Single	87.5%	94.4%
Married/de facto	12.5%	5.6%
Ethnicity		
Caucasian	37.5%	61.1%
Other	62.5%	38.9%
Employment		
Employed	93.3%	88.2%
Other [a]	6.7%	11.8%
Education		
Tertiary	20%	22.3%
Secondary	80%	72.2%

Note. [a] Includes individuals who are not working, retired, and unemployed. Standard deviations are presented in parentheses.

Table 4
Study 2 group means, standard deviations, and test statistics for questionnaire responses (N = 35).

Questionnaire	Group				$F(30)$	p	η^2_p
	High-OC ($n = 16$)		Low-OC ($n = 19$)				
	M	*SD*	*M*	*SD*			
OCI-R	35.86	13.72	6.28	2.24	81.66	<0.001	0.73
DOCS	21.93	9.97	7.11	4.96	30.32	<0.001	0.50
DASS-21	33.57	23.50	16.78	14.95	6.07	0.02	0.17

Note. OCI-R = Obsessive-Compulsive Inventory − Revised; DOCS = Dimensional Obsessive-Compulsive Scale; DASS-21 = Depression Anxiety and Stress Scales − 21.

Importantly, the high-OC group self-reported significantly more OC symptoms compared to the low-OC group on the OCI-R and the DOCS, suggesting that our group allocation according to pre-screening scores was successful. Similar to Study 1, the high-OC group also reported significantly more general distress (DASS-21).

2.2.3. Distance judgement task

Deviation scores for both groups across the three phases are displayed in Fig. 3. Identical to Study 1, we tested our hypotheses within a 2 (Group: high- vs. low-OC) × 3 (Phase: P1, P2, P3) repeated measures ANOVA with group as the between-subjects variable and phase as the within-subjects variable. There was no significant main effect of group, $F(1, 33) = 1.24$, $p = 0.27$, $\eta^2_p = 0.04$, suggesting that (averaging across phases) groups did not differ on their average deviation scores (i.e., accuracy). Contrary to prediction, the high-OC group had significantly higher accuracy scores than the low-OC group (i.e., low deviation scores) during phase 1 when feedback was initially unavailable, $t(33) = -2.12$, $p = 0.04$, Cohen's $d = 0.73$.

There was, however, a significant main effect of phase, $F(2, 32) = 10.57$, $p < 0.001$, $\eta^2_p = 0.40$, suggesting that (averaging across groups) participants differed in accuracy between phases. Importantly, we tested our predictions regarding the effect of viewing feedback on participants' accuracy in producing the target distances by examining the quadratic contrast (P2 − viewing feedback vs. P1 and P3 − no feedback). As expected, there was a main effect of phase for this contrast, $F(1, 33) = 11.74$, $p = 0.002$, $\eta^2_p = 0.26$, suggesting that viewing feedback during the second phase improved accuracy (i.e., lower deviation scores) across both groups. Contrary to prediction, however, the group × phase interaction was not significant, $F(1, 33) = 0.56$, $p = 0.46$, $\eta^2_p = 0.02$, suggesting that viewing feedback did not differentially improve accuracy between the two groups.

We did not find a significant group × phase interaction effect for the linear contrast (P1 vs. P3), $F(1, 39) = 1.28$, $p = 0.27$, $\eta^2_p = 0.04$. That is, there was insufficient evidence to suggest that viewing feedback in phase 2 affected groups differently in their accuracy during phase 3 (compared to phase 1) when feedback was unavailable.

A two-tail independent samples *t*-test was conducted to test the prediction that high-OC participants would be more likely to request for feedback, compared to low-OC participants, on their performance when given the opportunity to do so during the fourth phase. Somewhat consistent with prediction, the high-OC group requested more feedback ($M = 3.06$, $SD = 1.34$) than the low-OC group ($M = 2.32$, $SD = 1.25$), $t(33) = 1.70$, $p = 0.10$, Cohen's $d = 0.57$, with this difference approaching significance.

The predictions of the SPIS hypothesis did not appear to generalise to distance perception. Contrary to prediction, the high-OC group was more accurate in distance production compared to the low-OC group when feedback was initially unavailable. Viewing feedback in phase 2 did not differentially affect groups' accuracy scores. Furthermore, there was tentative evidence to suggest that the high-OC group, compared to the low-OC group, demonstrated greater reliance on an external proxy (i.e., number of requests for feedback in phase 4).

3. General discussion

The present two studies aimed to replicate and extend Lazarov and colleagues' (2014) study. Their findings of a difference between high- and low-OC individuals on a magnitude production task were interpreted to suggest that the pervasive doubt experienced by individuals with OCD, including the doubting of sensory perception, stems from a deficiency in accessing internal states. We failed to substantially replicate their findings using a task similar to their biofeedback-aided muscle tensing task (i.e., grip strength task) and we were unable to extend their findings to another sensory domain (i.e., distance perception). Specifically, greater OC symptom severity in a non-clinical sample was not significantly associated with poorer access to the internal state of grip strength (Study 1) and was associated with significantly better distance perception (Study 2) prior to feedback. In both studies, viewing feedback improved the performance of both groups but there was no evidence to suggest that viewing feedback differentially affected group performance during phase 2. Finally, there was no evidence to suggest that groups in either study differed in their degree of reliance on external proxies.

Interestingly, we found tentative evidence in Study 1 to suggest that elevated levels of OC symptom severity was marginally associated with improved performance after receiving feedback. It appears that an improvement was observed because the high-OC group were slightly less accurate (albeit not significantly so) compared to the low-OC group in phase 1 when the task was first introduced. In this experiment, performance of the high-OC group was more influenced (in this case positively) by the viewing of the external proxy/feedback in phase 2. Perhaps the high-OC group was positively influenced by this feedback because they perceived the task of producing accurate grip strengths to be initially more difficult due to intrinsically elevated doubt in their performance. Although this explanation is speculative, participants may have then found the feedback helpful in alleviating this doubt.

This explanation could potentially account for the opposite pattern of results (albeit non-significant) in Study 2, where the performance of the high-OC group appeared to suffer after their experience with the feedback, despite being initially more accurate than the low-OC group in phase 1. This surprising finding might be due to the combined effects of the reduced difficulty of the distance judgement task and positive associations between OC symptoms and conscientiousness/perfectionism (Frost & Steketee, 1997; Frost, Marten, Lahart, & Rosenblate, 1990). As such, doubt would have had a minimal impact on performance and allowed for the high-OC group to demonstrate that they had superior or at least intact access to their internal states. Perhaps then, the introduction of the feedback did not have the predicted effect due to the nature of the feedback. Specifically, participants were told that they were either 'Too Close' or 'Too Far' away from the cut-out tree even if they were as little as 1 cm off from the target distance. This feedback might have introduced a significant degree of doubt in participants which compromised its utility as an external proxy. However, this interpretation of the perceived utility of the feedback is highly speculative. In a future replication using the current paradigm, the experimenter could ask participants to rate how helpful they found the feedback.

The idea that individuals with OCD are more influenced by feedback (irrespective of its helpfulness) is in line with other findings that proponents of the SPIS hypothesis argue support their theory. In addition to having groups with clinical OCD, non-OCD anxiety disorders, and a healthy control group complete the biofeedback-aided muscle tensing task, Lazarov et al. (2014) instructed groups to view pre-programmed, false biofeedback of their muscle tension levels and rate their perceived muscle tension on a visual analogue scale (0–100). They found that the OCD group was significantly more influenced by false biofeedback when assessing their own level of muscle tension compared to anxiety disorder and healthy control participants. False feedback did not differentially affect the groups' actual levels of muscle tension. From these findings, Lazarov et al. (2014) concluded that individuals with OCD are more influenced by external proxies due to deficient access to their internal states.

Our results from Studies 1 and 2 generally agree with the first half of their conclusion but not the latter. The finding that OC symptoms were not significantly associated with poorer access to internal states such as grip strength and distance perception is consistent with studies examining neuropsychological functioning in OCD. While these are largely separate domains, they are related in that they are both aspects of cognitive functioning. In the first meta-analysis of neuropsychological studies conducted in OCD populations, Abramovitch, Abramowitz, and Mittelman (2013) concluded that the magnitude of effect sizes indicating reduced performance in OCD across neuropsychological domains (i.e., attention, memory, executive functioning, processing speed, visuospatial abilities, and working memory) were moderate at best but not clinically significant.

Therefore, for individuals with OCD, any observed 'deficits' in these domains could be better attributed to reduced subjective cognitive confidence (a central characteristic of OCD; Aardema et al., 2009). This distrust/doubting of the senses in the absence of an actual deficit is what the cognitive appraisal (Rachman, 2002; Salkovskis, 1989) and the inference-based approach models (Julien, O'Connor, & Aardema, 2016) suggests causes and maintains OC symptoms. This idea is supported by another study by Lazarov et al. (2015), who demonstrated that experimentally increasing levels of doubt in healthy participants led to poorer accuracy on the biofeedback-aided muscle tensing task (when biofeedback was unavailable) compared to participants whose level of doubt was not manipulated. This difference was eliminated when viewing the biofeedback possibly because it temporarily eliminated doubt. With regards to clinical implications, it appears that resolving pathological doubt is imperative to the successful treatment of OCD. For example, the treatment based on the inference-based approach (inference-based therapy), which teaches the patient skills in effectively resolving doubt, has been shown to lead to positive treatment outcomes in OCD (Aardema, Emmelkamp, & O'Connor, 2005; Del Borrello & O'Connor, 2014; O'Connor, Koszegi, Aardema, van Niekerk, & Taillon, 2009).

3.1. Limitations and future directions

The use of non-clinical analogue samples in the current studies limited our ability to generalise our findings to the OCD population. Even though the use of analogue samples in OCD research is appropriate for understanding OC-related phenomena (Abramowitz et al., 2014), future studies will need to replicate the current studies in a clinical population. Furthermore, to be able to confidently conclude that any observed effects are unique to OCD, future studies should also include a clinical control group comprised of participants with mood or non-OCD anxiety disorders as well as a healthy control group.

As argued throughout this section, any observed effects in the current studies could have been accounted for by varying levels of doubt between groups. However, as doubt was not explicitly measured, we were unable to conclude the precise influence of doubt on the experimental tasks. As such, future replications of the current studies could treat OC symptoms as a dimensional construct in a clinical population and measure doubt during each phase so that its effects may be statistically controlled for in analyses. In addition to increasing analytic power, this dimensional approach to analyses has been recommended by Mataix-Cols, do Rosario-Campos, and Lackman (2005) given that the clinical presentation of OCD is better understood as a spectrum of overlapping symptoms rather than by the traditional nosological boundaries of OCD. Dimensional analyses are also an appropriate method for holding constant the effects of doubt (Preacher, Rucker, MacCallum, & Nicewander, 2005). Alternatively, future researchers could experimentally increase participants' levels of doubt and compare their performance on the experimental tasks to participants whose level of doubt is not manipulated.

Another advantage of a dimensional approach to analyses would be to appropriately examine the possibility that the variables examined in the current study were more closely associated with some presentations of OCD (e.g., contamination) than with others (e.g., symmetry). That is, our rationale for measuring distance perception in Study 2 was that it would be a form of perception that would be ecologically valid to individuals with OCD as they commonly rely on their vision to judge their distance away from threatening stimuli such as contaminated surfaces. Therefore, we might expect that accuracy and times requested for feedback on this experimental task would be significantly correlated with the contamination subscale on the DOCS rather than the symmetry subscale. However, the method of recruiting the current sample resulted in non-normal distributions of DOCS scores and thus precluded the use of these dimensional analyses.

4. Conclusions

In the current studies, there was minimal support for the SPIS hypothesis such that OC symptoms were not associated with deficient access to various internal states. Results instead were commensurate with contemporary cognitive models of OCD and the broader OCD literature, which suggest that individuals with OCD have a distrust of their senses despite relatively intact cognitive functioning. Future research with these experimental tasks is required to determine the precise influence of doubt on performance.

Declaration of interest

The authors declare no conflicts of interest.

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