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An investigation of the experience of control through the sense of agency in people with obsessive–compulsive disorder: a review and meta-analysis

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Review

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Abstract

The construct of sense of agency (SoA) has proven useful for understanding mechanisms underlying obsessive–compulsive disorder (OCD) phenomenology, especially in explaining the apparent dissociation in OCD between actual and perceived control over one's actions. Paradoxically, people with OCD appear to experience both diminished SoA (feeling unable to control their actions) and inflated SoA (having "magical" control over events). The present review investigated the extent to which the SoA is distorted in OCD, in terms of both implicit (ie, inferred from correlates and outcomes of voluntary actions) and explicit (ie, subjective judgment of one's control over an outcome) measures of SoA. Our search resulted in 15 studies that met the criteria for inclusion in a meta-analysis, where we also examined the potential moderating effects of the type of measure (explicit versus implicit) and of the actual control participants had over the outcome. We found that participants with OCD or with high levels of OCD symptoms show lower implicit measures of SoA and at the same time tend to overestimate their control in situations where they do not actually have it. Together, these findings support the hypothesized dissociation in OCD between actual and perceived control over one's actions.

1. Introduction

Obsessive–compulsive disorder (OCD) is a psychiatric condition characterized by intrusive thoughts, urges, or images (ie, obsessions) that cause marked distress or anxiety, and by feeling compelled to do something repetitively (ie, compulsions).[1] Although OCD is defined by the presence of obsessions and compulsions, its clinical presentation is highly heterogeneous.[2] Specifically, the question of control has been recognized as a central feature of OCD in classic as well as modern descriptions of the disorder.[3-6] Consistently, two control-related constructs have been suggested in OCD phenomenology:[5,6] the need for control (ie, the broad motivation to have control over events)[7] and the sense of control (ie, beliefs in one's ability to achieve or avoid specific outcomes through one's actions).[8] Clinical observations and empirical data suggest that the pattern of a low sense of control combined with a high need to control may be a core feature of OCD. Specifically, individuals with OCD experience a pervasive feeling of doubt and uncertainty regarding their actions,[9-11] while at the same time, they seem to exert conscious, deliberate, and reflective control over their own actions.[12,13] In support of this pattern, Reuven-Magril et al.[14] showed that people with OCD have an "illusory" sense of control, whereby they believe to have control over events that are actually uncontrollable and entirely externally generated. This "illusory" sense of control is consistent with the magical thinking that often leads individuals with OCD to believe that they have control/responsibility over events that are beyond their control,[15] and that their thoughts would automatically result in actions ("thought–action fusion")[16] or events in the world ("thought–event fusion").[17]

Consistent with this, in the last decade, the construct of sense of agency (SoA) has proven fruitful for understanding the experience of control in OCD phenomenology (for a comprehensive summary, see Szalai 2019).[18] The SoA can be defined as "*the sense that I am the one who is causing or generating an action*".[19] It can also be conceptualized as the feeling of control over one's actions and, through them, the course of external events.[20,21] The experience of SoA is believed to emerge phenomenologically from computational processes that comprise top-down contextual knowledge and bottom-up sensory signals, probing for a match between expected and actual results in the subjective experience of doing.[22,23] This integration process is attributed to a comparator model of motor control,[24] in which the prediction of the outcome of an action is compared with sensory feedback signals that provide information about the action being performed and its effects on the external environment.[25,26] According to Synofzik et al.,[27] the

SoA can be conceptualized as the expression of two intertwined phenomena. On the one hand, there is the feeling of agency, which is the subjective experience of fluently controlling the action one is currently making, arising from the comparator model mentioned above. To investigate this implicit measure of the SoA, paradigms have been developed in which the feeling of agency is not directly assessed by participants' reports but is rather inferred from correlates and outcomes of voluntary action (eg, sensory attenuation or intentional binding effects; see below).[21,28] On the other hand, there are the judgments of agency, which refer to the conceptual, interpretative judgments of being the agent of an action, and arise from integrating efferent–afferent contingencies with cognitive cues (ie, prior beliefs of control and responsibility, contextual knowledge relating to the action). To investigate these explicit measures of the SoA, researchers directly ask participants about their judgments of agency in a specific task (eg, asking to what degree they think their action brought about an effect)[29] or in non-context-specific situations (eg, asking to what degree they feel responsible for everything that results from their actions).[30] Even though the feeling of agency forms the evidence base for judgments of agency (eg, the belief in having turned on the light depends on the experience of having reached the light switch),[21] the implicit (ie, the feeling of agency) and explicit (ie, the judgments of agency) measures of the SoA are not always concordant.[31,32] Moreover, it has been noted that implicit measures do not reflect exclusively the effect of the comparator model described above. Implicit reports were consistently found to be influenced by high-level contextual information,[33] prior beliefs about the causal link between an action and a sensory change in the environment,[34] affective states,[35] conceptual beliefs,[36] and action selection processes.[37]

This theoretical background suggests that the SoA may constitute an important building block for OCD phenomenology of control. In their pivotal study, Gentsch et al.[38] examined event-related potentials in a task that assessed the sensory attenuation effect in OCD participants and nonclinical controls. Sensory attenuation is believed to stem from the comparator model mentioned above; specifically, if there is no discrepancy between the experienced action and its predicted effects, the effect is "cancelled" from the experience (ie, its sensory representation is attenuated).[25] Examining EEG responses to self-generated versus externally generated visual stimuli, they found that the suppression of the N1 component (a hallmark of the sensory attenuation process) was reduced in participants with OCD, demonstrating a reduced (implicit) SoA. In other words, subjects with OCD failed to predict and suppress the sensory consequences of their own actions. At the same time, the authors found that OCD participants, when directly asked to rate the relation between their actions and visual stimuli, reported a higher judgment of agency than controls and that their ratings were positively correlated with OCD symptoms severity.

A similar dissociation between implicit and explicit SoA was found by Oren et al.[39] using the intentional binding paradigm. This paradigm refers to the observation that when a voluntary action (eg, a self-conducted button press) produces an external sensory effect (eg, a sound played subsequently), action and effect are perceived as closer together in time.[40] In particular, the action is perceived as occurring later in time, while the effect of the action is perceived as occurring earlier.[22] Interestingly, when efferent motor information is not present, such as in passive movement or in passive observation of others, intentional binding is reduced or absent.[41] Oren et al. found that the intentional binding effect was reduced in participants presenting high scores of OCD symptoms, compared to those with low scores of OCD symptoms, indicating a diminished (implicit) SoA. At the same time, they found that the agency judgments of individuals presenting with high OCD symptoms were higher than those of individuals with low OCD symptoms in conditions which in fact afforded no control.

In addition to the abovementioned studies, growing evidence suggests that in OCD phenomenology, a decreased SoA also plays a role in a variety of experiences other than control over one's actions. Individuals with high scores on measures of OCD symptoms were found to omit agency or use grammatical framings that detach the event from the entity that caused it in their spoken language.[42] For example, if the experimenter described a picture in a simple sentence and then asked participants a why-question like "*The grandmother is covering the girl and now the girl is happy. Why is the girl happy?*" participants with low levels of OCD symptoms were more likely to use a sentence that expressed agency, such as "*The girl is happy because the grandmother is covering her*," while participants with high scores on measures of OCD symptoms were more likely to use a sentence that omitted agency, such as "*The girl is happy because she has a blanket.*" Furthermore, individuals with high levels of OCD symptoms were found to be more likely to attribute their thoughts to an external source than subjects with low levels of OCD symptoms.[43]

Converging support for reduced SoA in OCD comes from other OCD models, which have pointed to discrepancies in the integration of low-level cognitive processes (ie, direct experiences in the here and now) and high-level ones (ie, meta-representations, beliefs, intentions) to explain the uncertainty of the subjective experience of action. Considering an impairment at this level, it has been hypothesized that individuals with OCD exhibit a lack of accessibility to corresponding signals (ie, body states and sensations) that prevents them from experiencing success in achieving expected outcomes, thus leading them to seek out and rely on compensatory proxies (ie, observable behaviors or environmental stimuli).[44,45] In such a case, people with OCD would manifest difficulty in experiencing perceived control over goal-directed actions, since stopping those actions requires reliance on internal states.[46] In contrast, other authors have attributed these integration difficulties to an excessive uncertainty regarding state transition probabilities, which impairs the ability of individuals with OCD to predict ensuing feedback and makes them more surprised by expected outcomes.[47] A disrupted integration processing in individuals with OCD is expressed by specific subjective experiences, known as sensory phenomena (eg, "just-right perceptions," "feelings of incompleteness," and "not just-right experience"), which usually precede repetitive behaviors[48-50] and seem to be a core phenotype in OCD.[51] It has been argued that these sensory phenomena may be underpinned by an individual history of persistent inaccurate sensory predictions, in which the main element is a mismatch between the predicted effect and the actual effect that occurs from one's actions.[52,53] Since from an ethological perspective, ritual behavior plays a homeostatic function (ie, general ability to control external events) in different conditions of unpredictability (eg, newness and change coupled with an excessive need for control).[54-57] Thus, it is intriguing to hypothesize that OCD ritual compulsions may indeed represent a nonfunctional compensative attempt to cope with this sensorial mismatch.[58]

To sum up, the need for control is a prominent feature in OCD phenomenology, which is characterized by a fragile and often distorted sense of control over one's actions.[14] The construct of the SoA can provide a comprehensive theoretical framework for various mechanisms, both bottom-up and top-down, that underlies the discrepancy in individuals with OCD between their actual

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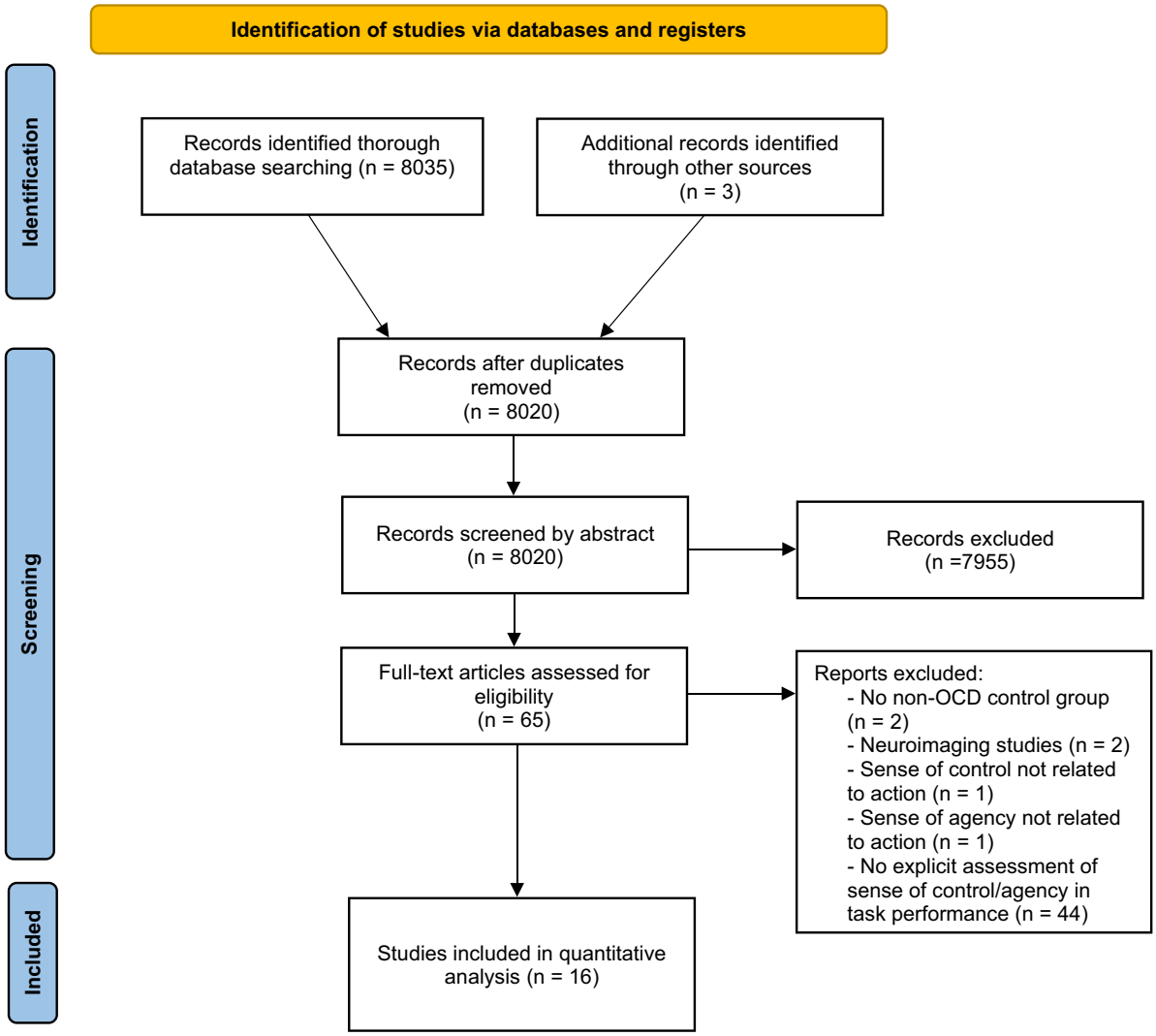

Figure 1. PRISMA flowchart of paper selection. Study selection process and reasons for exclusions.

and perceived sense of control.[18,59] More specifically, as implicit measures of SoA in OCD seem to indicate a decrease in control, while explicit measures suggest inflated subjective control in situations that are actually uncontrollable,[38,39] this dissociation may contribute to shed light on the distorted subjective experience of control in individuals with OCD.[14]

The present review and meta-analysis were designed to examine the sense of control in OCD through the construct of the SoA. For this purpose, we reviewed all research articles that assessed the SoA and/or sense of control over one's actions in participants with OCD as compared to healthy controls, as well as in subjects presenting high scores on OC symptom measures compared to subjects with low scores on these measures. This allowed us to address two major questions: (1) do individuals with OCD or with high levels of OC symptoms exhibit a diminished SoA/sense of control over their actions? and (2) are the implicit and explicit measures of SoA concordant or discordant in people with OCD or with high levels of OCD symptoms? In short, is OCD associated with a discrepancy between real and perceived control?

Our hypothesis is that individuals with OCD or with high levels of OCD symptoms have a reduced SoA/sense of control and that their judgment of the SoA/sense of control varies depending on the degree of control they actually have in the particular situation. In other words, we expected to find these individuals impaired in the process of perceiving control over their actions, with an aberrant tendency to overestimate their judgments of control in situations where they do not actually have it.

2. Method

The systematic review protocol was registered in Prospero before undertaking the review. The present report conforms with PRISMA guidelines.[60] Studies were selected following a systematic search for publications from the beginning of March 2023 to the end of March 2023. The search covered PubMed, PsycNet, and ISI Web of Science. All relevant subject headings and free-text terms were selected to represent OCD and SoA/sense of control over one's actions, using the following search terms (asterisk denotes truncation designed to capture grammatical variability): "obsessiv*" or "compulsiv*" or "OCD" with "agency," "control*," "action monitoring," and "performance monitoring." Additional records were identified by employing the similar articles feature in PubMed and the Cited Reference Search in ISI Web of Science.

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Table 1. Study Characteristics

References	Population	N OCD	N Control	% Females	Mean age (SD)
Belayachi and Van der Linden[61]	Analogue	22 (high checking)	31 (low checking)	72	Total sample = 22.5 (±3.14)
Ezrati et al.[62]	Analogue	26 (high OC)	28 (low OC)	68	High OC = 23.2 (±2.48); low OC = 23.6 (±1.8)
Ezrati et al.[63]	Analogue	34 (high OC)	34 (low OC)	66	High OC = 23.2 (±2.01); low OC = 23.6 (±2.43)
Gentsch et al.[38]	Clinical	18 (OCD)	18 (HC)	33.3	OCD = 35.4 (±9.5); HC = 37.4 (±9.8)
Gillan et al.[64]	Clinical	26 (OCD)	26 (HC)	58	OCD = 42.5 (±13.7); HC = 40.38 (±13.69)
Giuliani et al.[65]	Clinical	21 (OCD)	21 (HC)	33	OCD = 42.29 (±15.19) HC = 41.81 (±15.91)
Giuliani et al.[66]	Clinical	18 (OCD)	18 (OCD)	17	OCD = 28.94 (±7.81); HC = 29.33 (±7.43)
Lazarov et al.[44]	Analogue	19 (high OC)	19 (low OC)	76	Total sample = 22.53 (±1.72)
Lazarov et al.[67]	Clinical	20 (OCD)	20 (HC)	–	OCD = 39.57 (±11.02); HC = 38.25 (±6.05)
Oren et al.[42]	Analogue	32 (high OC)	29 (low OC)	55	High OC = 22.9 (1.7); low OC = 22.9 (±2.13)
Oren et al.[39]	Analogue	54 (high OC)	48 (low OC)	70	Total sample = 22.8 (±1.8)
Reuven–Magril et al.[14] (study 1)	Analogue	28 (high OC)	26 (low OC)	76	Total sample = 22.80 (±2.38)
Reuven–Magril et al.[14] (study 2)	Clinical	22 (OCD)	22 (HC)	45	OCD = 30.0 (±9.9); HC = 30.1 (±10.1)
Takashima et al.[68]	Clinical	12 (OCD)	12 (HC)	75	OCD = 41.17 (±13.58); HC = 41.17 (±14.42)
Vaghi et al.[69]	Clinical	27 (OCD)	27 (HC)	50	OCD = 39.52 (±10.65); HC = 40.67 (±11.29)
Zhang et al.[70]	Analogue	13 (high OC)	17 (low OC)	72	High OC = 21.00 (±1.63); Low OC = 21.35 (±1.6)

Note. The minus sign (–) represents data that were not available in the paper.
Abbreviations: HC, healthy controls; high checking, participants with high checking tendencies; high OC, participants with high obsessive–compulsive tendencies; low checking, participants with low checking tendencies; low OC, participants with low obsessive–compulsive tendencies; OCD, participants with OCD diagnosis.

Reference sections of review articles, book chapters, and studies selected for inclusion were searched for further studies.

2.1 Search selection process

Based on the inclusion and exclusion criteria outlined below, the titles and abstracts were independently screened by two reviewers (DFB and RD). Discrepancies were resolved by a discussion between the two reviewers. Full articles were then independently screened by each of the two reviewers. Where disagreements occurred, a consensus meeting was held to decide on study inclusion. The study selection process and reasons for exclusions are described in Figure 1. A study was included if: (1) it included participants diagnosed with OCD, using valid and accepted tools, and control participants with no psychiatric disorder or with another psychiatric disorder (eg, anxiety disorders, psychosis); (2) it included nonclinical participants and provided, using valid and accepted tools, a comparison between participants presenting with high versus low scores on OCD symptom measures; (3) the study attempted to assess basic processes that are believed to relate to a SoA/the sense of control on over one's own actions, using implicit (eg, sensory attenuation) or explicit measure (eg, judgments of agency) or both; (4) the study included adult participants (aged >18); and (5) the study was published in English. Studies were excluded on the following criteria: (1) they were review articles, case studies, or book chapters; (2) clinically relevant symptoms of OCD were not used in defining study groups; (3) they had no adequate control groups; (4) they were based on nonclinical populations without a comparison between participants presenting with high and low scores on OCD symptom measures; and (5) they presented only neuroimaging outcomes. The PRISMA flowchart is depicted in Figure 1, and the selected studies are summarized in Tables 1 and 2.

2.2 Statistical analysis

We analyzed the data using Comprehensive Meta-Analysis software, Version 4.[71] Based on the rationale expounded in the introduction, results related to explicit measures of the SoA were analyzed separately from those reflecting implicit measures. Hedges' g (the difference between the means in weighted pooled SD units) was used as the effect size index of the differences in SoA between individuals with OCD/with high levels of OCD symptoms and healthy control participants/with low levels of OCD symptoms. The analysis of these effects in each of the two groups (ie, explicit/implicit measures) was based on the random-effects model, whereas analyses comparing the effects between these groups were based on the fixed-effect model, as recommended by Borenstein et al.[72,73] In these between-group analyses, we used the Q-statistic to test the null hypothesis that explicit measures and implicit measures studies shared a common effect size. Finally, we examined the possible presence of publication bias (eg, overrepresentation of small studies with large effects)[74] using funnel plots with the one-tailed Egger tests.[75]

3. Results

Our search resulted in 15 studies that met the criteria for inclusion in the meta-analysis. Out of these, eight studies reported implicit SoA measures, nine reported explicit SoA measures, and two reported both types of measures. Seven studies consisted of clinical samples (individuals with OCD versus healthy controls), while eight studies consisted of nonclinical samples (ie, individuals presenting high scores on OCD symptoms versus individuals presenting low scores on OCD symptoms). Table 1 summarizes the characteristics of the studies included in the meta-analysis.

Considering the implicit measures, one study examined event-related potentials during sensory attenuation task),[38] one study

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Table 2. Implicit and Explicit Measures in the Studies Included in the Analysis

References	Population	Condition	Implicit measure of SoA	Explicit measure of SoA
Belayachi and Van der Linden[61]	Illusion of agency task	No control	–	Rating from 0 to 9 their judgment of being the author of the outcome.
Ezrati et al.[63]	Cervical range–of–motion device	Full control	Accuracy of repositioning the head to a target angle that was previously acquired actively or passively.	–
Ezrati et al.[62]	Computerized hand–reaching task	No control	Hand positioning accuracy after training with false feedback.	–
Gentsch et al.[38]	Active generation and passive observation of visual feedback	Mixed control	Suppression of the N1 component (EEG) of the event–related potential during active generation (motor effect) of visual feedback.	Using visual analog scale ratings, judgments of agency in the motor–effect task condition with low contingency.
Gillan et al.[64]	Illusion of control paradigm	No control	–	Visual analog scale ranging from 0 ("*no control*") to 100 ("*complete control*").
Giuliani et al.[65]	Discovery task	Full control	–	The ratio between the number of correct responses (ie, being the author of a beep) and the number of trials in the saccade condition (in which the origin of the beep is related to motor actions).
Giuliani et al.[66]	Discovery task	Full control	–	The ratio between the number of correct responses (ie, being the author of a beep) and the number of trials in the saccade condition (in which the origin of the beep is related to a motor action).
Lazarov et al.[45]	False biofeedback paradigm	No control	Subjective evaluations of muscle tension were measured with a 100–mm visual analog scale, which was anchored with "*my muscle feels really intense*" at the minimum state end and "*my muscle feels completely loose*" at the maximum state end.	–
Lazarov et al.[67]	False biofeedback paradigm	No control	Subjective evaluations of muscle tension were measured with a 100–mm visual analog scale, which was anchored with "*my muscle feels really intense*" at the minimum state end and "*my muscle feels completely loose*" at the maximum state end.	–
Oren et al.[42]	General knowledge	–	–	Sense of agency scale (SoAs).
Oren et al.[39]	Intentional binding task	No control	Subjective evaluation of the time interval between a voluntary action and its external sensory consequence.	Direct question: "*To what extent did you feel that you were the one who generated the tones? Please rate from 1 (not at all) to 8 (very much).*"
Reuven–Magril et al.[14] (study 1)	Illusion–of–control task	No control	–	Rate control estimations from 0 ("*no control*") to 100 ("*complete control*").
Reuven–Magril et al.[14] (study 2)	Illusion–of–control task	No control	–	Rate control estimations from 0 ("*no control*") to 100 ("*complete control*").
Takashima et al.[68]	Button pressing task	Full control	Expression of the late Bereitschaftspotential (EEG) during the execution of self–paced movements.	–
Vaghi et al.[69]	Contingency degradation experimental manipulation	No control	–	Causality judgment.
Zhang et al.[70]	False biofeedback paradigm	No control	Subjective assessments of muscle tension were measured with a 100–mm visual analog scale, which was anchored with "*my muscle feels really intense*" at the minimum state end and "*my muscle feels completely loose*" at the maximum state end.	–

Note. The minus sign (–) represents data that were not available in the paper.

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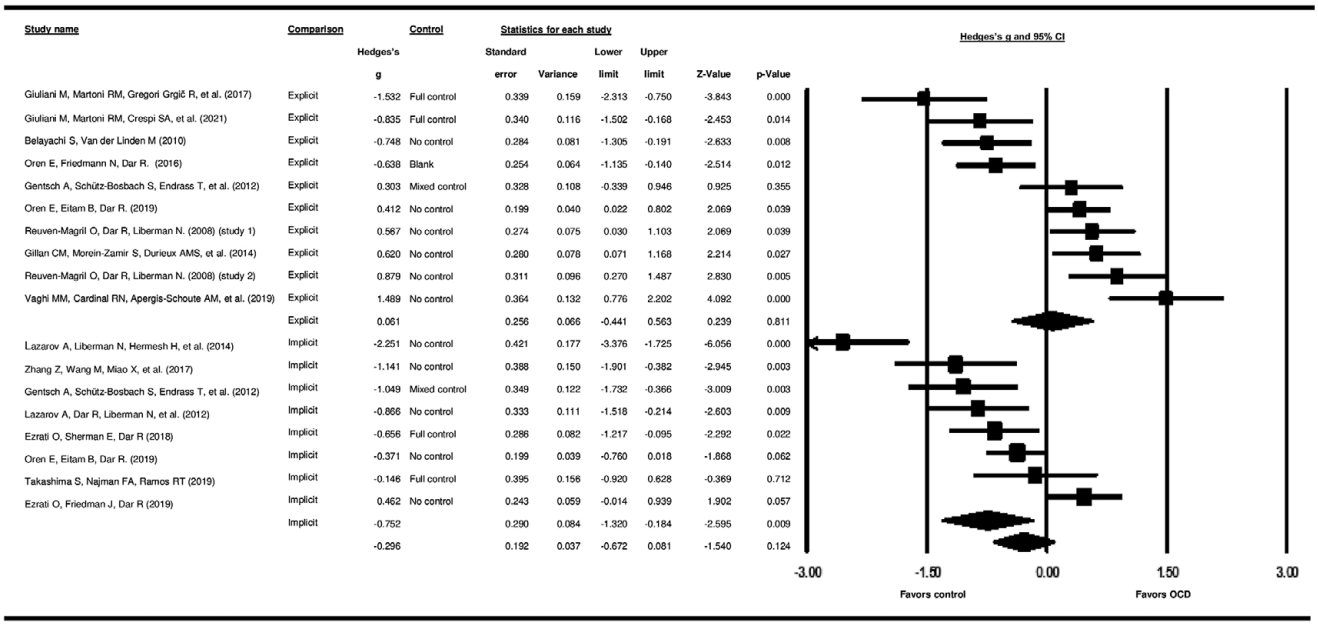

Figure 2. Effect sizes forest plot. Forest plot depicting effect sizes for explicit and implicit measures of the sense of agency. *Note*: Negative values of Hedges' g indicate lower scores of OCD participants as compared to control participants.

used the intentional binding task,[39] three studies used a false biofeedback paradigm (ie, participants were asked to evaluate their own muscle tension after viewing preprogrammed false feedback showing either increasing or decreasing levels of muscle tension),[45,67,70] one study used a computerized hand-reaching task (ie, participants were asked to perform accurate hand reaches without visual feedback in two separate sessions of a computerized hand-reaching task, once after valid feedback training of their hand location and once with false-rotated feedback),[63] one study used a head repositioning accuracy task (ie, participants were asked to reposition their head to a target angle that was acquired actively or passively and this performance; accuracy of repositioning was measured with a cervical range-of-motion device),[62] and one study used a spontaneous button presses under different levels of volitional experience (ie, they examined electroencephalographic correlates of automatic and volitional brain processes involved in the genesis of spontaneous movements).[68]

Considering the explicit measures, six studies[14,38,39,61,64,69] directly asked participants about their judgments of control or agency regarding a specific task (eg, asking to what degree they think their action brought about an effect), and one study[42] assessed control or agency judgments in non-context-specific situations (eg, asking to what degree they feel responsible for everything that results from their actions). In two studies,[65,66] judgments of control or agency were established using the ratio between the number of correct responses (ie, being the author of a beep) and the number of trials in a specific task condition, during which the origin of the beep was related to motor actions.

The forest plot (Figure 2) summarizes the main results of the meta-analysis. Implicit measures of SoA were lower in individuals with OCD or with high levels of OCD symptoms than in healthy control participants or with low levels of OCD symptoms, $Z = 2.697$, $p = .007$. In contrast, the corresponding effect with regard to explicit measures was not statistically significant, $Z = 0.239$, $p = .831$. The Q-statistic testing of the difference between these two effect sizes was statistically significant, $Q(1) = 4.421$, $p = .035$.

In a follow-up analysis, we examined whether the differences between individuals with OCD or with high levels of OCD symptoms and healthy control participants or with low levels of OCD symptoms in explicit reports of the SoA could be mediated by the actual level of control participants had in the experimental paradigm. We found that in the two studies in which participants had full control over the outcomes,[65,66] individuals with OCD or with high levels of OCD symptoms reported lower SoA than healthy control participants or with low scores of OCD symptoms, $Z = -4.361$, $p < .001$. Conversely, in the six studies in which participants had no control over the outcomes,[14,39,64,69] individuals with OCD or with high levels of OCD symptoms reported higher SoA than healthy control participants or with low levels of OCD symptoms, $Z = 4.089$, $p < .001$. The difference between these two effects was statistically significant, $Q(1) = 9.344$, $p = .002$. The results related to implicit measures of the SoA[38,39,44,62,63,67,68,70] were not affected by the level of actual control over the outcomes, $Q(1) = 0.312$, $p = .577$.

3.1 Publication bias (small study effect)

A funnel plot (ie, plotting effect sizes by SE of the studies) did not suggest over-presence of small studies with large effects (which might have indicated a publication bias) and the one-tailed Egger test was not statistically significant, $t(16)$ - = 1.636, $p = .061$.

4. Discussion

The present study aimed at investigating the sense of control in OCD phenomenology through the construct of the SoA. A specific objective of our meta-analysis was to examine a possible discrepancy between the actual and perceived sense of control over one's actions in people with OCD or presenting high levels of OCD symptoms, through the investigation of the implicit and explicit measures of the SoA.

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Our results show that implicit measures of SoA (ie, inferred from correlates and outcomes of voluntary actions) were lower in individuals with OCD or with high levels of OCD symptoms than in healthy controls or in individuals with low levels of OCD symptoms. These results are consistent with our expectations and hint at a deficiency in the process of perceiving oneself as the agent of one's actions. As this process depends on a complex integration of external and internal cues of proprioception, movement, and interoception,[76,77] our findings may suggest that in individuals with OCD or with high levels of OCD symptoms, there is a disruption at this level. This idea is supported by increasing evidence that people with OCD have difficulty in accessing their own internal states, such as interoceptive/proprioceptive signals,[45,62,63] as well as in the integration of sensory-motor cues.[78,79] These findings may indicate a perturbation in the comparator model of motor control described in the introduction,[24] which disrupts the "feeling of doing" along the intention–action–effect chain in individuals with OCD,[61] leading to the emergence of sensory phenomena (eg, "feeling of incompleteness" or "not just-right experience"). Consistent with this hypothesis, Szalai[18] and Malik et al.[32] suggested that the hyperactivity of fronto-striatal circuits exhibited by subjects with OCD[80,81] may lead to errors in sensory prediction and aberrant motor experiences. In a similar vein, it has been argued that OCD is the result of an individual history of persistent inaccurate sensory predictions.[52,53]

Our results show that explicit levels of SoA in individuals with OCD or with high levels of OCD symptoms are mediated by the actual level of control they had in the experimental paradigm. In fact, in situations in which participants had full control over the outcomes,[65,66] individuals with OCD or with high levels of OCD symptoms reported lower SoA than healthy controls or individuals with low levels of OCD symptoms. Conversely, in situations in which participants had no control over the outcomes,[14,39,64,69] individuals with OCD or with high levels of OCD symptoms reported higher SoA than healthy controls or individuals with low levels of OCD symptoms. Three main explanations may be suggested. First, as proposed by Reuven-Magril et al. and Oren et al.,[14,39] one way to explain this discrepancy is that a lower feeling of agency together with a high need for control may increase motivation for control, even if illusory. In accordance with this hypothesis, Reuven et al.[14] found an association in individuals with OCD between illusion of control and more repetitive control attempts. This relationship is consistent with the evidence that compulsive behavior, which is characterized by inflated repetition of acts and with a high prevalence of superfluous or nonfunctional acts,[57] plays a compensative role in regaining a subjective perception of controllability.[55,56,82] The increased perception of control may arise from the fact that in compulsive behavior, the focus of attention is directed to the low-level features of the motor action flow, thus enhancing cognitive control.[12] We suggest that the sensory experience of performing repetitive acts, along with the cognitive monitoring necessary to carry them out, may lead to an inflated sense of control compared to what is really afforded by the situation. Another possible explanation, not mutually exclusive, concerns the Seeking Proxies for Internal States (SPIS) model of OCD.[67,83] According to this model, OCD is related to a diminished access to internal states. Assuming that the SoA is an internal state, the SPIS model would predict that people with OCD or with high levels of OCD symptoms would have a diminished perception of their SoA. If so, we would expect that their judgments of agency would regress toward the mean, as would be the case for any judgments based on "noisy" signals. This would mean that the judgment of agency would be overly high in situations of zero or low control and too low in situations of high or complete control, as confirmed by the pattern of findings in the current meta-analysis. Finally, as argued by Buehner et al.[36,84] the distinction between SoA and causality in agency measures is controversial (eg, in the intentional binding task, the intentional binding effect can be substantially related to the experience of causal relationship between action and effect). Consistent with this hypothesis, a causal view of SoA has recently been proposed, according to which the SoA would represent the awareness of causing effects through actions rather than the awareness of performing goal-directed actions.[85] Thus, the crucial point is not the congruency of the movement goal with the actual outcome, but the subject's representation that a movement causes an outcome. Consistent with this suggestion, in our study, we found that individuals with OCD or with high levels of OCD symptoms showed a greater sense of control in situations in which they actually had no control over the outcome and a lesser sense of control in situations in which they actually did have control. According to the hypothesis described above, an aberrant awareness of causing effect through actions might have led them to underestimate or overestimate the effect of their actions in the real world. Since explicit self-attributions are also influenced by a combination of predictive and inferential processes and by individual differences related to cognitive capacities,[31] we speculate that the discrepancy in the judgment of causality may reflect maladaptive appraisals and dysfunctional metacognitive beliefs (ie, an inflated sense of responsibility, overestimation of threat, and inferential confusion),[86] which may play a part in OCD phenomenology.

Several limitations should be considered. First, the present results should be viewed with caution due to the small number of studies included, particularly in the follow-up analysis where we compared the effect of the actual level of control on explicit SoA measures. Particularly, in this domain, our results should be considered exploratory and tentative. Second, all the studies in the analysis were cross-sectional; therefore, they do not allow to draw firm conclusions with regard to the complex processes underlying the SoA, which may change over time or be phase-dependent. Third, our meta-analyses included only studies with adult populations; it would be interesting to confirm these results also in childhood and adolescence and to examine their longitudinal stability. Fourth, many of the studies consisted of nonclinical samples. Even though the validity of "analog" samples of high and low scorers on measures of OCD is high,[87] our results may not be completely representative of the experience of agency in OCD. Fifth, the current meta-analyses did not examine the influence of past or current psychotherapeutic, medical, or psychosocial interventions (these data were not reported in the original studies, and in any case, there were too few studies with clinical OCD to allow for such analyses). Similarly, we could not examine the effects of comorbid diagnoses or the duration of untreated illness. Sixth, we could not investigate the relationship between the SoA and clinical features of OCD, such as symptom severity, symptom dimensions, cognitive beliefs, and insight. Given the clinical heterogeneity of OCD, one may speculate that a disruption in SoA at different levels may be related to the developmental pathways of different OCD phenotypes. Finally, as stated in the introduction, the literature on implicit SoA measures does not provide a consistent picture. In fact, the two main implicit measures commonly used to evaluate the pre-reflective SoA (ie, temporal binding and sensory attenuation) were found to be uncorrelated[31] and to be influenced by high-level contextual information,[33] prior beliefs about the causal link between an action and a sensory change in the environment,[34] affective states,[35] conceptual beliefs,[36] and action selection processes.[37] Relatedly, it has been argued that

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reports elicited using implicit SoA measures might also be judgment effects rather than perceptual effects.[88,89] Hence, some measures that we considered implicit may not represent the perceptual differences between self-generated and externally generated action effects, but rather represent an intrinsic difficulty in accessing internal cues.[67,83]

Despite the above limitations, the present study may have significant clinical implications. Our results underscore the dissociation between the actual and the perceived control of one's action in individuals with OCD or with high levels of OCD symptoms, which may underlie several clinical manifestations (eg, sensory phenomena) of OCD. We might speculate that correcting the processes involved in this illusory sense of control may help people with OCD in achieving more accurate levels of self-efficacy, reducing the urge to perform compulsive rituals, and attenuating the inflated sense of responsibility for events that have no real causal connection to them.[14]

In conclusion, our results suggest that people with OCD or with high levels of OCD symptoms are characterized with a distortion in the process of perceiving their control over their actions and tend to overestimate their judgments of control in situations where they do not actually have it. Together, these findings support the hypothesized dissociation between actual and perceived control over actions in OCD.

Author contribution. Davide Fausto Borrelli and Reuven Dar conceived the idea and collected the data. Davide Fausto Borrelli and Reuven Dar conducted the statistical analyses and the literature searches and wrote the first manuscript. Matteo Tonna and Reuven Dar supervised the study and edited the manuscript. All authors contributed to the article and approved the submitted version.

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