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Effectiveness of Repetitive Transcranial Magnetic Stimulation (rTMS) on Emotion Regulation and Doubt in Adults with Obsessive–Compulsive Disorder

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ABSTRACT

Objective: This quasi-experimental study evaluated the effectiveness of repetitive transcranial magnetic stimulation (rTMS) on emotion regulation and pathological doubt in adults with obsessive–compulsive disorder (OCD).

Methods and Materials: Using a pretest–posttest control group design, 15 clients with a diagnosis of OCD who were referred to Norali Clinic in Tehran in the second half of 2024 were selected through convenience–purposive sampling and randomly assigned to experimental and control groups. All participants completed the Maudsley Obsessive–Compulsive Inventory and the Emotion Regulation Questionnaire at baseline. The experimental group then received 16 sessions of high-frequency rTMS over the dorsolateral prefrontal cortex in addition to routine care, while the control group received routine care only. After the intervention, both groups completed the posttest measures. Data were analyzed using descriptive indices, the Kolmogorov–Smirnov test, and multivariate analysis of covariance (MANCOVA).

Findings: Compared with the control group, the experimental group showed a significant increase in emotion regulation strategies and a significant reduction in pathological doubt and obsessive–compulsive symptoms ($p < 0.05$). Changes were consistent with neurobehavioral and neurobiological models that link prefrontal modulation to improved cognitive control over intrusive thoughts and compulsive urges.

Conclusion: The findings suggest that rTMS targeting the prefrontal cortex can be an effective adjunctive treatment for improving emotion regulation and reducing doubt-related symptoms in individuals with OCD. Further studies with larger samples, sham-controlled designs, and follow-up assessments are recommended to consolidate evidence for the clinical use of rTMS in OCD.

Keywords: repetitive transcranial magnetic stimulation, obsessive–compulsive disorder, emotion regulation, doubt, prefrontal cortex.

Introduction

Obsessive-compulsive disorder (OCD) is a debilitating anxiety disorder characterized by recurrent obsessions and/or compulsions that cause marked distress, are time-consuming, and significantly interfere with the individual's normal life or relationships. A person with OCD may experience obsessions only, compulsions only, or both (Bandyopadhyay Prasanta et al., 2014). OCD is defined by intrusive obsessive thoughts, urges, or images and/or by a compulsion to perform certain acts or both; (Stein et al., 2019). Obsessions refer to thoughts, mental images, or sudden urges to do or say something that distress the person and recur persistently. Compulsions are behaviors the person feels compelled to repeat to reduce anxiety or prevent a feared event. Many people with OCD experience both distressing thoughts and repetitive behaviors. Neuropsychological research indicates that individuals with OCD often show poorer performance on executive functions (Stein et al., 2019).

In the 1940s, OCD was referred to as a "doubt disorder." A person with OCD may doubt even the most basic facts about themselves, others, or the world they live in. Such doubt can stem from unconscious factors; for example, a sense of inner insecurity may generate doubts in one's external life (Hirschtritt et al., 2017). People with OCD may even question their gender, sanity, the possibility of becoming a killer, and other matters. This doubt can overpower even very intelligent individuals because its roots lie in internal brain mechanisms outside the person's control. Such doubt drives the person to check things repeatedly or to constantly question themselves and others (Drubach, 2015).

Research evidence also shows that difficulties in regulating emotions—such as anger and anxiety—play a role in the emergence of problems. The ability to manage one's emotions is termed emotion regulation. Gross proposes that emotion regulation refers to processes that influence emotions, emotional experiences, and their expression, helping individuals develop awareness and acceptance of emotions, control impulsive behaviors, and act in ways that serve personal and situational goals (Gross & John, 2003). One of the most comprehensive cognitive models of emotion regulation is Gross & John, (2003) process model. Before an

emotion is fully experienced, emotional cues are appraised; these cues can be evaluated along various dimensions, and following this appraisal, different physiological, behavioral, and experiential responses may be elicited (Gross & John, 2003).

Emotion regulation is an antecedent process and is regarded as a primary self-care strategy (Mayer et al., 2001). It encompasses conscious and unconscious strategies aimed at maintaining, increasing, or decreasing the emotional, behavioral, and cognitive components of an emotional response (Gross, 2001). Reappraisal and suppression are among the most studied strategies (Gresham & Gullone, 2012). Cognitive reappraisal involves changing the meaning of a situation and thereby altering its emotional impact; by contrast, suppression is a form of response modulation that entails the sustained inhibition of behavior (Gross, 2001). Such inhibition or avoidance of psychological experiences—including thoughts, emotions, sensations, memories, and urges—can have various negative consequences (Kashdan et al., 2006). Emotion regulation affects how people adapt to stressful life events (Pellitteri), and successful regulation plays an important role in adaptation and well-being (Wang et al., 2015).

Some studies have shown, in a subset of patients with OCD, increased alpha activity across many brain regions—especially temporal, parietal, and occipital areas—consistent with findings by Kuskowski et al., (1993), as well as frontal involvement accompanied by moderate beta increases in posterior temporal regions (Hammond, 2003). If electroencephalographic indices could be altered, treatment outcomes might improve; this may be achievable with transcranial magnetic stimulation (TMS) (Galhardoni et al., 2015). TMS is a safe, noninvasive method that affects cortical activity in the targeted area by delivering magnetic pulses, producing changes in glucose metabolism and neurotransmitter activity within that region (Dionisio et al., 2018). In this technique, a strong electric current passes through a coil placed on the scalp, generating magnetic fields that induce weaker electric currents in the cerebral cortex and thereby evoke action potentials in the stimulated neural tissue (Lefaucheur, 2019). Studies in healthy individuals indicate that high-frequency rTMS over the dorsolateral prefrontal cortex (DLPFC) alters glutamatergic neuronal activity; glutamate changes are

not confined to the stimulation site, with increases also observed in the right DLPFC and left cingulate cortex (Fisicaro et al., 2019). Changes in glutamate levels depend on baseline concentrations: participants with lower baseline glutamatergic levels show increases after rTMS. Stimulating a node within a brain network using rTMS can modify the functioning of that network and even other networks (Klomjai et al., 2015). Recent neuroimaging studies further demonstrate reduced activity in the reward circuit—particularly in regions such as the nucleus accumbens and the anterior cingulate cortex (ACC)—in patients with OCD (Zijlstra et al., 2009).

The use of brain stimulation in treating mood and psychiatric disorders is a relatively new area of research (Vicario & Nitsche, 2013), and there are very few studies in this context, especially in Iran. In light of the foregoing, the present study seeks to answer whether rTMS of the prefrontal cortex is effective for cognitive functions, self-regulation, and doubt in individuals with OCD.

Methods and Materials

Design and Participants

This applied study used a quasi-experimental pretest–posttest control-group design. The study population comprised individuals with obsessive-compulsive disorder (OCD) who visited psychology and counseling clinics in Tehran during the second half of 2024. Sampling was convenience- and purposive-based at the Norali Clinic, and the required sample size for this investigation was calculated to be 15 participants.

Inclusion criteria were: a psychiatrist's diagnosis of OCD for at least six months, and no engagement in psychotherapeutic programs or changes to pharmacotherapy outside the study's educational/therapeutic intervention during the trial. Exclusion criteria were: unwillingness to continue participation, absence from more than two treatment sessions, and lack of an OCD diagnosis.

Instruments

Maudsley Obsessive–Compulsive Inventory (MOCI)

Developed by Hodgson & Rachman (1977) to investigate the type and scope of obsessive-compulsive problems, the MOCI contains 30 true/false items (half keyed “true,” half “false”). In its initial validation at the Maudsley Hospital, it effectively distinguished 50 OCD

patients from 50 neurotic controls. In addition to a total obsessiveness score, it yields four subscales: checking, washing/cleaning, slowness–repetition, and doubt–conscientiousness. The questionnaire is designed so that a highly obsessive individual answers “yes” to exactly half the items and “no” to the other half. Total scores range from 0 to 30. Reliability and validity have been confirmed across clinical samples in various countries; for example, Sanavio reported a correlation of .70 between MOCI total scores and the Padua Inventory, and test–retest reliability has been reported as high ($r = .89$) (Rachman & Hodgson, 1980). In Iran, Dadfar et al. (2020) reported a test–retest reliability of .85, and reported an overall reliability of .84 and convergent validity of .87 with the Yale–Brown Obsessive–Compulsive Scale. In a study with 40 patients, Hodgson & Rachman (1977) showed that the MOCI total score is sensitive to treatment change. Overall, the MOCI is considered a suitable tool for clinicians and researchers to assess treatment outcomes and to examine the etiology, course, and prognosis of different obsessive-compulsive complaints (Emmelkamp et al., 1985).

Emotion Regulation Questionnaire (ERQ)

Developed by Gross & John (2003), this scale assesses two emotion-regulation strategies: cognitive reappraisal and expressive suppression as cited in (Tashk et al., 2011). The ERQ has 10 items: items 1, 3, 5, 7, 8, and 10 measure reappraisal, and items 2, 4, 6, and 9 measure suppression. Items are rated on a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree). Gross & John (2003) reported Cronbach's alpha coefficients of .79 for reappraisal and .73 for suppression. In Iran, Tashk et al. (2011) confirmed construct validity in a two-factor structure and reported Cronbach's alphas of .87 (reappraisal) and .90 (suppression).

Procedure

First, a pretest was administered to both the experimental and control groups. The experimental group then received 16 sessions of rTMS treatment, while the control group received no intervention during this period. After completion of the experimental sessions, a posttest was administered to both groups. Findings were compared and summarized using analysis of covariance with the pretest as a covariate.

Data Analysis

Data were analyzed using descriptive and inferential statistics. To assess normality, the Kolmogorov–Smirnov

(K-S) test was applied. When normality was met, descriptive indices (tables, charts, means, standard deviations, etc.) were reported, and hypotheses were tested using multivariate analysis of covariance (MANCOVA). Because the study design could be vulnerable to threats to internal validity, covariance

analysis was used to control for these potential confounders.

Findings and Results

Among participants in the study, 15 were assigned to the control group and 15 to the experimental group.

Table 1

Descriptive statistics for self-regulation and doubt at pretest and posttest by group

Group	Variable	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Control	Reappraisal	18.40	3.098	18.92	3.207
	Suppression	12.53	3.739	12.73	3.223
	Self-regulation (total)	30.93	5.300	31.65	5.137
	Doubt	4.50	1.427	4.97	1.260
Experimental	Reappraisal	19.93	3.039	22.75	3.342
	Suppression	12.67	3.716	15.41	4.348
	Self-regulation (total)	32.60	5.345	38.16	5.189
	Doubt	5.07	1.568	2.93	1.147

To examine the effectiveness of prefrontal rTMS on self-regulation in individuals with OCD, a multivariate analysis of covariance (MANCOVA) was conducted. Box's M test yielded a significance level of 0.518. Because this value exceeds the 0.05 threshold, the null hypothesis of

equal covariance matrices was supported. Kolmogorov-Smirnov tests indicated that pretest and posttest score distributions were normal for all variables (all $p > .05$). Levene's tests were nonsignificant for all variables, supporting the assumption of homogeneity of variances.

Table 2

Multivariate analysis of covariance comparing self-regulation between experimental and control groups

Effect	Test	Value	F	df Effect	df Error	p	Effect size
Group	Pillai's Trace	0.452	10.313	2	25	0.001	0.452
	Wilks' Lambda	0.548	10.313	2	25	0.001	0.452
	Hotelling's Trace	0.825	10.313	2	25	0.001	0.452
	Roy's Largest Root	0.825	10.313	2	25	0.001	0.452

For all four multivariate statistics (Pillai's, Wilks' λ , Hotelling's Trace, and Roy's Largest Root), the significance level was less than .01 ($p < .01$). Thus, the null hypothesis was rejected, indicating a significant posttest difference in self-regulation between the

experimental and control groups. Accordingly, prefrontal rTMS was effective for self-regulation. To assess group differences on each self-regulation component, between-subjects effects were tested; results are presented in Table 3.

Table 3

Between-subjects effects comparing self-regulation components at posttest

Variable	Source	SS	df	MS	F	p	Effect size
Reappraisal	Between groups	51.070	1	51.070	8.289	0.008	0.242
	Error	160.185	26	6.161			
Suppression	Between groups	39.678	1	39.678	11.353	0.002	0.304
	Error	90.865	26	3.495			

As shown, F values for both self-regulation components were significant at the .01 level ($p < .01$).

Therefore, the null hypothesis was rejected and the research hypothesis supported. Given the higher

posttest means in the experimental group relative to the control group, prefrontal rTMS was effective and increased self-regulation among individuals with OCD.

Table 4

Analysis of covariance comparing doubt between experimental and control groups

Source of variation	SS	df	MS	F	p	Effect size
Pretest	0.149	1	0.149	0.100	0.755	0.004
Group	30.682	1	30.682	20.446	0.001	0.431
Error	40.517	27	1.501			
Total	71.675	29				

As shown in Table 4, the obtained F value for group was 20.446 with $p < .01$, leading to rejection of the null hypothesis and support for the research hypothesis. Based on the lower posttest mean in the experimental group, prefrontal rTMS was effective and reduced doubt in individuals with OCD.

Discussion and Conclusion

The findings of the present study showed that rTMS applied to the prefrontal cortex led to significant improvements in self-regulation and emotion regulation among individuals with obsessive-compulsive disorder. These results align with studies by [Semnani et al., \(2025\)](#) and more recent work by [Wang et al., \(2025\)](#) and [Brewer et al., \(2022\)](#), which reported post-stimulation improvements in facets of memory, alertness, and brain activity.

Conversely, the study by [Hamid et al., \(2025\)](#)—although focused on changes in inner speech and working memory—differs somewhat in its emphasis on self-regulation. In addition, the work of [Stein et al., \(2019\)](#), which highlighted the role of neurofeedback in reducing obsessive-compulsive symptoms, underscores different points related to multimodal interventions and the use of multiple approaches. Ultimately, the present study's conclusions are clearly in line with prior literature while simultaneously emphasizing the individual's neurophysiological features.

From a cognitive-neuroscience standpoint, the prefrontal cortex is recognized as a key hub for emotion regulation and executive control. Contemporary theories posit that optimal functioning in this area requires precise integration and coordination among neural networks, including circuits involved in affective response, memory, and decision-making. By delivering

alternating magnetic pulses to the prefrontal cortex, repetitive transcranial magnetic stimulation (rTMS) may modulate synaptic activity and enhance neural plasticity, thereby adjusting the electrophysiological patterns of this region. Such changes can improve network coordination and, in turn, enhance cognitive functioning and emotion regulation in patients. In this regard, the present findings are fully consistent with theories on the role of neuromodulation in improving neural self-regulation. A closer look at the data also indicates that the posttest reduction in doubt in the experimental group depends on several neurophysiological and functional aspects. Prior research has shown that directly stimulating the prefrontal cortex can modify brain oscillatory patterns and improve coordination among brain regions, concurrently reducing symptoms of disorders such as OCD and improving working memory. For example, [Semnani et al., \(2025\)](#) found that rTMS had a more significant effect on symptom reduction than pharmacotherapy. Furthermore, [Rang Wang et al., \(2025\)](#) reported improvements in working memory and alertness in older adults—changes plausibly arising from optimization of prefrontal function. [Brewer et al., \(2022\)](#) also observed increased brain activity following repeated stimulation, reflecting the positive impact of this intervention on cognitive performance.

The study by [Hamid et al., \(2025\)](#), centered on decreasing inner speech and increasing working memory, reported positive psychological effects but primarily examined cognitive processes, whereas the current study focused on self-regulation and emotion regulation. Meanwhile, [Stein et al., \(2019\)](#) proposed neurofeedback as a complementary method for improving obsessive-compulsive symptoms; this suggests that combining diverse therapeutic approaches

may yield additive benefits when using neural interventions such as rTMS. In addition, findings by [Khan et al., \(2024\)](#) on sustained low-frequency oscillatory activity in the frontal cortex may indicate heightened sensitivity of this region to neural interventions, potentially enhancing emotion-regulatory capacity.

In sum, rTMS targeting the prefrontal cortex is not only statistically significant in its effects but, from both theoretical and practical perspectives, represents a modern and effective method for improving self-regulation in individuals with OCD. These results underscore the importance of neurophysiological changes and improved coordination of neural networks, demonstrating that targeted interventions can directly modulate cognitive and affective processes. The alignment of the present findings with prior studies (e.g., [Semnani et al., 2025](#)) is evident. Emphasizing the neuroscientific foundations and emotion-regulation models clarifies the effective role of rTMS in modulating prefrontal function, and these findings can serve as a robust scientific basis for developing and refining neuromodulation-based treatments.

In this study, the posttest mean scores for doubt in the rTMS group were significantly lower than in the control group. This empirical result, which reflects a reduction in doubt associated with adjustments in neurophysiological functioning of the prefrontal cortex, can be explained within neurobehavioral frameworks and neurobiological models. In other words, the observable decrease in doubt following rTMS indicates concurrent improvements in executive functioning and more precise regulation of neural networks in regions implicated in information processing and decision-making ([Breda & Freire, 2024](#); [Rachman, 2002](#));. While consistent with prior research—such as [Khan et al., \(2024\)](#) and [Semnani et al., \(2025\)](#) on the positive effects of rTMS—these results also complement studies like [Hamid et al., \(2025\)](#) and [Stein et al., \(2019\)](#), which emphasize the importance of stimulation parameters and target site in neural change, thereby highlighting the multilayered impact of this intervention on the nervous system. Moreover, recent studies (e.g., [Brewer et al., 2022](#); [Khan et al., 2024](#); [Wang et al., 2025](#)) point to improvements in memory and attention following similar interventions; thus, the observed reduction in doubt may be part of a broader structural shift in the

coordination of brain networks that ultimately enhances cognitive performance.

From neurobiological perspectives, modulation of prefrontal neuronal activity after rTMS can be conceptualized as a regulatory mechanism within the nervous system. Optimal functioning of this region in information processing and deliberate decision-making plays a central role in inhibiting illogical responses and reducing doubt ([Breda & Freire, 2024](#)). Magnetic stimulation can, by increasing plasticity and reconfiguring synaptic connections, improve the balance between excitatory and inhibitory pathways—a phenomenon framed in functional models as a tool for calibrating cognitive responses ([Rachman, 2002](#)). Furthermore, precise tuning of neural patterns in the prefrontal cortex may reduce anxiety and enhance supervisory capacities—effects observed in studies such as ([Semnani et al., 2025](#) and [Brewer et al., 2022](#)). In line with this, the present findings suggest that reduced doubt reflects modulation of brain networks achieved through targeted stimulation and corresponds to structural and functional changes within the brain.

The effects of rTMS on doubt can be interpreted not only neurophysiologically but also through neurobehavioral theories. On one hand, neurobehavioral models propose that OCD-related disturbances arise from impaired synchronization between prefrontal activity and subcortical structures such as the limbic system and basal ganglia, a deficit that increases doubt and disrupts decision-making ([Naghavi et al., 2025](#)). On the other hand, parameters such as intensity, frequency, and coil orientation can substantially influence therapeutic effectiveness. International findings—such as those presented by ([Breda & Freire, 2024](#) and [Rachman, 2002](#))—also emphasize the importance of precise neural-network tuning for cognitive improvement. Recognizing the prefrontal cortex as a pivotal hub for information processing and executive decision-making offers a scientific basis for explaining the positive effects of rTMS, which emerge through modulation of synaptic connectivity and improved neuronal coordination.

Overall, the present study indicates that rTMS, as a noninvasive therapeutic method, contributes meaningfully to enhancing executive functioning and reducing doubt in individuals with OCD. The concordance of these results with existing theoretical

and empirical evidence—such as (Semnani et al., 2025; Naghavi et al., 2025), and contemporary international research (Breda & Freire, 2024; Rachman, 2002)—provides a strong foundation for developing more precise explanatory models. Simultaneously, the findings highlight the importance of improved synchronization of neural activity in regulating cognitive responses and fostering positive structural and functional brain changes. In other words, the observed reduction in doubt reflects a substantive shift in neural patterns and network coordination that can inform the design of optimized therapeutic protocols in psychiatric disorders.

Using a sample of 30 participants and recruiting via convenience sampling limits generalizability and statistical power. The lack of strict control over factors such as symptom severity, medication changes, and prior treatment history increases potential confounds when interpreting rTMS effectiveness. Restricting the sample to clients of Tehran clinics in the second half of 1403 may have introduced geographic and temporal constraints that limit generalization to other regions and periods. Outcomes were assessed only in the short term; thus, no information is available on the durability of rTMS effects. Future studies should incorporate long-term follow-up designs to examine maintenance of therapeutic gains and to determine appropriate intervals for booster sessions. Employing controlled study designs with reference groups and managing potential confounders (e.g., pharmacotherapy, symptom severity, treatment history) will enable a more precise appraisal of rTMS effects. Subsequent research could also investigate rTMS in combination with other treatments (e.g., pharmacological and psychological therapies) to more comprehensively understand its adjunctive role in improving OCD. Given the observed effectiveness in enhancing self-regulation, it is recommended that rTMS be considered as a complementary or alternative method in clinical settings.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contribute to this study.

References

- Bandyopadhyay Prasanta, S., Forster Malcolm, R., Oxford, E., Barkow Jerome, H., Leda, C., John, T., William, B., Richardson Robert, C., Beck Aaron, T., & John, R. A. (2014). American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders: Dsm-5, Washington, DC, American Psychiatric Publishing, 2013. Ananth Mahesh, In defense of an evolutionary concept of health nature, norms, and human biology, Aldershot, England, Ashgate. *Philosophy*, 39(6), 683-724. <https://doi.org/10.3390/life15030394>
- Breda, V., & Freire, R. (2024). Repetitive transcranial magnetic stimulation (rTMS) in major depression. *Recent Advances and Challenges in the Treatment of Major Depressive Disorder*, 145-159. https://doi.org/10.1007/978-981-97-4402-2_8
- Brewer, G., Centifanti, L., Caicedo, J. C., Huxley, G., Peddie, C., Stratton, K., & Lyons, M. (2022). Experiences of mental distress during COVID-19: Thematic analysis of discussion forum posts for anxiety, depression, and obsessive-compulsive disorder. *Illness, Crisis & Loss*, 30(4), 795-811. <https://doi.org/10.1177/10541373211023951>
- Dadfar, M., Abdel-Khalek, A. M., & Lester, D. (2020). The revised arabic scale of obsession-compulsion (ASOC): Validation with Iranian psychiatric outpatients. *Mental health, religion & culture*, 23(3-4), 274-288. <https://doi.org/10.1080/13674676.2020.1721448>
- Dionisio, A., Duarte, I. C., Patricio, M., & Castelo-Branco, M. (2018). The use of repetitive transcranial magnetic stimulation for stroke rehabilitation: a systematic review. *Journal of stroke and cerebrovascular diseases*, 27(1), 1-31. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2017.09.008>
- Drubach, D. A. (2015). Obsessive-compulsive disorder. *CONTINUUM: Lifelong Learning in Neurology*, 21(3), 783-788. <https://doi.org/10.1212/01.CON.0000466666.12779.07>

- Emmelkamp, P., Hoekstra, R., & Visser, S. (1985). The behavioral treatment of obsessive-compulsive disorder: Prediction of outcome at 3.5 years follow-up. In *Psychiatry the State of the Art: Volume 4 Psychotherapy and Psychosomatic Medicine* (pp. 265-270). Springer. https://doi.org/10.1007/978-1-4684-4697-5_45
- Fiscarò, F., Lanza, G., Grasso, A. A., Pennisi, G., Bella, R., Paulus, W., & Pennisi, M. (2019). Repetitive transcranial magnetic stimulation in stroke rehabilitation: review of the current evidence and pitfalls. *Therapeutic advances in neurological disorders*, *12*, 1756286419878317. <https://doi.org/10.1177/1756286419878317>
- Galhardoni, R., Correia, G. S., Araujo, H., Yeng, L. T., Fernandes, D. T., Kaziyama, H. H., Marcolin, M. A., Bouhassira, D., Teixeira, M. J., & De Andrade, D. C. (2015). Repetitive transcranial magnetic stimulation in chronic pain: a review of the literature. *Archives of physical medicine and rehabilitation*, *96*(4), S156-S172. <https://doi.org/10.1016/j.apmr.2014.11.010>
- Gresham, D., & Gullone, E. (2012). Emotion regulation strategy use in children and adolescents: The explanatory roles of personality and attachment. *Personality and individual differences*, *52*(5), 616-621. <https://doi.org/10.1016/j.paid.2011.12.016>
- Gross, J. J. (2001). Emotion regulation in adulthood: Timing is everything. *Current directions in psychological science*, *10*(6), 214-219. <https://doi.org/10.1111/1467-8721.00152>
- Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of personality and social psychology*, *85*(2), 348. <https://doi.org/10.1037/0022-3514.85.2.348>
- Hamid, I., Suriati, S., & Amir, M. (2025). Enhancing self-regulated learning: the moderating role of social support in the relationship between authoritative parenting and student autonomy. *Jurnal Konseling dan Pendidikan*, *13*(1), 131-146. <https://doi.org/10.29210/1138200>
- Hammond, D. C. (2003). QEEG-guided neurofeedback in the treatment of obsessive compulsive disorder. *Journal of Neurotherapy*, *7*(2), 25-52. https://doi.org/10.1300/J184v07n02_03
- Hirschtritt, M. E., Bloch, M. H., & Mathews, C. A. (2017). Obsessive-compulsive disorder: advances in diagnosis and treatment. *Jama*, *317*(13), 1358-1367. <https://doi.org/10.1001/jama.2017.2200>
- Hodgson, R. J., & Rachman, S. (1977). Obsessional-compulsive complaints. *Behaviour research and therapy*, *15*(5), 389-395. [https://doi.org/10.1016/0005-7967\(77\)90042-0](https://doi.org/10.1016/0005-7967(77)90042-0)
- Kashdan, T. B., Barrios, V., Forsyth, J. P., & Steger, M. F. (2006). Experiential avoidance as a generalized psychological vulnerability: Comparisons with coping and emotion regulation strategies. *Behaviour research and therapy*, *44*(9), 1301-1320. <https://doi.org/10.1016/j.brat.2005.10.003>
- Khan, A. U., Irwin, Z., Mahavadi, A., Roller, A., Goodman, A. M., Guthrie, B. L., Visscher, K., Knight, R. T., Walker, H. C., & Bentley, J. N. (2024). Low-Frequency Oscillations in Mid-rostral Dorsolateral Prefrontal Cortex Support Response Inhibition. *Journal of Neuroscience*, *44*(40). <https://doi.org/10.1523/JNEUROSCI.0122-24.2024>
- Klomjai, W., Katz, R., & Lackmy-Vallée, A. (2015). Basic principles of transcranial magnetic stimulation (TMS) and repetitive TMS (rTMS). *Annals of physical and rehabilitation medicine*, *58*(4), 208-213. <https://doi.org/10.1016/j.rehab.2015.05.005>
- Kuskowski, M. A., Malone, S. M., Kim, S. W., Dysken, M. W., Okaya, A. J., & Christensen, K. J. (1993). Quantitative EEG in obsessive-compulsive disorder. *Biological psychiatry*, *33*(6), 423-430. [https://doi.org/10.1016/0006-3223\(93\)90170-1](https://doi.org/10.1016/0006-3223(93)90170-1)
- Lefaucheur, J.-P. (2019). Transcranial magnetic stimulation. *Handbook of clinical neurology*, *160*, 559-580. <https://doi.org/10.1016/B978-0-444-64032-1.00037-0>
- Mayer, E. A., Craske, M., & Naliboff, B. D. (2001). Depression, anxiety, and the gastrointestinal system. *Journal of clinical psychiatry*, *62*, 28-37. <https://www.psychiatrist.com/pdf/depression-anxiety-and-the-gastrointestinal-system-pdf/>
- Naghavi, A., Dadgar, H., Daraei, G., & Modarreszadeh, A. (2025). On the Effects of Non-Invasive Brain Stimulation Techniques on Developmental Dyslexia: A Systematic Review of Randomized Controlled Trials. *Iranian Journal of Psychiatry*, *20*(2), 209. <https://doi.org/10.18502/ijps.v20i2.18203>
- Pellitteri, J. S. An Aesthetic Approach to Emotions: The Development of the Aesthetic Descriptors of Emotion Measure (ADEM). Available at SSRN 4602618. <http://dx.doi.org/10.2139/ssrn.4602618>
- Rachman, S. (2002). A cognitive theory of compulsive checking. *Behaviour research and therapy*, *40*(6), 625-639. [https://doi.org/10.1016/S0005-7967\(01\)00028-6](https://doi.org/10.1016/S0005-7967(01)00028-6)
- Rachman, S., & Hodgson, R. J. (1980). Obsessions and compulsions. (*No Title*). <https://lccn.loc.gov/79018440>
- Semnani, Y., Badiezhadegan, M., & Harami, R. V. (2025). The frequency of minor physical abnormalities in patients with obsessive-compulsive disorders compared to other psychiatric disorders; a multi-center study. *Journal of Preventive Epidemiology*, *10*(1). <https://doi.org/10.34172/jpe.2025.38249>
- Stein, D. J., Costa, D. L., Lochner, C., Miguel, E. C., Reddy, Y. J., Shavitt, R. G., van den Heuvel, O. A., & Simpson, H. B. (2019). Obsessive-compulsive disorder. *Nature reviews Disease primers*, *5*(1), 52. <https://doi.org/10.1038/s41572-019-0102-3>
- Tashk, A., Helfroush, M. S., & Kazemi, K. (2011). A novel fingerprint matcher based on an ergodic 2-D Hidden Markov Model. *AEU-International Journal of Electronics and Communications*, *65*(9), 742-749. <https://doi.org/10.1016/j.aeue.2010.11.002>
- Vicario, C. M., & Nitsche, M. A. (2013). Non-invasive brain stimulation for the treatment of brain diseases in childhood and adolescence: state of the art, current limits and future challenges. *Frontiers in systems neuroscience*, *7*, 94. <https://doi.org/10.3389/fnsys.2013.00094>
- Wang, H.-n., Bai, Y.-h., Chen, Y.-c., Zhang, R.-g., Wang, H.-h., Zhang, Y.-h., Gan, J.-l., Peng, Z.-w., & Tan, Q.-r. (2015). Repetitive transcranial magnetic stimulation ameliorates anxiety-like behavior and impaired sensorimotor gating in a rat model of post-traumatic stress disorder. *PLoS One*, *10*(2), e0117189. <https://doi.org/10.1371/journal.pone.0117189>
- Wang, R., Zhang, K., Wang, Y., Brown, K., & Zhao, Y. (2025). "It's Mentally Painful to Stop": Design Opportunities in In-Situ Self-Management Technology for People with Obsessive-Compulsive Disorder. *arXiv preprint arXiv:2501.13308*. <https://doi.org/10.1145/3663547.3746394>
- Zijlstra, F., Veltman, D. J., Booij, J., van den Brink, W., & Franken, I. H. (2009). Neurobiological substrates of cue-elicited craving and anhedonia in recently abstinent opioid-dependent males. *Drug and alcohol dependence*, *99*(1-3), 183-192. <https://doi.org/10.1016/j.drugalcdep.2008.07.012>