



Placebo and nocebo effects on cognition: Mechanisms, mediators, and cognitive resource constraints

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ABSTRACT

Placebo and nocebo effects are well established in domains such as pain and motor performance; however, their impact on cognitive functioning remains a matter of debate. This narrative review provides a state of the art on placebo and nocebo research across different cognitive domains, identifies major methodological limitations and gaps in the literature, and proposes new hypotheses to guide future research. Given the limited number of studies and the heterogeneity in experimental paradigms, cognitive outcomes, and procedures, the available evidence supports only preliminary conclusions. Some studies suggest that reward-based learning and emotional processing may be susceptible to placebo and nocebo manipulations, whereas evidence concerning memory, attention, and working memory is limited and inconclusive. Building on this synthesis, we propose that factors such as outcome measures, task-specific features, and intervention type may modulate these effects. We also hypothesize that placebo/nocebo interventions, operating through implicit (e.g., conditioning) or explicit (e.g., verbal instructions) mechanisms, may influence cognitive performance differently depending on whether expectations target cognition directly or indirectly. These hypotheses remain to be tested using controlled and directly comparable experimental designs. By highlighting gaps in the literature, this review aims to stimulate future research establishing whether placebo and nocebo effects can be reliably elicited in specific cognitive functions and clarifying how and to what extent different procedures can influence them. These lines of research could have long-term translational implications, ultimately improving the effectiveness of neuropsychological interventions and cognitive training programs that leverage positive beliefs and mitigate negative expectations.

1. Introduction

The placebo effect is a psychobiological phenomenon whereby an inert intervention produces beneficial outcomes that cannot be attributed to its intrinsic properties, but rather to suggestions, beliefs, rituals, and contextual cues surrounding its administration (Colloca and Miller, 2011a). Its negative counterpart, the nocebo effect, refers to a worsening of symptoms or performance following an inert treatment, accompanied by negative verbal suggestions or cues of worsening (Colloca and Miller, 2011a). Both phenomena are driven by expectations (Kirsch, 2018; Benedetti, 2008; Colloca and Miller, 2011a, 2011b), learning processes (Colloca et al., 2008a; Colloca, 2014; Colloca and Miller, 2011a) and social influence (Colloca and Benedetti, 2009; Bajcar and Babel, 2025).

Although placebo and nocebo effects have been extensively documented across a wide range of domains, including clinical conditions, pain, and motor performance (Benedetti et al., 2003; Fiorio and Barbani, 2023; Burke et al., 2026), their role in cognition remains poorly understood. In this narrative review, we provide a comprehensive synthesis of the current evidence on placebo and nocebo effects in the cognitive domain. Specifically, we examine the cognitive functions investigated to date—including attention, memory, executive functions (working memory, cognitive control, and cognitive flexibility), reasoning, learning, reward-based learning, and emotional processing—as well as the experimental paradigms used to assess them. With this synthesis, we aim to map the existing evidence, highlighting methodological heterogeneity and the key gaps in the literature, thereby

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providing a foundation for future research on the topic.

Drawing on the conceptual and mechanistic overlap between placebo/nocebo phenomena and cognitive processes, we propose that their interaction may be more extensive than previously recognized. Within this hypothesis, we suggest that shared neuroanatomical circuits may contribute to cognitive performance through additive or competitive mechanisms, depending on the demands placed on common cognitive resources. We further hypothesize that placebo and nocebo interventions may influence cognition both directly, by enhancing or impairing specific cognitive functions, and indirectly, through psychological mediators such as motivation, affect, and task engagement. In addition, the manner in which expectations are induced, through explicit verbal suggestions, conditioning procedures, or their combination, may represent an important determinant of the magnitude and direction of these effects.

This narrative review has two main objectives: (1) to map the available evidence on placebo and nocebo effects in cognitive domains; (2) to propose new hypotheses to be tested in future studies. Investigating placebo and nocebo effects in cognition not only improves our understanding of how expectations can influence cognitive functioning but also has important translational implications. Specifically, across a wide range of clinical conditions, including cancer, cardiovascular disease, neurological diseases, psychiatric disorders, and chronic pain, cognitive difficulties may not only reflect underlying disease-related changes but may also be influenced by patients' expectations regarding their cognitive functioning, significantly impacting overall disease burden (Sinke et al., 2016; Burke et al., 2026). Negative beliefs about cognitive consequences or disease progression may therefore exacerbate patients' impairments, potentially creating a vicious cycle and negatively impacting performance. Supporting this possibility, Suhr and Gunstad (2002) demonstrated that patients with mild brain injury, who were led to believe that their condition was associated with cognitive impairment, performed worse on tests of memory and intellectual ability than patients who were not provided with such information. These findings confirm the impact of negative expectancies on cognitive difficulties and the need to develop new strategies that leverage positive expectancies to counteract or even reverse these detrimental effects. Therefore, this review highlights the need for further research into the mechanisms underlying the impact of expectancy on cognition, while also encouraging systematic studies of how different procedures influence the generation of these effects. Ultimately, this investigation could contribute to the development of more targeted and effective cognitive training interventions (Denkinger et al., 2021), improving the interpretation of neuropsychological assessments, and enhancing clinical interventions by leveraging positive expectancies while minimizing the negative impact of negative anticipatory beliefs.

2. Method

2.1. Literature Search Strategy

In this narrative review, we applied a structured search. Two databases, Scopus and PubMed, were used to search published articles from January 2000 to July 2026, with the following search keywords: ("placebo effect OR "nocebo effect") AND ("attention" OR "executive functions" OR "executive functioning" OR "executive control" OR "cognitive control" OR "memory" OR "working memory" OR "cognitive flexibility" OR "inhibition" OR "shifting" OR "updating" OR "learning" OR "reinforcement learning" OR "implicit learning" OR "reward-based learning" OR "learning by reward" OR "cognitive training" OR "emotions"). Filters were applied regarding language (English), and type of publication (original article or randomized control trials). By applying these criteria, our search identified 11061 studies.

2.2. Screening/eligibility process

A descriptive flowchart of the selection process is depicted in Fig. 1. To select the articles for this review, we applied the following inclusion criteria: articles published in peer-reviewed journals and reporting a placebo and/or nocebo deceptive manipulation in healthy participants; reporting at least a pre-post measure or a control condition (in randomized order) in within-subjects designs, or a control group in the case of between-subjects designs; reporting at least one objective measure of cognitive performance (e.g., reaction times, accuracy), using neuropsychological measures or behavioral paradigms and including tasks that allow to isolate the specific cognitive function under investigation (e.g., complex arithmetic, mathematical tasks, and reading tasks, involving multiple cognitive abilities, were excluded).

After carefully reading titles and abstracts to exclude duplicates, invalid DOI records, and studies outside the scope of this review, we selected 128 studies, which were fully read to accurately determine whether they met all inclusion criteria. Of these, 34 studies were finally included. Moreover, we included another article identified via citation. At the end of this process, we included 35 studies in this review (Fig. 1).

3. Results

Our search yielded 35 studies, totaling 3490 participants, of whom 2081 (60%) identified themselves as female. Participants' ages ranged from 18 to 56 years (mean age: 23.60 years). A schematic overview of all studies included in the review, with authors' names, year of publication, sample, cognitive function investigated, outcome task, and type of placebo and/or nocebo intervention (i.e., the medium by which expectancy is conveyed) is presented in Table 1. It should be noted that the studies included in this review adopted different types of interventions (either active or sham) to induce placebo and nocebo effects. A first consideration concerns the substantial heterogeneity in the procedures used to convey specific expectations. Some studies coupled specific instructions with stimulation procedures (e.g., electrical, magnetic, or thermal), applied to the head or body, whereas other studies used chemical means (e.g., pills, sprays, or odors), or some form of training (e.g., cognitive training, video games). Moreover, while some studies induced expectations about treatment effects through verbal or written instructions, others reinforced expectations through conditioning procedures. Comparing the different approaches is out of scope in this review. Nonetheless, we acknowledge that the type of intervention may shape placebo and nocebo effects on specific cognitive functions through contextual cues, prior knowledge, and social factors surrounding the intervention.

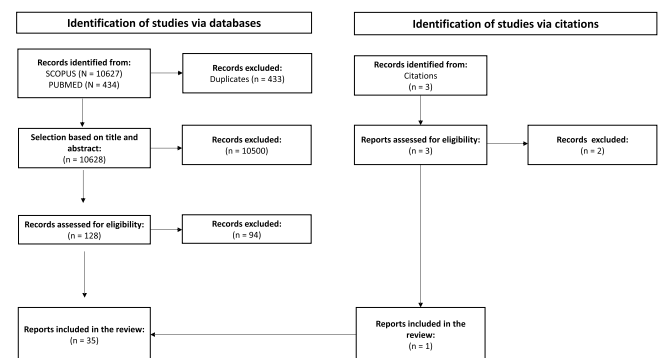


Fig. 1. Flowchart of the selection procedures. After identifying records using databases, we assessed for eligibility 128 records and selected 35 for inclusion in the review.

Table 1

Overview of the studies included in this review.

Authors	Year	Sample	Cognitive function	Task	Intervention	Effect size	Main outcomes
ATTENTION							
Höfler et al.	2018	N = 52	Visuospatial attention	Balloon task	Low-intensity sham TMS for 4 min, along with verbal instructions	Fixations: $\eta^2 = 0.08$ Dwell time: $\eta^2 = 0.10$	Nocebo increased the number of fixations and dwell time on the left side in nocebo responders.
Höfler et al.	2019	N = 40	Visuospatial attention	Balloon task	Sham TMS for 4 min along with verbal instructions	Fixations: $\eta^2 = 0.50$ Reaction times: $\eta^2 = 0.41$	Nocebo responders showed more left-sided fixations in the nocebo condition compared to the control condition, and responded faster to left-sided targets in the high-load condition.
Parong et al.	2022	N = 125	Visuospatial attention	UFOV; ANT task; Paper folding task; Mental Rotation task	N-back task associated with verbal suggestions and conditioning	UFOV: $\eta^2 < 0.01$ ANT: $\eta^2 = 0.01$ Paper folding: $\eta^2 = .02$ MR: $\eta^2 < 0.01$ NC†	The placebo effect, compared to the nocebo effect, does not modulate visual selective attention and spatial cognition.
Fresson et al.	2017	N = 80	Selective visuospatial attention	Vigilance subtest TAP; D2 task	Inert lamp exposition coupled with verbal information	Sustained attention: omissions: $\eta^2 = 0.02^*$ errors: $\eta^2 = 0.02^*$ Divided attention: omissions: $\eta^2 < 0.01^*$ errors: $\eta^2 < 0.01^*$ Alertness: RT with warning: $\eta^2 = 0.01^*$ RT without warning: $\eta^2 = 0.01^*$ NC†	No significant effect of placebo and nocebo intervention on selective and visuospatial attention.
Winkler & Hermann	2019	N = 75	Sustained divided attention	TAP	Inert nasal spray coupled with specific information	Sustained attention: omissions: $\eta^2 = 0.02^*$ errors: $\eta^2 = 0.02^*$ Divided attention: omissions: $\eta^2 < 0.01^*$ errors: $\eta^2 < 0.01^*$ Alertness: RT with warning: $\eta^2 = 0.01^*$ RT without warning: $\eta^2 = 0.01^*$ NC†	No significant effect of placebo and nocebo on sustained and divided attention.
Looby & Earleywine	2011	N = 96	Selective attention, psychomotor speed	DSST; CPT II	Inert pill passed off as methylphenidate	NC†	No significant effect of placebo on selective attention and psychomotor speed.
Harrell & Juliano	2009	N = 60	Sustained attention	RVIP	Caffeinate and decaffeinate coffee crossed with positive and negative instructions	RT: $\eta^2 = 0.08^*$ Hits: $\eta^2 = 0.07^*$ Sensitivity: $\eta^2 = 0.07^*$	In the placebo group, those who were told “impair”, showed enhanced performance and those who were told “enhance” showed impaired performance.
Harrell & Juliano	2012	N = 80	Sustained attention	RVIP	Nicotine and denicotinized cigarettes along with specific instructions	NC†	No significant effect of placebo and nocebo on sustained attention.
Colagiuri & Boakes	2010	N = 31	Sustained attention	RVIP	Inert pill coupled with false feedback about the performance at the task	RTs: $\eta^2 = 0.14^*$	Faster RTs in participants who believed they had received active treatment.
Vodyanyk et al.	2021	Study 1: N = 145 Study 2: N = 74 Study 3: N = 30 Study 4: N = 210	Spatial attention	Mental Rotation task	Working-memory training along with verbal instructions and conditioning	NC†	No significant placebo effect on spatial attention in all 4 studies.
Piedimonte et al.	2024	N = 36	Visual attention	Visual perceptual task	Sham transcranial electrical stimulation coupled with verbal instructions and conditioning	Visual accuracy: $\eta^2 = 0.77^*$ P300: Centroparietal: $\eta^2 = 0.39^*$ Parieto-occipital: $\eta^2 = 0.35^*$	Significant increase from baseline to test in visual accuracy for the placebo group; significant decrease in visual accuracy from baseline to test in the nocebo group; increase in the amplitude of P300 after placebo and decrease after nocebo.
Tiraboschi et al.	2019	N = 52	Selective attention	UFOV	Video-game training along with verbal information	$\eta^2 = 0.09$	Significant increase in accuracy in the placebo group.
Joessel et al.	2025	N = 90	Selective attention	UFOV	Video-game training along with verbal information	NC†	No significant placebo and nocebo effect on selective attention.
Gonçalves et al.	2026	N = 140	Selective attention	UFOV	Video-game training along with verbal information	Mean hit rate: $\eta^2 = 0.02^*$	No significant placebo effect on selective attention.
Sinke et al.	2016	N = 43	Sustained attention	RSVP - simple detection	Thermal pain stimulation coupled with instruction of its effect on cognition	RT: $\eta^2 < 0.01^*$ Accuracy: $\eta^2 < 0.01^*$	No significant placebo and nocebo effect on sustained attention.
Potthoff & Hartmann	2026	N = 197	Sustained attention	Visual discrimination task	White noise along with written verbal suggestions	RTs: $\eta^2 < 0.01^*$ Error rate: $\eta^2 < 0.01^*$	No significant placebo and nocebo effect on sustained attention.

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Table 1 (continued)

Authors	Year	Sample	Cognitive function	Task	Intervention	Effect size	Main outcomes
MEMORY							
Fresson et al.	2017	N = 80	Memory	Word pair memory task; SOPT	Inert lamp exposition coupled with verbal information	NC†	No significant placebo and nocebo effect on memory.
Blokland	2023	N = 65	Long- and short-term memory	Verbal word learning task; Pattern separation task	Inert pill coupled with verbal suggestions	Verbal learning: $\eta^2 = 0.02^*$ Pattern separation: NC†	No significant placebo and nocebo effect on long- and short-term memory.
Looby & Earleywine	2011	N = 96	Memory	CVLT II; RMBT-II; Digit span	Inert pill passed off as methylphenidate	NC†	No significant placebo effect on memory.
Sinke et al.	2016	N = 43	Short-term memory	RSVP - counting task	Thermal pain stimulation coupled with instruction of its effect on cognition	$\eta^2 = 0.1^*$	Enhanced memory performance in placebo group in painful trials compared to non-painful trials; impaired memory performance in nocebo group in painful trials compared to non-painful trials.
EXECUTIVE FUNCTIONS, COGNITIVE CONTROL AND FLEXIBILITY							
Parong et al.	2022	N = 125	WM	N-back	N-back task associated with verbal suggestions and conditioning	$\eta^2 = 0.04$	Positive expectancy significantly enhanced post-training n-back performance.
Parong et al.	2022	N = 125	WM	O-span task	N-back task associated with verbal suggestions and conditioning	$\eta^2 < 0.01$	No placebo and nocebo effect on O-span.
Wang et al.	2023	N = 142	WM	N-back task	Physical exercise	Accuracy: $\eta^2 = 0.05$ RTs: NC†	No placebo and nocebo effect on n-back.
Rabipour et al.	2018	N = 88	WM	N-back	N-back task and active or sham tDCS coupled with verbal suggestions	$\eta^2 = 0.05^*$	No significant placebo effect on n-back.
Rabipour et al.	2019	N = 121	Response inhibition	Grooved Pegboard Test	Active or sham tDCS over left or right motor cortex coupled with verbal suggestions	Stimulation over motor cortex representing preferred hand: $\eta^2 = 0.01^*$ Stimulation over motor cortex representing non-preferred hand: $\eta^2 < 0.01^*$	No significant placebo and nocebo effect on response inhibition.
Tsai et al.	2018	N = 122	WM	Visual n-back task	N-back training coupled with verbal instructions	Expectancy: $\eta^2 = 0.01$ Treatment by expectancy: $\eta^2 < 0.01$	No significant placebo and nocebo effect on visual n-back.
Winkler & Hermann	2019	N = 75	WM	N-back task	Inert nasal spray coupled with specific information	Omissions: $\eta^2 = 0.016$ Errors: $\eta^2 = 0.04$	No significant placebo and nocebo effect on n-back.
Blokland	2023	N = 65	WM	N-back	Inert pill coupled with verbal suggestions	NC†	No significant placebo and nocebo effect on n-back.
Schwartz & Büchel	2015	N = 37	Cognitive control	Flanker task	Tones of different frequencies along with specific instructions and conditioning	Success rate: $\eta^2 = 0.01$ RTs: $\eta^2 < 0.01$	No significant placebo and nocebo effect on Flanker task.
Wang et al.	2023	N = 142	Cognitive control	Go/No Go task; More-odd shifting task	Physical exercise coupled with specific instructions of its effect on cognition in a previous session	Go/no Go: $\eta^2 = 0.08$ More-odd shifting task: NC†	d-scores derived from Go/No go were significantly smaller in post-test compared to pre-test in the nocebo group.
Magalhães et al.	2013	N = 28	Cognitive control	Stroop task	Sham EEG coupled with specific instructions	Interference: $\eta^2 = 0.23^*$ Facilitation: $\eta^2 = 0.14^*$	Stroop interference on accuracy was decreased with positive suggestions and increased with negative suggestions; Stroop facilitation was decreased with negative suggestions.
Rabipour et al.	2018	N = 88	Executive functions	Standardized executive function composite score	N-back task and active or sham tDCS coupled with verbal suggestions	$\eta^2 = 0.05$	Greater improvement in participants receiving High expectation priming compared to Low expectation priming; a significant difference in post-stimulation between High and Low expectation priming.
Fresson et al.	2017	N = 80	Cognitive control	Stroop task	Inert lamp exposition coupled with verbal information	NC†	No significant placebo and nocebo effect on cognitive control.
Parong et al.	2022	N = 125	Flexibility	Task switching	N-back task associated with verbal suggestions and conditioning	$\eta^2 = 0.04$	Placebo group performed significantly better at task-switching.

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Table 1 (continued)

Authors	Year	Sample	Cognitive function	Task	Intervention	Effect size	Main outcomes
Parong et al.	2022	N = 125	Flexibility	Countermanding task	N-back task associated with verbal suggestions and conditioning	$\eta^2 = 0.01$	No significant placebo and nocebo effect on this task.
Van Elk et al.	2020	N = 57	Cognitive control	Flanker task	Sham tDCS along with instructions of its positive or negative effect on cognition.	NC†	No significant placebo and nocebo effect on cognitive control.
HIGH-ORDER COGNITION							
Blokland	2023	N = 65	Reasoning	Tower of London	Inert pill coupled with verbal suggestions	$\eta^2 = 0.01^*$	No significant placebo and nocebo effect on reasoning.
Vodyanik et al.	2021	Strudy 1: N = 145 Study 2: N = 74 Study 3: N = 30 Study 4: N = 210	Reasoning	Matrix reasoning task	Working-memory training with verbal instructions and conditioning	NC†	No significant placebo effect on reasoning in all 4 studies.
Parong et al.	2022	N = 125	Reasoning	RAPM; UCMRT	N-back task associated with verbal suggestions and conditioning	RAPM: $\eta^2 = 0.07$ UCMRT: $\eta^2 = 0.03$	Placebo intervention enhanced performance at RAPM and UCMRT.
Foroughi et al.	2016	N = 50	Reasoning	RAPM; BOMAT	Self-assignment through ad-hoc advertisement	RAPM: $d = 0.98$ BOMAT: $d = 1.34$	Participants in the placebo group scored significantly higher in post compared to pre in RAPM and BOMAT.
Rozenkrantz et al.	2017	N = 90 for CFG	Creativity	CFG; AUT	Odor along with specific instructions of its effect on creativity	CFG: $d = 0.46$; AUT: $d = 0.43$	The placebo group showed significantly higher originality than the control group in the CFG and AUT.
LEARNING							
Villa-Sánchez et al.	2021	N = 90	Implicit Learning	SRTT	Sham tDCS along with information of its effect on attention	NC†	No significant placebo effect on implicit learning.
Colagiuri et al.	2011	N = 164	Implicit learning	Visual learning task with implicit learning	Odor coupled with information of its effect on cognitive performance	RTs: $\eta^2 = 0.01$ Cueing: $\eta^2 = 0.01$	Positive expectation group had faster search times with the odor than without the odor and showed a stronger cueing effect compared to negative expectation group and controls. Negative expectation group displayed a smaller cueing effect compared to control group.
Turi et al.	2017	N = 30	Reward-based learning	Monetary reward-based reinforcement-learning task	Combination between sham stimulation and verbal suggestions	NC†	Placebo expectations improved reward-learning performance and increased the learning rate from rewards.
Turi et al.	2018	N = 80	Reward-based learning	Instrumental learning task	Combination between active sham stimulation on F3 and F4, verbal suggestions and conditioning	NC†	Participants receiving placebo suggestions showed improved learning accuracy; those receiving nocebo suggestions exhibited impaired performance.
Augustat et al.	2024	N = 141	Reward reinforcement learning	Probabilistic reinforcement learning	Binaural beats along with verbal instructions with different degrees of uncertainty	$\eta^2 = 0.07^*$	Learning from positive feedback was greatest under intermediate treatment uncertainty.
EMOTIONS							
Coleshill et al.	2021	N = 96	Emotions	Dot probe task	Inert nasal spray along with instructions that it can decrease or increase pain	500 ms stimulus presentation: $\eta^2 = 0.03^*$ 1250 ms stimulus presentation: $\eta^2 < 0.01^*$	No significant placebo and nocebo effect on emotions.
Schienze et al.	2016	N = 23	Emotions	Eye tracking	Inert pill along with instructions of its positive effect on disgust relief	Mean fixation duration: $\eta^2 = 0.09$ Number of fixations: $\eta^2 = 0.10$ Dwell time: $\eta^2 = 0.09$	The placebo enhanced the number of fixations for disgusting images.
Gresml et al.	2018	N = 37	Emotions	Eye tracking	Inert pill along with instructions it can reduce phobic symptoms	Fixations count: $\eta^2 = 0.22$ Dwell time: $\eta^2 = 0.24$	In the placebo condition, both the fixation count and the dwell time on the spider pictures increased.
Mostaoui et al.	2025	N = 49	Emotions	Emotional Interference task	Inert nasal spray with verbal instruction of its positive effect on emotions	Attentional bias fearful vs happy faces in high attention condition: $d = 0.32$	Placebo decreased the difference in RTs between fearful and happy faces, selectively when attention was focused on faces.

Note. *The effect size was derived from the statistics reported in the cited study. †NC = not calculated: The effect size could not be calculated because the original article did not report sufficient statistical information. RTs = Reaction times; η^2 = Partial eta squared; d = Cohen's d ; WM = Working memory; UFOV = Useful Field of View

task; ANT = Attentional Network Test; TAP = Test of Attentional Performance; CPT II = Conners' Continuous Performance Test II; DSST = Digit Span and Digit Symbol Substitution Test (WAIS-III); RVIP = Rapid Visual Information processing; RSVP = Rapid Serial Visual Presentation task; SOPT = Self-Ordered Pointing test; CVLT II = California Verbal Learning test; RMBT-II = Rivermead Behavioral Memory test; RAPM = Raven Progressive Matrices; BOMAT = Bochumer Matrices Test; UCMRT = University of California Matrix Reasoning Task; CFG = Creative Foraging Game; AUT = Alternate Uses Test; SRTT = Serial Reaction Time task.

3.1. Attention

Attention is a multifaceted cognitive function comprising several distinct but interrelated components. Selective attention enables individuals to prioritize task-relevant information while filtering out distracting stimuli; divided attention refers to the ability to process multiple sources of information simultaneously and manage concurrent tasks effectively; sustained attention reflects the capacity to maintain focus on relevant stimuli over extended periods of time (Eysenck and Keane, 2015). A specific form of selective attention is visuospatial attention, which involves directing and allocating attentional resources to particular locations in space. In this section, we present and discuss the impact of placebo or nocebo procedures on specific attentional functions (i.e., *selective attention*, *visuospatial attention*, and *sustained attention*).

In the domain of *selective attention*, Tiraboschi et al. (2019) demonstrated an effect of positive suggestions associated with a 15-minute video game training on the Useful Field of View (UFOV) task, in which participants must identify in which direction the target stimulus was presented among distractors. Compared with the control group, the placebo group showed better performance on the UFOV but not on the attentional blink task, in which participants had to identify a white letter in a stream of letters rapidly presented on a PC screen, as well as a black 'X' letter. However, these findings were not replicated in two subsequent studies that employed the same procedure and task (Joessel et al., 2025; Gonçalves et al., 2026). Additional studies have generally reported null findings. For example, Parong et al. (2022) found no effect of either positive or negative verbal information associated with a working memory training (experimental condition) combined with a conditioning phase or with an active control training (control condition) on the performance in the UFOV task (Parong et al., 2022). Moreover, this study found no evidence of either placebo or nocebo effects on other types of cognitive tasks, such as the mental rotation task, a classical paradigm requiring participants to decide if two simultaneously presented, differently oriented shapes are identical or mirrored, the paper folding task, in which, after a sheet of paper is folded in various ways before being cut one has to indicate how a sheet of paper would appear once unfolded, and the Attentional Network Test (Fan et al., 2002), which assesses the three core components of attention: alerting, orienting and executive functions. Similarly, Sinke et al. (2016) found no modulation of attentional performance in a target-detection task following a placebo/nocebo procedure that combined painful stimulation with verbal instructions about its effects on cognitive performance.

Despite this predominance of negative findings, recent evidence has provided compelling support for the possibility that placebo and nocebo interventions can influence attentional processing. Using a reinforced expectancy paradigm that combined verbal suggestions with conditioning, Piedimonte, Volpino et al. (2024) investigated both behavioral and neurophysiological (EEG) markers of visual attention. Participants performed a visual discrimination task before and after receiving sham (i.e., inactive) electrodes applied on the occipital region that were presented as having the property to improve (placebo group) or to decrease (nocebo group) the performance at the visual task. The control group was told that the electrodes were not active. Remarkably, the manipulation produced diametrical effects on visual accuracy: performance improved in the placebo group and deteriorated in the nocebo group. Even more importantly, these behavioral changes were paralleled by corresponding modulations of the P300 component, a well-established electrophysiological marker of attentional allocation. Specifically, P300 amplitude increased in the placebo group and decreased in the nocebo group after the respective interventions compared to baseline,

whereas it remained stable across sessions in the control group (Piedimonte, Volpino et al., 2024). Although currently limited to a single study, these findings are particularly relevant because they suggest that placebo and nocebo effects may not merely alter subjective perceptions of performance but may also influence neural mechanisms underlying attention. As such, they offer important proof of concept that attentional functions could be altered when expectations are effectively induced and reinforced.

Regarding *visuospatial attention*, two studies used the Balloon Test, a visual search task that requires participants to find a target (i.e., a small circle) among many distractors (i.e., stylized balloons composed of a circle and a small vertical line at the bottom) with varying levels of visual load (Höfler et al., 2018, 2019). In both studies, a nocebo procedure was used, in which sham TMS was presented as a head massage tool capable of modulating left-sided attention. In the first study (Höfler et al., 2018), participants received either negative suggestions indicating that the sham stimulation would impair left-sided attention or no information about its effects. Strikingly, individuals classified as nocebo responders (i.e., whose treatment effectiveness ratings were above the median values) showed more fixations and longer exploration times on the left side of the visual field, accompanied by faster reaction times. Thus, despite reporting a subjective worsening of their attentional abilities, these participants exhibited objectively enhanced visuospatial performance. This paradoxical pattern was replicated in the subsequent study in which participants received either positive or negative verbal suggestions regarding the effects of sham TMS (Höfler et al., 2019). Once again, nocebo responders showed increased attention to the left side of space, as reflected in more left-sided fixations and faster detection of left-sided targets, particularly under high attentional load. In contrast, the placebo manipulation failed to produce measurable changes in either eye-movement patterns or reaction times. Hence, rather than producing the expected deterioration in performance, nocebo suggestions appeared to induce an increased allocation of attentional resources toward the threatened spatial domain, resulting in enhanced objective performance despite a subjective perception of decline. Taken together, these findings suggest that negative expectations may, under specific circumstances, trigger compensatory attentional mechanisms that counteract the anticipated impairment.

Nevertheless, the literature on visuospatial attention remains largely characterized by null findings. In addition to the absence of effects reported by Parong et al. (2022), other studies found no evidence that placebo or nocebo manipulations influence visuospatial attention (Vodyanik et al., 2021; Fresson et al., 2017) or psychomotor speed (Looby and Earleywine, 2011). Notably, in the latter study, the intervention successfully enhanced participants' subjective perceptions of intellectual energy and cognitive efficiency, yet these changes were not accompanied by objective improvements in performance. The dissociation between subjective beliefs and behavioral outcomes highlights the complexity of expectancy effects and underscores the importance of considering both subjective and objective measures when investigating placebo and nocebo phenomena in cognition.

Among studies investigating *sustained attention*, only Colagiuri and Boakes (2010) demonstrated a positive modulation following a placebo procedure in the Rapid Visual Information Processing (RVIP) task, a paradigm requiring participants to continuously monitor a rapid stream of digits and respond whenever three consecutive odd or even numbers appear. In this study, the placebo intervention consisted of an inert pill administered along with information that it could contain either caffeine or an inert substance. After ingesting the pill, a group of participants was conditioned by means of a surreptitious amplification of the feedback of performance at the RVIP task to reinforce their belief

about the effectiveness of the pill. Results showed that participants who believed they had received the active treatment (placebo responders) performed better than those who believed they had ingested an inert pill (Colagiuri and Boakes, 2010). However, these findings were not replicated neither by Harrell and Juliano, 2009 and Harrell and Juliano, 2012, who employed a different placebo procedure involving either decaffeinate coffee or denicotinized cigarettes coupled with specific information, nor by a subsequent study (Winkler and Hermann, 2019) in which the placebo intervention consisted of an inert nasal spray and sustained attention was evaluated with the Test of Attentional Performance (TAP; Zimmermann and Fimm, 2002). To reconcile these opposite results, it is essential to consider the different methodological approaches employed in these studies. Colagiuri and Boakes (2010) distinguished between placebo responders and non-responders, thus increasing the probability of detecting a significant effect, whereas the other studies did not differentiate between subgroups of participants. Moreover, it is important to note that, in Harrell and Juliano, 2009 and Harrell and Juliano, 2012, coffee and cigarettes may not be a suitable medium for conveying positive expectations, as they are commonly associated with negative outcomes. This association could have undermined the credibility of the placebo manipulation, ultimately attenuating the emergence of the placebo effect.

Finally, a recent study (Potthoff and Hartmann, 2026) failed in inducing objective placebo and nocebo effects on sustained attention by applying a white noise together with information that it could either enhance (placebo), impair (nocebo) or induce no effect (control) on cognitive performance. Despite the absence of changes in performance, subjective beliefs were positive in the placebo group and negative in the nocebo group, suggesting that expectancy manipulations may influence subjective perceptions without altering actual cognitive performance.

Although these procedures are generally not particularly effective in modulating attention, the evidence presented in this section suggests that conditioning may uniquely drive placebo or nocebo effects on visual and visuospatial attention. This aligns with the notion that placebo and nocebo effects in the attentional domain may be potentiated through learning mechanisms. On the contrary, the heterogeneity of studies investigating sustained attention does not allow for drawing definitive conclusions.

3.2. Memory

Memory refers to the cognitive processes involved in encoding, storing, maintaining, and retrieving information (Atkinson and Shiffrin, 1968). The majority of the studies have examined placebo and nocebo effects using standardized neuropsychological assessments, providing a broader evaluation of memory-related cognitive functioning.

Evidence regarding placebo and nocebo effects on *short- and long-term memory* is similarly sparse and inconclusive, with only a minority of studies reporting significant placebo or nocebo effects. One notable exception is the fMRI study conducted by Sinke et al. (2016), which examined whether expectations can influence short-term memory. In this study, participants received positive or negative verbal information about the effects of pain on performance in a short-term memory task. During the task, participants were asked to count how many times a target stimulus appeared while receiving painful or non-painful thermal stimulation. Despite comparable pain ratings, participants who were led to expect that pain would improve cognition performed better on the memory task during painful trials than during non-painful trials, whereas those expecting pain to worsen performance showed the opposite pattern. The study did not include a neutral-expectancy condition and therefore cannot fully disentangle the effects of pain from those of expectancy. Nevertheless, the findings suggest that positive expectations may mitigate, and potentially even reverse, the disruptive effects of pain on memory (Kuhajda et al., 1998; Mazza et al., 2018). These behavioral effects were accompanied by increased activation of the superior parietal cortex during painful stimulation in the

positive-expectancy group, suggesting that expectancy-related changes in memory were associated with corresponding changes in neural activity. Highlighting how expectations can influence the impact of pain on cognition may have translational relevance for clinical populations, such as fibromyalgia and other chronic pain conditions, in which pain negatively affects both patients' well-being and cognitive functioning (Kaptchuk et al., 2020; Burke et al., 2026).

The same expectancy manipulation failed to influence performance on a simple detection task administered within the same experimental protocol. This dissociation is particularly informative because it indicates that the observed effects were not attributable to a general enhancement of attention or arousal but rather reflected a more specific modulation of short-term memory processes. One possible interpretation is that pain-related expectations may be more likely to influence higher-order cognitive operations, such as memory maintenance and manipulation, than relatively automatic processes such as stimulus detection (Moore et al., 2012).

In contrast, most other studies investigating memory have reported null findings. No significant placebo or nocebo effects on memory performance were observed by Fresson et al. (2017), Blokland (2023), or Looby and Earleywine (2011). Notably, the credibility and strength of the expectancy manipulations employed in some of these studies may have been limited, as reflected by relatively weak manipulation-check ratings (Looby and Earleywine, 2011; Fresson et al., 2017). Consequently, the absence of behavioral effects may partly reflect insufficient expectation induction rather than a complete insensitivity of memory processes to placebo and nocebo influences.

An additional and theoretically important observation emerges from studies showing that placebo and nocebo interventions can alter subjective experiences without affecting objective memory performance. For example, Blokland (2023) reported changes in self-perceived motivation and attentional engagement despite no measurable improvements in memory outcomes. This dissociation between subjective and objective effects closely mirrors findings in the attentional domain (Höfler et al., 2018, 2019; Winkler and Hermann, 2019) and suggests that placebo and nocebo manipulations may exert a stronger influence on metacognitive judgments and self-perceptions than on cognitive performance itself.

Taken together, the current evidence provides limited support for a direct modulation of memory by placebo and nocebo interventions. Nevertheless, the few positive findings, combined with recurrent dissociations between subjective experience and objective performance, point to a potentially important role of expectations in shaping how individuals perceive and evaluate their cognitive functioning. Future research should clarify the conditions under which these subjective and objective effects diverge and identify the neural and psychological mechanisms that mediate this dissociation.

3.3. Executive functions, cognitive control and flexibility

Executive functions are the high-order abilities that enable us to act efficiently in dynamic environments (Cohen, 2017). Within this broader framework, *working memory* is a temporary capacity system that holds and manipulates information to support ongoing cognitive activities such as learning, reasoning, and comprehension (Baddeley, 2007). *Cognitive control* refers to the processes that allow information processing and behavior to vary adaptively depending on current goals, characterizing a broad class of mental operations, including representation and maintenance, as well as strategic processes such as attention allocation and stimulus-response mapping. It is associated with a wide range of processes and is not restricted to a particular cognitive domain. For example, impairments in cognitive control may be associated with specific deficits in attention, memory, language comprehension, and emotional processing (Friedman and Robbins, 2022). Within the domain of cognitive control, key subcomponents include *inhibitory control*, which enables the suppression of task-irrelevant information, and

planning and strategy, which involve the formulation, organization, and implementation of goal-directed behavior. In addition, cognitive and behavioral flexibility allows the appropriate adjustment of thoughts and behaviors in response to changing environmental demands and relies on the ability to appropriately switch between cognitive sets (*switching abilities*). In this section, we review several studies examining the effects of placebo and nocebo manipulations on executive tasks, including *inhibition, switching, and planning and strategy*.

Studies investigating placebo and nocebo effects on working memory appear relatively consistent across the experimental paradigms employed. The most frequently used task is the n-back, which requires participants to continuously monitor a sequence of stimuli and determine whether the current item matches one presented n positions earlier. This task is particularly suited to assessing the online maintenance and updating of information and has therefore become a standard measure of working memory performance.

Studies show that *working memory* performance does not appear to be significantly affected by expectancy-based manipulations, regardless of the type of intervention employed. The only study reporting a potentially positive effect was conducted by Parong et al. (2022), who combined expectancy-inducing verbal information with a conditioning procedure. Participants received either positive or negative information about the cognitive benefits of a working memory training program based on the n-back task. To reinforce these expectations, the authors implemented a conditioning phase in which task difficulty was covertly manipulated during an intermediate assessment, making performance appear either better or worse depending on the experimental condition. While participants in the placebo condition showed greater accuracy on the n-back task than those in the nocebo condition, no effects emerged on an untrained measure of working memory, the Operation Span task, which requires simultaneous processing and storage of information by solving arithmetic problems while memorizing sequences of letters. Although these findings suggest that expectations may influence performance on the trained task, their interpretation requires caution. Importantly, the study did not include a neutral control condition without expectancy manipulation, making it impossible to determine whether the observed difference reflected a genuine placebo enhancement, a nocebo-induced impairment, or a combination of both. Consequently, the magnitude and direction of the expectancy effect cannot be reliably established.

More importantly, these findings contrast with the broader literature, which has consistently reported null effects of placebo and nocebo manipulations—including sham cognitive enhancement procedures, placebo treatments, and expectancy manipulations—on working memory (Blokland, 2023; Schwarz and Büchel, 2015; Winkler and Hermann, 2019; Wang et al., 2023). For example, Tsai et al. (2018), Rabipour et al., 2018 and Rabipour et al., 2019 found that explicit expectancy instructions did not, per se, influence performance on working memory and response inhibition. Interestingly, despite the absence of a direct effect on task performance, Rabipour et al. (2018) reported a significant interaction between expectations and intervention type. Specifically, participants who received active transcranial direct current stimulation (tDCS) over the dorsolateral prefrontal cortex (DLPFC) combined with low-expectation priming exhibited the poorest performance on the n-back task.

Although this result does not support a direct placebo or nocebo effect on working memory, it raises the intriguing possibility that expectations may modulate the efficacy of active brain stimulation (Braga et al., 2021). Given the central role of the DLPFC in both working memory and expectancy-related processes, these findings suggest a potential interaction between neural mechanisms underlying cognitive control and the formation of treatment expectations, with important implications for interpreting brain stimulation studies.

Regarding *cognitive control*, one of the most compelling demonstrations was provided by Magalhães De Saldanha da Gama et al. (2013), who investigated *inhibitory control* using the Stroop task, in which

participants must name the color of written words that may have a congruent (e.g., the word “yellow” written in yellow) or incongruent meaning with respect to the color (e.g., the word “yellow” written in red). Participants wore a sham EEG cap described as a sophisticated “Brain Wave Machine” capable of either enhancing (placebo group) or impairing (nocebo group) color perception. The manipulation successfully altered performance: participants in the placebo group exhibited reduced Stroop interference, whereas those in the nocebo group showed increased interference. These findings indicate that expectations can influence cognitive control processes, particularly the ability to inhibit competing information. Importantly, the study implemented rigorous controls for potential confounders, including participants’ prior knowledge of EEG technology, and embedded the intervention within a highly credible medical context characterized by white laboratory coats, blood pressure measurements, and other clinical cues. This methodological approach highlights the critical contribution of contextual and social factors in strengthening placebo and nocebo effects. However, subsequent studies have not consistently replicated these findings. Fresson et al. (2017) found no evidence of placebo-related modulation on either the Stroop task, the Go/No-Go task—a classic measure of response inhibition requiring participants to execute or withhold motor responses depending on the presented cue—or the TAP Flexibility subtest, which assesses *switching abilities* through alternating response rules. Nevertheless, these null findings should be interpreted cautiously, as participants reported low credibility ratings for the intervention, suggesting that the expectancy manipulation may have been insufficiently convincing to generate robust placebo effects.

Evidence for nocebo effects on inhibitory control remains similarly limited. Wang et al. (2023) reported a nocebo-induced decline in Go/No-Go performance following a two-session expectancy manipulation. Participants received positive, negative, or neutral information, depending on the experimental group, regarding the purported cognitive effects of an acute bout of aerobic exercise performed during a previous session. Only negative expectations led to a deterioration in inhibitory performance, providing preliminary evidence that nocebo effects may impair response inhibition.

More promising evidence emerges in the domain of *cognitive flexibility*. Using a combination of verbal suggestions and conditioning procedures associated with cognitive training, Parong et al. (2022) examined the effects of placebo and nocebo manipulations on performance in the Task-Switching paradigm (in which participants must categorize stimuli based on their position) and Countermanding task (which asks participants to press one of two keys on either the same or the opposite side of the target). Participants in the placebo group exhibited greater cognitive flexibility than those in the nocebo group, particularly in the Task-Switching task. Notably, this advantage persisted at a delayed follow-up assessment even after participants had been debriefed about the nature of the manipulation. These findings suggest that expectancy-induced changes in cognitive flexibility may be relatively durable and can persist even after explicit awareness of the intervention. At the same time, the differential sensitivity observed across tasks underscores the importance of task-specific characteristics in determining whether placebo and nocebo effects emerge.

In contrast, other studies employing the Flanker task—a paradigm assessing conflict monitoring and inhibitory control—failed to identify any placebo or nocebo effects, regardless of whether conditioning procedures were included (Schwarz and Büchel, 2015; Van Elk et al., 2020). The coexistence of positive and negative findings across seemingly similar executive paradigms suggests that placebo and nocebo effects in this domain are highly sensitive to methodological factors, including the credibility of the intervention, the strength of expectancy induction, and the specific cognitive demands of the task.

Taken together, the available evidence indicates that executive functions may be more amenable to placebo and nocebo modulation than attention or memory, particularly in the domains of inhibitory control and cognitive flexibility. It emerges, moreover, that paradigms

assessing the same cognitive functions may not be modulated to the same extent. For example, Stroop and Go/No-Go paradigms may be more sensitive to placebo and nocebo interventions than Flanker tasks (Magalhães De Saldanha da Gama et al., 2013; Wang et al., 2023; Schwarz and Büchel, 2015; Van Elk et al., 2020).

3.4. High-order cognition

Reasoning is the cognitive process by which individuals draw conclusions and make inferences from available information (Evans, 2017). Traditionally, reasoning has been divided into two major forms: inductive reasoning, in which conclusions are probabilistic and extend beyond the available evidence, and deductive reasoning, in which the truth of the premises logically guarantees the truth of the conclusion (Heit, 2000). As a higher-order cognitive ability, reasoning emerges from the interaction of multiple processes, including attention, working memory, learning, and prior knowledge. Given its central role in problem-solving, decision-making, and academic achievement, understanding whether expectations can influence reasoning performance has important implications for educational settings, cognitive assessment, and cognitive enhancement interventions.

To date, only a limited number of studies have examined placebo and nocebo effects on reasoning. One of the first demonstrations was provided by Foroughi et al. (2016), who employed an implicit procedure to induce expectations by recruiting participants through specific advertisements that framed the study as “brain training and cognitive enhancement” for the placebo group or as “generic” for the control group. In other words, by taking part in the study, participants self-assigned themselves to a placebo or control group, without any external manipulation of expectations (apart from the specific advertisement) (Foroughi et al., 2016). Participants completed inductive reasoning ability tasks (i.e., the Raven Advanced Progressive Matrices (RAPM) and the Bochumer Matrices Test (BOMAT)) on two consecutive days, with a single session of cognitive training (an adaptive n-back task) interleaved between them. Importantly, on the second day, parallel versions of both tasks were applied to avoid learning effects. This procedure successfully modulated objective performance: the placebo group scored significantly higher post-training than pre-training at both tests, whereas no difference was observed in the control group. These results were later replicated by Parong et al. (2022), who applied a similar placebo intervention (i.e., working memory training coupled either with positive or negative information, along with a conditioning procedure) and evaluated its effect on the RAPM and on the University of California Matrix Reasoning Test (UCMRT), a different task investigating the same ability. Again, performance on the RAPM and UCMRT was modulated by expectations, with better performance in the placebo group than in the nocebo group, and RAPM has proven to be more susceptible than UCMRT (Parong et al., 2022). Conversely, Vodyanik et al. (2021) reported no significant change of reasoning performance after manipulating participants’ expectations about the effectiveness of a cognitive training intervention. Similarly, another study found no change in performance on a computerized version of the Tower of London, a task designed to assess planning ability, following a placebo intervention consisting of an inert pill with specific information about its positive effects (Blokland, 2023).

Finally, in the domain of creativity, Rozenkrantz et al. (2017) led participants in the placebo group to believe that an odorant could enhance creativity, whereas participants in the control group received no additional information. After this manipulation, a test of creativity was applied to all the sample (CFG), while a test of divergent thinking was applied to a subgroup (AUT). The placebo group showed higher originality than controls in the creative foraging game (CFG), in which they were asked to search for interesting and beautiful shapes in a defined geometric space. Participants in the placebo group also showed better performance on the AUT. Although these findings provide preliminary evidence that placebo interventions can enhance creativity,

they should be interpreted with caution. Given that the study relied on a between-subjects design, it is not possible to exclude the influence of pre-existing individual differences between groups that may have contributed to the observed effects. Consequently, more rigorous studies are needed to establish whether placebo and nocebo interventions can reliably modulate creativity and to clarify the mechanisms underlying these effects.

Overall, the available evidence indicates that reasoning may be one of the few cognitive domains in which placebo effects can emerge with some consistency, although the findings remain limited and far from conclusive. Importantly, the observed effects appear to depend not only on the cognitive function under investigation but also on the specific outcome measures used to assess it. This pattern mirrors findings from other cognitive domains and reinforces the notion that placebo and nocebo effects are strongly task-dependent.

3.5. Learning

Learning refers to the process through which individuals acquire new knowledge, skills, or behavioral patterns through experience, practice, or instruction (Daw and Shohamy, 2008). This process can be conscious (i.e., explicit and voluntary) or unconscious (i.e., implicit learning). A particularly important form of learning is reward-based learning, in which actions, stimuli, or contexts are associated with positive or negative outcomes, leading to adaptive changes in behavior (Sutton and Barto, 1998). Reward-based learning relies heavily on dopaminergic signaling, which strengthens or weakens neural representations according to experienced outcomes. Because these mechanisms are central to motivation, habit formation, and decision-making, understanding how expectations interact with reward learning is of particular theoretical and clinical relevance.

Research on *implicit learning* remains relatively limited and has produced mixed results. Villa-Sánchez et al. (2021) compared the effects of two different placebo interventions on visuomotor implicit learning, assessed using a serial reaction time task (SRTT). Participants of different groups received either a motor-related placebo intervention consisting of sham transcutaneous electrical nerve stimulation (TENS) accompanied by positive suggestions regarding movement execution, a cognitive-related placebo intervention involving sham tDCS presented as a tool to improve attention and concentration, or no intervention. Interestingly, only the motor-related placebo improved overall response selection performance, whereas the cognitive-related placebo failed to produce measurable effects. However, neither intervention influenced sequence-specific learning itself, indicating that placebo effects may have acted on general task performance rather than on the implicit acquisition of sequential regularities (Villa-Sánchez et al., 2021). Evidence for expectancy effects on implicit learning was also reported by Colagiuri et al. (2011) using a contextual cueing paradigm. In this study, an odor was paired with positive, negative, or neutral information, and participants subsequently completed a visual search task in which repeated spatial configurations implicitly predicted target location. Participants exposed to positive information responded more quickly to repeated configurations than those exposed to negative information, whereas negative suggestions impaired performance relative to the neutral condition. Importantly, participants remained unaware of the repeated spatial patterns, demonstrating that the observed effects occurred at an implicit level.

Regarding *reward-based learning*, converging evidence suggests that expectations can influence performance. Two studies from the same research group demonstrated that sham tDCS can influence reward-based learning through expectancy-related mechanisms. In the first study (Turi et al., 2017), verbal instructions were conveyed regarding the effects of tDCS, which varied the perceived certainty of the intervention’s efficacy, with higher certainty leading to greater reward learning and learning rates for gains (i.e., how much the individual updates their future decisions based on positive outcomes). In the

second study (Turi et al., 2018), verbal suggestions accompanying sham tDCS were reinforced through a conditioning procedure that experimentally altered task difficulty. Under these conditions, the placebo intervention improved accuracy and promoted more adaptive learning strategies; the nocebo intervention produced the opposite pattern, reducing performance and increasing behavioral noise.

In a further study, Augustat et al. (2024) investigated whether a placebo manipulation influences reward reinforcement learning by varying beliefs about the efficacy of a sham intervention across different levels of expected treatment efficacy. In an online experiment, participants listened to binaural beats for three minutes and then performed a probabilistic reinforcement learning task. Participants were assigned to one of five groups, differing in the specified probability of treatment efficacy, ranging from 0% to 100% in 25% increments. Although placebo instructions did not affect behavioral performance, computational modeling showed that learning from positive feedback was greatest under intermediate treatment uncertainty (50% expected efficacy) rather than under maximal probability of efficacy. These findings suggest that placebo manipulations can modulate reward reinforcement learning and that treatment uncertainty may play a more important role than the valence of expectations. Taken together, the evidence reviewed here suggests a possible distinction between implicit learning and reward-based learning. While findings regarding implicit learning remain sparse and inconsistent, very preliminary evidence suggests that reward-based learning can be influenced by placebo and nocebo manipulations. Consequently, reward-based learning may represent a privileged domain for investigating how expectations shape cognition, offering a valuable model for understanding the broader interaction between placebo/nocebo mechanisms and cognitive functioning. Importantly, at present, the available studies do not allow us to draw any definitive conclusion, and additional research is needed to clarify the conditions under which expectancy effects influence different forms of learning and to determine whether similar mechanisms operate across implicit and explicit learning processes.

3.6. Emotions

Emotions are complex psychological states arising from the interaction of subjective experiences, physiological responses, and behavioral tendencies. According to the influential two-factor theory proposed by Schachter and Singer (1962), emotions emerge from the cognitive interpretation of bodily signals, through which individuals assign meaning to their internal sensations and feelings. Emotions exert a profound influence on cognition and behavior, shaping decision-making, social interactions, well-being, and both physical and mental health (Izard, 2010). It is important to note that this review included studies that investigated the impact of placebo and nocebo procedures on emotional processing, assessed through objective behavioral measures that could reflect underlying cognitive-affective mechanisms, such as attentional bias, emotional interference task, and eye fixation patterns. Conversely, we excluded studies that relied exclusively on subjective, self-reported emotional ratings, as these results may be more susceptible to experimental confounding, are difficult to compare across studies, and depend on individuals' metacognitive abilities (LeDoux, Hofmann, 2018; Gardhouse and Anderson, 2013).

One of the most widely used experimental approaches to studying emotions is the assessment of emotional attentional biases, based on the assumption that emotional states shape visual attention. In this regard, a useful paradigm is the Emotional Interference Task (Brassen et al., 2010, 2011), in which participants respond to lateralized targets while ignoring emotional facial distractors. By manipulating the congruency between attentional cues and target locations, the task allows researchers to examine how the allocation of attentional resources affects vulnerability to emotional distraction. Using this paradigm, Mostaoui et al. (2025) demonstrated that placebo interventions can modulate emotional processing. Participants received an inert nasal spray

described as oxytocin and accompanied by positive suggestions about its emotional benefits. Compared with controls, the placebo group showed improved task performance and reduced interference from highly arousing negative stimuli, particularly in conditions where attentional resources were more available. Neuroimaging findings further revealed decreased activation in emotional interference networks, increased recruitment of the lateral prefrontal cortex, and reduced activity in limbic appraisal regions. Together, these results suggest that placebo effects can enhance top-down emotional regulation, thereby reducing the impact of emotionally salient distractors.

Another objective method for investigating emotions is eye fixations (Vaidya et al., 2014), based on the assumption that changes in the number of fixations on an emotional image may indicate approach/-avoidance of that emotion. Two studies manipulated expectations and used eye tracking as an indirect objective measure of emotions. A first study (Schienle et al., 2016) recruited healthy women with moderate disgust proneness, who underwent two sessions in which they passively viewed images with or without emotional meaning (i.e., disgust, fear, neutral, fractal). In one of the two sessions, a placebo procedure was administered, consisting of ingesting an inert pill along with information about its purported positive effects in reducing disgust symptoms, while in the second session no pill was administered. The results revealed a modulation of the spatial fixation pattern following the placebo intervention (Schienle et al., 2016), suggesting that expectations positively modulate the disgust experience. These results were confirmed in a second experiment, in which healthy women viewed two pictures on the screen, one on the left and one on the right. The pairs of pictures could be disgust-neutral or neutral-neutral. The task was repeated with and without the placebo pill, with the same instructions as in the previous experiment. After the placebo, a marked increased number of fixations on disgusting images was observed, likely reflecting a reduction in the adoption of avoidance strategies after the placebo pill (Schienle et al., 2016). Similar findings were observed in the context of spider phobia. Gremsl et al. (2018) administered an inert pill accompanied by positive suggestions that it would alleviate phobic symptoms. Following the placebo intervention, visual engagement with fearful stimuli increased, suggesting that placebo-induced expectations can attenuate avoidance behaviors, a core feature of anxiety-related conditions.

In contrast, Coleshill et al. (2021) found no placebo or nocebo effects using the Dot-Probe task, which requires participants to respond to targets appearing at locations previously occupied by emotional or neutral stimuli (MacLeod et al., 1986). Participants received an inert nasal spray accompanied by either positive or negative information regarding its effects, yet no changes in emotional attentional bias emerged. However, this null finding should be interpreted cautiously, as the reliability and validity of the Dot-Probe task as a measure of emotional processing have been increasingly questioned (Schmukle, 2005; Xu et al., 2025). Consequently, the absence of effects may reflect limitations of the outcome measure rather than a genuine lack of emotional modulation. It should be noted that in this study, the placebo and nocebo interventions focused on pain relief and exacerbation, respectively, and the outcome measure aimed at assessing the impact of this procedure on attentional bias to emotion. Collectively, these studies provide converging evidence that placebo interventions can modulate emotional experiences and emotion-related behaviors. Notably, the observed effects extend beyond subjective reports and are reflected in objective behavioral and neurophysiological measures, indicating that placebo effects can influence both the experience and regulation of emotions. Overall, the available evidence suggests that emotions may be among the cognitive-affective domains most responsive to placebo effects, with great part of the available studies reporting significant positive findings. By contrast, the evidence remains insufficient to draw conclusions regarding nocebo effects.

These observations may have important translational implications, suggesting that placebo mechanisms may support emotional reappraisal and potentially enhance the efficacy of both pharmacological and

psychotherapeutic interventions.

4. Discussion

This narrative review examined placebo and nocebo effects across different cognitive domains (Fig. 2).

A first consideration regards the magnitude of the effects observed across the studies. Overall, the reported or derived effect sizes are small to moderate in magnitude (i.e., partial η^2 ranging from 0.04 to 0.10), with some studies reporting larger effects. In addition, several studies included relatively large samples, often ranging from 80 to more than 140 participants and, in some cases, exceeding 190.

The heterogeneity of the available evidence and the inconsistent reporting of effect sizes across studies warrant caution when interpreting the overall strength and magnitude of placebo and nocebo effects on cognition. Moreover, the effects do not appear to be uniform across cognitive domains but rather depend on several interacting factors, including the outcome measures employed, the nature of the expectancy-induction procedure, and the specific cognitive processes involved. Hence, the agenda for future studies should: (1) include rigorous experimental designs that disentangle the contributions of verbal suggestions, conditioning, and other contextual factors; (2) examine whether placebo and nocebo effects preferentially modulate specific cognitive functions; (3) identify the neural mechanisms underlying these effects.

Building on the current evidence, we propose here some hypotheses that could be tested in future studies. Our perspective assumes that placebo and nocebo effects may shape cognition through multiple mechanisms (Fig. 3).

The first hypothesis is that placebo and nocebo effects may exert either a direct influence on cognitive functions or an indirect influence through mediating factors such as motivation, reward processing, emotional states, or self-efficacy beliefs. Second, for cognitive functions that heavily rely on frontal brain regions, particularly executive functions, the emergence of placebo and nocebo effects may be constrained by competition for limited cognitive resources. In such cases, the neural systems required to generate and maintain expectations may overlap with those necessary for task execution, potentially attenuating the effect. Third, the effectiveness of placebo and nocebo interventions may critically depend on the mechanisms through which expectations are induced. Procedures based on explicit verbal suggestions and those relying on implicit learning through conditioning are likely to engage distinct cognitive and neural processes, leading to differential effects across cognitive domains and task demands.

In the following sections, we elaborate on these hypotheses and discuss how they may account for the diverse patterns of placebo and

nocebo responsiveness observed across cognitive functions.

Among all examined cognitive domains, those in which placebo and nocebo effects appear to exert an influence are learning and reward-based learning (Colagiuri et al., 2011; Turi et al., 2017; 2018). This susceptibility is likely attributable to the substantial overlap between the neural systems involved in expectancy processing and those supporting reinforcement learning, particularly dopaminergic cortico-striatal circuits (De la Fuente-Fernández et al., 2001; De La Fuente-Fernandez, Stoessl, 2002; Scott et al., 2008; Brietzke et al., 2022). For example, it has been proposed that reward mechanisms may be involved when manipulating expectations (Brietzke et al., 2022), as supported by neurochemical evidence of dopamine release in the striatum during the placebo response in patients with Parkinson's disease (De la Fuente-Fernández et al., 2001; De La Fuente-Fernandez, Stoessl, 2002; De la Fuente-Fernández, 2009) and in healthy participants (Scott et al., 2008). Moreover, learning is a crucial mechanism underlying placebo and nocebo effects, to the point that reinforcing expectations through conditioning enhances these effects (Colloca et al., 2008b). Hence, the placebo effect may exert a *direct*, additive influence on learning and reward-based learning by acting on shared mechanisms. Another domain in which compelling evidence emerges is emotional processing (Schienle et al., 2016; Gremsl et al., 2018; Mostaui et al., 2025). Specifically, placebos appear to modulate eye fixations toward emotional images and to reduce processing of irrelevant, high-arousing aversive stimuli, suggesting a more effective strategy for emotional regulation (Schienle et al., 2016; Gremsl et al., 2018). In contrast, performance on the Dot-Probe task was not similarly modulated (Coleshill et al., 2021), potentially reflecting the limited sensitivity of this paradigm to detect placebo-induced modulations of emotions (Schmukle, 2005; Xu et al., 2025). More complex paradigms, such as the Emotional Interference task, could be instead more sensitive to placebo-related modulations of affective processing. From a neurophysiological perspective, a putative complex neural architecture could underlie this influence. Positive expectations induced by a placebo are known to activate the frontal cortex (Lidstone and Stoessl, 2007; Krummenacher et al., 2010), which, in turn, could down-regulate limbic appraisal networks, as shown in a recent fMRI study (Mostaui et al., 2025). As a result, placebos can act by *directly* decreasing the activation of emotion-related brain circuits, potentially alleviating negative affect. Although preliminary, the results from these studies open promising avenues for implementing new interventions to relieve negative emotions, with potentially relevant impact in the clinical domain.

While the direct effects of placebo and nocebo interventions have been observed in some cognitive functions, their potential *indirect* effects remain largely unexplored. Several cognitive functions, including working memory, attention, and executive control, are known to be influenced by emotional states, motivation, and reward processing (Spaniol et al., 2014; Savine and Braver, 2010; Gong and Li, 2014; Weiss et al., 2025; Lautenbach, 2025; Yang et al., 2013; Lagner et al., 2015; Cohen et al., 2010; Vanlessen et al., 2013; Yeung et al., 2024). Given this close interplay, an important avenue for future research is to investigate whether placebo and nocebo interventions may affect these cognitive functions *indirectly* by modulating emotional, motivational, and reward-related processes.

Concerning executive functions, such as working memory, cognitive control, and flexibility, results appear inconclusive, and a possible explanation may lie in the type of tasks used to assess these functions. In this regard, it is noteworthy that certain behavioral paradigms used to assess cognitive control and flexibility, such as the Stroop test, Go/No-Go, and Task Switching, appear particularly suitable to capture the influence of placebo and nocebo effects; instead, other paradigms, such as the Flanker task, the Countermanding task, or the n-back task, did not show any modulation. This suggests that not all the tasks designed to assess executive functions may be equally sensitive to the placebo and nocebo manipulations. A possible explanation for the heterogeneous results across paradigms is the competition for the same resources

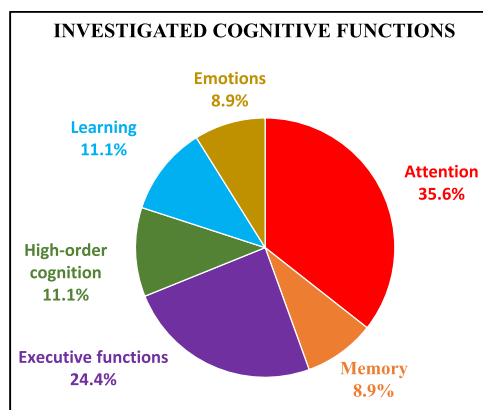


Fig. 2. Investigated cognitive functions. Percentage of studies categorized by cognitive function relative to the total number of studies included in this review.

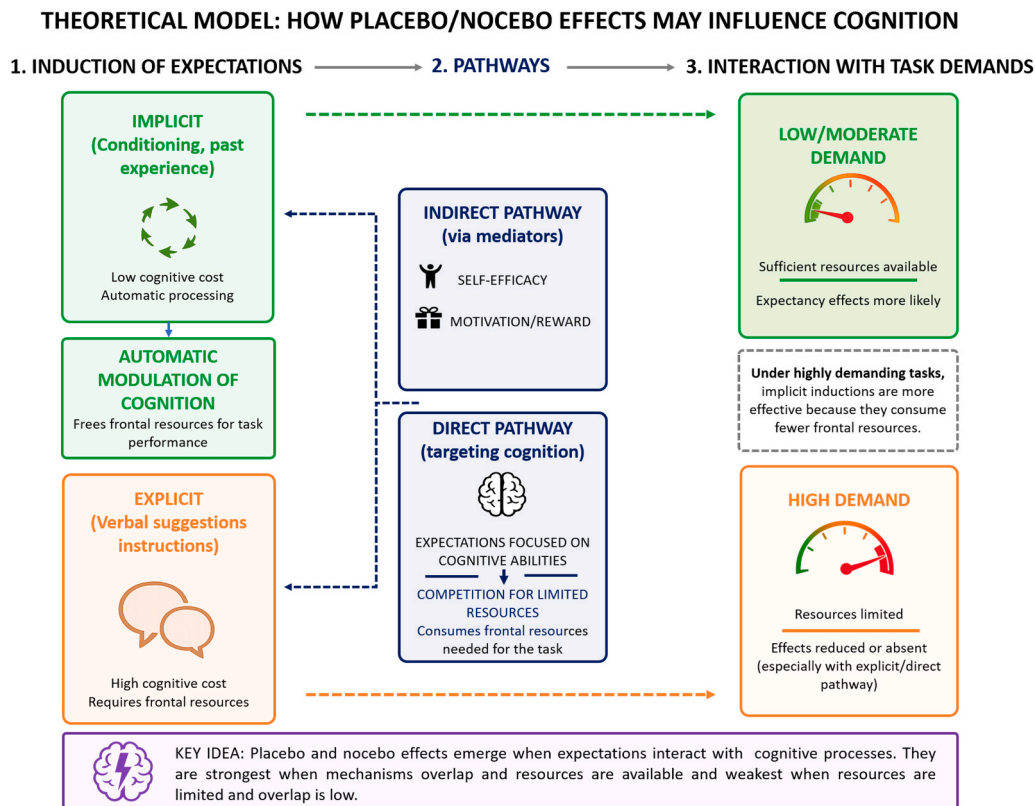


Fig. 3. Theoretical model: how placebo/nocebo effects may influence cognition. The model suggests that placebo and nocebo effects influence cognitive performance through expectancy, motivation, and reward-related mechanisms. We propose that these effects may be stronger when cognitive resources are available and when tasks engage processes related to self-efficacy and motivation/reward. In contrast, effects are weaker and more variable in domains requiring substantial executive control.

between placebo/nocebo effects and task execution. At the neuroanatomical level, placebo and nocebo effects engage frontal brain regions that are consistently involved in various cognitive functions, such as the DLPFC and the anterior cingulate cortex (ACC) (Lui et al., 2010; Krummenacher et al., 2010; Egorova et al., 2015; Villa-Sánchez et al., 2018; Bingel et al., 2011; Atlas et al., 2012; Petrovic et al., 2002; Zubieta et al., 2005; Wager et al., 2004; Price et al., 2007; Tu et al., 2019; Armbruster et al., 2012; Wager and Atlas, 2015). The contribution of frontal regions appears crucial in inducing the placebo effect, to the point that alterations in their function can abolish this phenomenon (Krummenacher et al., 2010; Benedetti et al., 2006; Benedetti, 2010; Villa-Sánchez et al., 2018). Notably, the ACC and DLPFC are thought to cooperate in specific high-order functions, such as cognitive control (Kondo et al., 2004; Kerns et al., 2004; Silton et al., 2010), decision-making (Fleming et al., 2012), and goal-directed behavior (Watson et al., 2018). The overlap of brain regions between different functions can either facilitate (Ito et al., 2017) or interfere with cognitive performance (Watanabe and Funahashi, 2014; Hester et al., 2004; Klingberg and Roland, 1997). Specifically, shared neural underpinnings may facilitate a more efficient allocation of cognitive resources, thereby enhancing cognitive functions through the placebo effect. On the other hand, concurrent activation of the same brain regions may lead to competition for available resources, thus hindering placebo and nocebo effects. It could be hypothesized that during the execution of highly demanding cognitive tasks, such as the n-back task (Yeung and Han, 2023), the system may prioritize task execution over the processing of placebo- or nocebo-induced expectations, thereby saturating available cognitive resources and impeding the emergence of placebo and nocebo effects (Fig. 3). Conversely, less-demanding tasks may leave some residual cognitive resources available for the generation of placebo and nocebo effects. This resource-availability hypothesis is supported by a

recent study that elegantly demonstrated that the placebo effect can emerge when attentional resources are available, but not when attention must be pre-allocated to a spatial location (Mostaoui et al., 2025). This proposal resonates with the notion that the limited pool of attentional resources can hardly be allocated to both the task and expectancy processing, leading to attenuated placebo and nocebo effects. Consistent with this interpretation, Rabipour et al., 2018 and Rabipour et al., 2019 found that positive expectations alone were insufficient to enhance performance on the n-back task, the Grooved Pegboard Test, and a choice reaction time task, assessing response time and response inhibition. However, performance improved when positive expectations were combined with anodal tDCS over the left DLPFC (Rabipour et al., 2018). These findings suggest that, in highly demanding cognitive tasks, increasing prefrontal cortical excitability may help overcome the interference between concurrent cognitive processes, thereby enabling placebo effects to emerge. Supporting this view, Mahesan et al. (2023) showed that anodal tDCS over the left DLPFC improves interference resolution during dual-task performance, highlighting the critical role of this region in managing cognitive resources under conditions of high interference. If the resource-availability hypothesis is confirmed, an important next step will be to identify which cognitive tasks provide sufficient resources for placebo effects to occur and which task demands may instead limit their expression.

Despite extensive investigation in the attentional domain, only a small number of studies have demonstrated an effective placebo and/or nocebo modulation. Specifically, one study found an effect on sustained attention (Colagiuri and Boakes, 2010), two studies successfully modulated visual attention (Piedimonte et al., 2024; Tiraboschi et al., 2019), and two studies found a paradoxical amelioration in visuospatial attention following a nocebo procedure (Höfler et al., 2018, 2019). It is important to note that in attentional domain, various paradigms have

been applied, clarifying a modulation in RVIP and perceptual tasks, but not in RSVP (Sinke et al., 2016), mental rotation task (Parong et al., 2022; Vodyanik et al., 2021), subtests of TAP (Fresson et al., 2017; Winkler and Hermann, 2019), visuospatial attention tasks like the Balloon task (Höfler et al., 2019), nor neuropsychological tests (Looby and Earleywine, 2011). It is possible to hypothesize that some abilities, such as sustained attention, may be more resistant to modulation, or that the task demands may interfere with the effect (as for the resource-availability hypothesis explained above).

It should be noted that the type of intervention may shape placebo and nocebo effects on specific cognitive functions through contextual cues, prior knowledge, and social factors surrounding the intervention. Evidence from other domains suggests that equivalence across placebo procedures should not be assumed. For example, in the pain domain, placebo pills and sham acupuncture needles have been found to induce different responses (Kong et al., 2013), while oxygen inhalation produced greater placebo-related hypoalgesic effects than inert pills (Benedetti and Dogue, 2015). TENS and sham tDCS were found to induce different placebo effects (Villa-Sánchez et al., 2021), which may be localized to the body region where the intervention is applied (Emadi Andani et al., 2025), broadly consistent with spatial proximity beliefs in non-invasive electrical stimulation (Villa-Sánchez et al., 2026). These findings indicate that the procedure used to induce placebo effects may influence the resulting response. However, direct comparisons between different placebo procedures with respect to cognitive functions are currently lacking. Therefore, findings obtained using different procedures should not be treated as directly comparable. Appropriately controlled studies directly comparing different procedures within the same experimental paradigm are needed to establish whether and to what extent their effects differ.

Further considerations concern the interplay between the cognitive function investigated, the demands of the task at hand and the type of intervention applied. Specifically, manipulations that exploit learning processes (e.g., an inert intervention combined with a conditioning procedure) operate implicitly, thus allowing the allocation of cognitive resources to the task and favoring the emergence of placebo or nocebo effects. In contrast, interventions acting at the explicit level (i.e., verbal information about the effects of a treatment) may require additional resources for processing or maintenance, thereby hindering placebo and/or nocebo effects in complex cognitive functions or tasks with high cognitive demands.

Moreover, procedures acting directly on cognition ("the pill will improve memory") may be less effective than those focused on mediators ("the pill will reduce anxiety"). To date, the available evidence does not allow a conclusion; further research is warranted to provide experimental support for this hypothesis. Regarding sham brain stimulation or training, their ability to induce placebo and nocebo effects on cognition may depend on participants' prior knowledge and beliefs about these approaches (Vodyanik et al., 2021; Tsai et al., 2018; Rabipour et al., 2018; Villa-Sánchez et al., 2021; Braga et al., 2021). For instance, individuals who have a negative mindset towards brain stimulation, possibly because it may evoke associations with electroconvulsive therapy, may show reduced responsiveness to placebo. The systematic assessment of previous knowledge and exposure to specific interventions should be included in placebo and nocebo research. Future studies could compare different placebo approaches within the same cognitive domain and using comparable paradigms. This investigation could help refine the effects of both active and placebo interventions on cognitive functions.

4.1. Limitations

The number of studies focusing on specific functions, such as learning, emotions, and reasoning, remains limited compared to those examining executive functions and attention. This represents a limitation of this review in interpreting the findings. Furthermore, the great

heterogeneity of tasks and procedures in these studies prevents definitive conclusions. For example, the manipulation check has not been included in all studies and, when present, it is composed of different questionnaires, thereby impeding direct comparisons across studies. Indeed, to ascertain whether a placebo/nocebo effect can be induced on cognitive functions, an evaluation of the intervention's credibility should be conducted to distinguish a pure lack of effect from a failure in modulating expectations.

Importantly, the use of different placebo and nocebo procedures, including pills, sham stimulation, odors, and nasal sprays, introduces substantial methodological variability and heterogeneity across studies. This limits the extent to which their findings can be directly compared, even when the same cognitive function is investigated. Consequently, the available evidence should be interpreted with caution and does not allow us to determine whether specific placebo and nocebo procedures differ in their effectiveness in modulating particular cognitive functions. Future research should employ experimentally controlled designs that directly compare different procedures within the same paradigm to determine whether placebo and nocebo effects vary as a function of both the procedure employed and the cognitive function investigated. These limitations notwithstanding, this review offers valuable suggestions for optimizing experimental procedures to enhance positive expectations and mitigate the influence of negative expectations in the cognitive domain, with important translational implications for clinicians and neuropsychologists.

5. Conclusions

Although the paucity of studies and heterogeneity of experimental procedures and paradigms do not permit definitive conclusions, the present review suggests that certain cognitive tasks may be more susceptible to placebo and nocebo effects than others. We speculate that this differential modulation may be due to shared neural correlates and/or motivational and contextual factors related to placebo/nocebo manipulation. On the other hand, domains such as attention and working memory appear to be less influenced by these procedures. We speculate that tasks that demand greater cognitive resources may not allow for the contemporary elaboration or maintenance of placebo/nocebo expectations, thereby undermining the generation of the effect. Further, the choice of intervention type (i.e., inert pills vs sham stimulation) may be crucial, given that externally driven expectations may interact with pre-existing beliefs about the intervention. Given that these hypotheses remain speculative, further research is needed to provide data that can test this eventuality. This investigation is crucial not only for a deeper understanding of placebo and nocebo effects in the cognitive domain but also for enhancing neuropsychological interventions and neurorehabilitation and for controlling for confounding factors during clinical evaluation.

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Declaration of Generative AI and AI-assisted technologies in the writing process

During manuscript preparation, the authors used ChatGPT-5.6 to assist with grammar and language editing and to generate images. The authors reviewed and edited all outputs and take full responsibility for

the content of the publication.

Declaration of Competing Interest

Sara Assecondi is named inventor on a patent application (publication number WO/2022/106850), titled "Improving cognitive function", currently in the PCT phase (international application No. PCT/G82021/053019).

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