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Effect of cognitive training on executive functions and anxiety in patients with mild cognitive impairment: a systematic review

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Abstract

Introduction: Previous studies have reported changes in executive functions (working memory, inhibition, cognitive flexibility) and mood (anxiety and depression) in patients with Mild Cognitive Impairment (MCI). Different tools have shown to improve cognitive performance in this population, and computerized cognitive training is one of the most studied strategies. However, there is no consensus about near-transfer or far-transfer effects. Therefore, a systematic review is relevant for determining the effects of cognitive training on executive functions and mood. Aim: This systematic review aims to identify the effect of cognitive training on executive functions and anxiety in patients with MCI.

Methods: For the systematic search, the following search equation was used: "mild cognitive impairment" AND "executive functioning" AND "cognitive training" AND "anxiety". We retrieved a total of 525 papers, but only 37 of them met the inclusion criteria. Articles published between January 2003 and February 2023 were included.

Results: The results revealed two research trends: (a) the effect of computerized cognitive training and virtual reality on executive functions and anxiety in people with MCI and (b) the effect of emerging intervention strategies on executive functions and anxiety in people with MCI. The effect of cognitive training on inhibitory control, working memory, reasoning, and attention was found to be predominant, even when it is not significant on all these variables. Studies on the effect of cognitive training on anxiety are still limited in number.

Conclusion: Conducting longitudinal studies is necessary to understand the effect and underlying mechanisms of cognitive training.

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1. Introduction

Mild cognitive impairment (MCI) is a term used to refer to an intermediate state between normal aging and dementia. It is characterized by a certain degree of cognitive deficit that does not interfere with activities of daily living (Petersen et al., 1999, 2004, 2014, 2018). Individuals with MCI show cognitive decline, compared to their previous level of brain functions, in areas such as memory, language, attention, motor skills, social cognition, and executive functions. Although people with MCI may remain independent, they require increased cognitive effort or compensation strategies for adaptation (American Psychiatric Association, 2013). MCI is defined as a clinical construct consisting of acquired cognitive impairment without functional limitation, presenting heterogeneous features and underlying pathologies, including Alzheimer's disease, hippocampal sclerosis, frontotemporal degeneration, or Lewy body disease, or sometimes normal age-related changes (Frisoni et al., 2023; National Institute on Aging, n.d.; Petersen et al., 2018)

Recent research highlights that MCI is not a uniform condition but a syndrome with diverse etiologies and manifestations, often leading to structural and functional changes in the brain. Neuroimaging studies have identified significant atrophy in regions such as the hippocampus, which is critical for memory processes, and the entorhinal cortex, which plays a key role in spatial navigation (Apostolova et al., 2006; Miao et al., 2022). These changes are often accompanied by alterations in brain connectivity patterns, suggesting a disruption in the neural networks that support cognitive functions (Klyucherev et al., 2022).

From a neuropsychological perspective, individuals with MCI exhibit deficits in multiple cognitive domains, which can vary depending on the underlying pathology. For instance, those with Alzheimer's-related MCI may show prominent impairments in episodic memory, while individuals with vascular contributions might display greater deficits in executive functions and processing speed (Petersen et al., 2018). These cognitive deficits are often associated with behavioral and psychological symptoms such as irritability, anxiety, and depression, which further complicate the clinical picture and impact the quality of life of patients and their caregivers (Baquero et al., 2004; Mah et al., 2015)

MCI is diagnosed based on a) cognitive deficit symptoms, b) third-party corroboration of such deficit, c) evidence of cognitive decline through neuropsychological assessment, d) normal performance of activities of daily living, and e) nonexistent clinical explanation for progression (Petersen et al., 1999). MCI is likely to progress into a major neurocognitive disorder—also known as dementia—at an annual rate of 10–15% (Petersen et al., 2001). Nevertheless, some individuals with MCI can revert to normal aging, so it is not necessarily a pre-dementia state (Sachdev et al., 2015).

The prevalence of MCI rises steadily with age as follows: 60–64 years, 6.7%; 65–69 years, 8.4%; 70–74 years, 10.1%; 75–79 years, 14.8%; and 80–84 years, 25.2% (Petersen et al., 2018a). Nonetheless, some studies report even higher prevalence rates of up to 42% (Ward et al., 2012), which may be attributed to factors such as sex, occupation, education, and diagnostic method used in the trials. Prevalence rates in Colombia vary by region. In Medellín (Antioquia), the prevalence of amnestic MCI is 9.7% (Henao Arboleda et al., 2008); in Bogotá (Cundinamarca), it is 34% (Pedraza et al., 2017); and in Manizales (Caldas), it is 18.11% (Restrepo de Mejía et al., 2020). These rates are expected to increase considering the rise in life expectancy and the growth of the population over 60 years old. Although exact MCI statistics are not available, the number of people with major neurocognitive disorder is expected to reach 152 million by 2050 (World Health Organization, 2017). Therefore, the prevalence of MCI is likely to increase as a possible precursor of such disorder, making it a rapidly growing public health issue.

In addition, while aging is the main risk factor for MCI, there are other potentially modifiable risk factors that are not necessarily a natural or inevitable aging feature. In this regard, the World Health Organization has provided cognitive intervention guidelines for reducing cognitive impairment risks (World Health Organization, 2019). Systematic reviews are thus critical for identifying the effect of cognitive training on MCI-compromised executive functions, including planning (Yanmin et al., 2007; Martinez Morales et al., 2023; Del Signore et al., 2023), working memory (Papp et al., 2011; Saunders & Summers, 2010), reasoning (Urbanowitsch et al., 2015), and others (Corbo & Casagrande, 2022; Tripathi et al., 2015).

Furthermore, MCI is usually associated with behavioral and psychological symptoms such as irritability (35%) and anxiety (24%) (Baquero et al., 2004). Approximately 50% of individuals with MCI exhibit at least one neuropsychiatric symptom since the onset of cognitive deficit symptoms (Lyketsos et al., 2002). According to the study by Steinberg et al. (2008), the most prevalent neuropsychiatric symptoms in dementia patients include depression (77%), apathy (71%), and anxiety (62%). These symptoms are not only common but tend to persist and increase in prevalence over time (Steinberg et al., 2008).

Anxiety in particular has been associated with medial temporal lobe atrophy and predicts conversion to Alzheimer's disease. A study found that the severity of anxiety in patients with amnestic MCI is associated with a higher conversion rate to Alzheimer's, even after controlling for depression and cognitive decline. Anxiety also predicted a higher rate of entorhinal cortical volume decline, suggesting a direct or indirect neurodegenerative impact (Mah et al., 2015) These symptoms can include depression, apathy, aggression, and sleep disorders, which significantly affect the quality of life of patients and their caregivers (Geda et al., 2014; Rosenberg et al., 2011). The presence of these neuropsychiatric symptoms has been associated with a higher rate of progression to dementia (Steinberg et al., 2008).

Early identification and treatment of these neuropsychiatric symptoms are crucial. Cognitive-behavioral therapy and coping skills training have been shown to be effective in reducing anxiety and improving mood in patients with MCI (Hwang et al., 2004). Research also suggests that physical exercise and socially stimulating activities can have beneficial effects on behavioral and psychological symptoms in these patients (Ngandu et al., 2015). Another study demonstrated the potential of VR training to improve cognitive function in patients with amnestic MCI, indicating a reduction in anxiety levels among participants (Thapa et al., 2020). Considering the neurological, psychological, and functional changes associated with MCI, these findings underscore the necessity of a comprehensive approach that includes cognitive training to effectively manage anxiety and improve the overall well-being of patients with MCI.

Based on the current understanding of MCI and its associated neuropsychiatric symptoms, we hypothesize that comprehensive cognitive training can significantly reduce anxiety and improve executive functions and the overall well-being of patients with MCI.

2. Methods

For tracking studies on cognitive training in patients with MCI, we used the Scopus database and the Web of Science (WoS) platform. From the former, we retrieved papers including the search equation: “mild cognitive impairment,” “executive functioning,” “cognitive training,” and “anxiety,” and for the latter, articles with the keywords “mild cognitive impairment,” “cognition,” and “cognitive training.” We applied these search equations to trials published between January 2003 and July 2024. The search produced a total of 50 studies that met the criteria related to: executive function, mild cognitive impairment, cognitive training, anxiety. However, no articles were manually removed to improve the accuracy of the analyzed results (see figure 1 and figure 2).

Once the results were obtained, they were loaded onto the Tree of Science (ToS) web platform (Robledo et al., 2014). This tool enables the construction and practical understanding of the theoretical framework and state of the art based on the initial search in WoS. The Tree of Science algorithm is based on graph theory, where articles are represented as nodes and citations between them are represented as links. Therefore, each node represents a unit of knowledge located within the network. The most important nodes are identified based on their position, which is determined according to the links that connect them to other nodes (Hirsch, 2005). In this regard, the studies located at the root are the seed references on executive functioning impairments and mild cognitive impairment in adults with an anxiety diagnosis, and those in the trunk are the structural articles. Finally, the leaves are articles that determine current perspectives or trends on the topic (see table 1).

Studies included in this review had to meet the following criteria:

- Participants diagnosed with mild cognitive impairment (MCI).
- Cognitive training interventions aimed at improving executive functions and reducing anxiety.
- Controlled and randomized studies.
- Publications in peer-reviewed journals between January 2004 and July 2024.
- Reports of results in terms of executive functions and anxiety.
- Studies including active control groups.

Studies were excluded if they:

- Did not include participants with MCI or subjective memory complaints.
- Did not evaluate cognitive training interventions.
- Did not report results on executive functions or anxiety.
- Were narrative reviews, editorials, commentaries, or opinion articles.
- Were not published in peer-reviewed journals.
- Were review studies, research protocols, or meta-analyses.

2.1 Study Selection and Data Extraction

Study selection was carried out in two stages: Titles, keywords, and abstracts of articles identified in the initial search were evaluated to determine their eligibility. Disagreements were resolved through discussion and consensus. Selected articles were thoroughly reviewed to confirm their inclusion. Data extraction was performed using a standardized template. This template included the following criteria: reference, country, sample, percentage of women, age, MCI diagnosis, cognitive tasks, affective and activities of daily living questionnaires, neuroimaging, stimulation method, and findings.

2.2 Methodological Quality Assessment of Included Studies

The methodological quality of the included studies was assessed using the "NIH Quality Assessment Tool for Studies."

Criterion	Yes	No	Other (CD, NR, NA)
Was the review based on a focused question that is adequately formulated and described?	X		
Were eligibility criteria for included and excluded studies predefined and specified?	X		
Did the literature search strategy use a systematic and comprehensive approach?	X		
Were titles, keywords, abstracts, and full-text articles independently reviewed for inclusion and exclusion to minimize bias?	X		
Was the quality of each included study independently assessed by two or more reviewers using a standard method to evaluate its internal validity?	X		
Were the included studies listed along with important characteristics and results of each study?	X		
Was publication bias assessed?		X	
Was heterogeneity assessed? (This question applies only to meta-analyses)			X

Quality Rating: Reviewer #1: [María Alexandra Cardona Tangarife] Reviewer #2: [Daniel Alfredo Landinez Martínez]

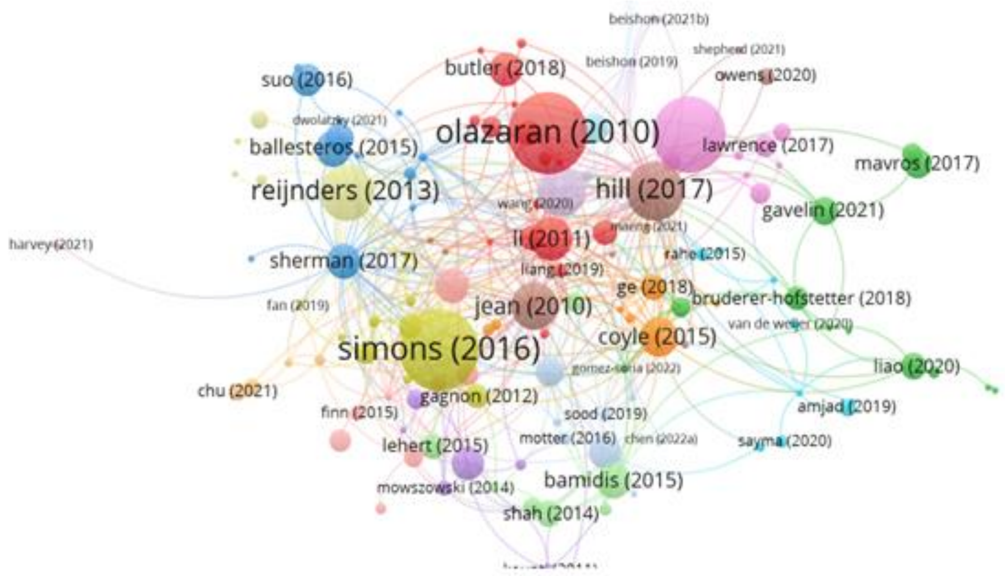

Figure 1. Final Citation Network (Research Communities)

3. Results

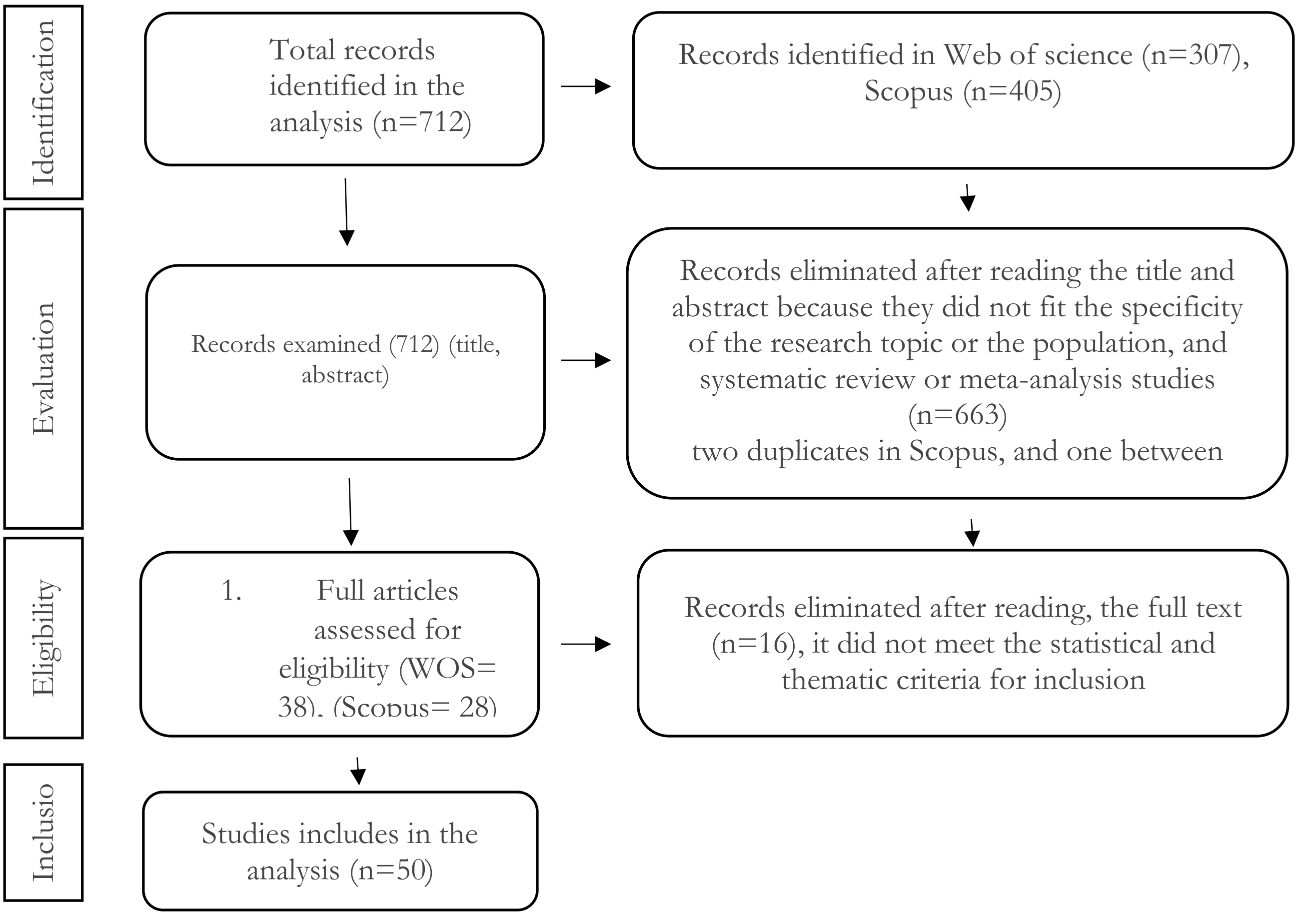

Figure 2. PRISMA flow chart depicting the selection methodology

Table 1. Studies included in the systematic review

Reference	Country	Sample	Percentage of women	Age	MCI diagnosis	Cognitive tasks	Affective and activities of daily living questionnaires	Neuroimaging	Stimulation method	Findings
Antonenko et al. (2024)	Germany	EG (23) CG (23)	39.1%	69.8	NA	Letter updating, N-back, Markov decision-making, AVLT, WMT-2	ADCS-MCI-ADL, Clinical Dementia Rating	sMRI	tDCS	No superior performance enhancements in for full intervention participants 40.
Bahar-Fuchs et al. (2017)	Australia Uk USA	MCI (8) NPS (12) MCI+(25)	50% 58.3% 40%	74.8 71.5 76.0	BADL, ACE-III, GDS	SYDBAT, RAVLT, ROCF, MMQ, TMT A & B, CDR, LPS	GAI, GDI, BADL, NPI	NR	CCT	Home-based Computerized Cognitive Training with adaptive difficulty and personal tailoring appears superior to more generic Computerized Cognitive Training in relation to both cognitive and non-cognitive outcomes.
Baik et al. (2024)	South Korea	EG(25) CG(25)	NR	67.08 65.64	MoCA,	DST, SWF, PWF	GDS	NR	Home-based computerized cognitive training (HB-CCT)	Home-based computerized cognitive training significantly improved cognitive function and reduced depression levels compared to the control group. No side effects were observed.
Bampa et al. (2024)	Greece	EG(22) CG (23)	66.67%	62.78	MMSE, MoCA,	MMSE, MoCA, WCST-64, Doors and People test	GDS, BDI, BAI, SAST, NPI	NR	MTP (Metacognitive Training Program)	Positive effects of MTP were evident over a six-month period; significant improvements in cognitive flexibility, immediate visual recall, metacognitive control, metacognitive beliefs of attention, and increased use of cognitive strategies.

Barban et al. (2016)	Italy Greece Spain	EG (61) CG (53) MCI-t (46) MCI-r (60) AD-t (42) AD-r (39)	55.73% 58.49% 45.65% 48.33% 69.04% 71.79%	70.9 72 74.4 72.9 76.7 76.9	MMSE	RAVLT, TMT A & B, ROCF	Lawton & Brody IADL	NR	CCT (software SOCIABLE)	The results corroborate the positive effect of process-based cognitive training and its maintenance, primarily on memory, in healthy elderly and MCI participants that did not seem to be potentiated by reminiscence therapy. Moreover, the results are very promising for participants with mild Alzheimer's disease.
Barnes et al. (2009)	USA	EG (25) CG (22)	40.9% 40%	74.1 74.8	RBANS	CVLT-II, COWAT, BNT, TMT A & B, D-KEFS	Geriatric Depression Scale	NR	CCT (Posit Science Corporation)	The study found that verbal learning and memory measures favored the intervention group, while language and visuospatial function measures favored the control group, indicating domain-specific effects. It concluded that intensive, computer-based mental activity is feasible for MCI subjects.
Belleville et al. (2006)	Canada	EG (20) CG (9)	NR	NR	MDRS	BEMSIDR, Stroop, ROCF, DO-80	GDI	CT	CCT (program developed by Kramer et al.)	These results suggest that persons with MCI can improve their performance on episodic memory when provided with cognitive training.
Belleville et al. (2011)	Canada	EG (15) CG (15)	73.3% 66.6%	70.13 70	MMSE, MDRS, MEB, Côte-des-Neiges CMB, RL/RI, Stroop, ROCF, SDMT	MMSE, MDRS, MEB, Côte-des-Neiges CMB, RL/RI, Stroop, ROCF, SDMT, MMSE, MDRS,	NR	fMRI	CCT (Côte-des-Neiges) + Trainings	These results indicate that memory training can result in significant neural changes that are measurable with brain imaging. They also show that the brains of people with mild cognitive impairment remain highly plastic.
Belleville et al. (2022)	Canada France	N (749)	62.0%	75.15	NA	SDMT, MMSE, CAIDE	NR	NR	MI (cognitive training, physical activity, nutrition, and omega-3 polyunsaturated fatty acids)	The non-linear function indicates that a higher dose is not necessarily better in multidomain interventions. The optimal dose was about half of the potentially available sessions.

Chen et al. (2022)	USA	EG (56) CG (28)	42.9% 53.6%	75.23 73.68	MoCA	MoCA	GDI	sMRI, fMRI	CCT (network on VSOP, vision-based processing speed)	This suggests that enhancing brain integration may provide a target for developing effective cognitive training.
De Sousa et al. (2020)	Germany	MCI (16) NC (32)	31.25% 68.75%	70 69	CERAD, MMSE	CERAD, MMSE, TMT A & B, DST, RWT	PANAS, WHOQOL	NR	tDCS + OLM	Object-location memory training+anodal transcranial direct current stimulation (atDCS) enhanced training success only in MCI patients, but not in healthy elderly.
Dwolatzky et al. (2021)	Israel	EG (13) CG (10)	76.9% 80%	82.8 83.7	MoCA	CogSym, NeuroTrax	NT	fMRI, fVR	CCT (Feuerstein Memory Program developed by the author RSF)	These initial findings from their pilot study support the design of randomized trials to evaluate the effect of cognitive training using the FIE program on brain volumes and cognitive function.
Finn & McDonald (2011)	Australia	EG (8) CG (8)	62.5% 37.5%	69 76.38	MMSE	CANTAB, RVP, PAL	DASS	NR	CCT (Lumosity)	Participants improved their performance across various tasks with training. There was some evidence of generalization of training to visual sustained attention. No significant effects of training were observed on self-reported everyday memory functioning or mood.
Gagnon & Belleville(2012)	Canada	FP (12) VP (12)	NR	67.0 68.42	MMSE	Stroop, ROCF, MDRS, BNT	Geriatric Depression Scale	NR	Dual training	These findings indicate that cognitive intervention may improve attentional control in persons with MCI and an executive deficit.
Gajewski et al. (2020)	Germany	EG (32) ACG (33) PCG (37)	62.5% 62.9% 61.5%	71 71 70	NA	d2, DST, LPS, Stroop, MWT-B	NR	NR	CCT & PPCT	Word fluency improved after cognitive training (CT), but the Stroop test did not show significant improvement compared to the active control. CT showed far transfer effects to dissimilar psychometric tests, but no transfer to daily attentional or memory functions as assessed by the Cognitive Failures Questionnaire.

Givon Schaham et al. (2024)	Israel	EG(31) CG(30)	46,7 45,2	75.6 75.1	MoCA	**CPTask**, VITask, SAT, Go/no go,, DST, MRT, MT, WebNeuro	Geriatric Depression Scale	NR	TECH: daily self-training with tablet apps, weekly group sessions	Significant improvement in global cognition (MoCA) for TECH group (d = 0.52 to 0.66). No significant differences in controlled attention, cognitive flexibility, inhibition, working memory, or problem-solving.
Grimaud et al. (2021)	France	EG (24) CG (24)	NR	72.95 70.87	NA	MMSE > 27, MHVS, TMT A & B, Stroop, 2-Back Test, LCT	HADS	NR	Games	Results show that the cognitive stimulation program using leisure activities with games is effective on speed of processing, memory span, inhibition and self-esteem but shows no benefits on shifting and updating.
Herrera et al. (2012)	France	EG (12) CG (12)	45.45% 54.54%	75.09 78.18	MMSE	RAVLT, RL/RI, ROCF, TMT A & B	GDI, ADLS	CT	CCT	Cognitive training based on recognition holds promise as a preventive therapeutic method and could be proposed as a non-pharmacological early-intervention strategy.
Innes et al. (2021)	USA	MdG (10) MsG (10) SSG (20)	NR	NR	NA	TMT A & B	POMS	NR	Meditation, music program, regular stimulation	Findings of this pilot feasibility trial suggest incorporation of an enhanced usual care (EUC) program is feasible, and that participation in a simple 12-week relaxation program may be helpful for adults with subjective cognitive decline versus engagement in an EUC program.
Jahouh et al. (2021)	Spain	EG (40) CG (40)	NR	83.25 85.05	MCE GDS	MCE GDS	YSGD	NR	Wii video games	The results showed that the Wii® video console had a positive influence for older people, increasing cognitive status and levels of activities of daily living, and psychological status.
Jhaveri et al. (2023)	USA	EG (10)	70%	73	MoCA	TMT-A, TMT-B, Stroop test	NR	NR	Dual-task training (SMARTfit)	The SMARTfit dual-task training had a positive impact on the participants' cognitive function, improving their cognitive speed and flexibility, as well as their ability to inhibit interference.

Kang et al. (2021)	Korea	VR (23) CG (18)	70.7% 73.9%	75.48 73.28	MMSE	CDR-SOB, ROCF, TMT A & B, DR	ADLS	fMRI, fVR	VR (invasive)	Fully immersive VR cognitive training had positive effects on the visuospatial function, apathy, affect, quality of life, and increased frontal-occipital functional connectivity in older people in a predementia state.
Kim et al. (2021)	Korea	MCI (22) NC (22)	77.3% 90.9%	74.23 71.45	CERAD	CRIq, CERAD, BNT, ROCF	NR	NR	VR	This study revealed different impacts of Cognitive reserve on cognitive training according to the participants' cognitive status.
Lee et al. (2022)	Taiwan	EG (12) CG (12)	41.66% 50%	67.67 70	MMSE	Flanker Task CNA	NR	EEG	Magical intervention	The results of the present study showed that the 6-week magic intervention had beneficial effects on the cognitive and electrophysiological performance in the elderly subjects with MCI.
Liao et al. (2020)	Tauwan	VR (18) CPT (16)	61.1% 75%	75.5 73.1	MMSE MoCA	MoCA, EXIT-25,	Lawton & Brody IADL	NIRS	VR-based physical and cognitive training vs CPT	VR-based physical and cognitive training improves cognitive function, instrumental activities of daily living and neural efficiency in older adults with MCI.
Luo et al. (2024)	China	EG (19) CG (19)	65.79%	70.58	MoCA, MMSE	MoCA, MMSE, AVLT, STT-A, STT-B, VFT, BNT, SDMT	SAS, GDS, QoL-AD, Lawton IADL	NR	SPI-CrEAS (short-period intensive CrEAS program)	Cognitive improvements following initial CrEAS were sustained, with further enhancements in verbal function after SPI-CrEAS.
Manenti et al. (2024)	Italy	EG1(23) EG2 (21) CG1 (20) CG2 (23) CG3(22)	52%	76.5	MMSE	RAVLT, FCSRT, TMT, ROCF, Raven's Matrices, Verbal Fluency, BADA	Geriatric Depression Scale, NPI, Quality of Life in Alzheimer's Disease, BDAL, IADL.	NR	tDCS combined with VR Rehabilitation System and telerehabilitation	Significant improvement in episodic memory in the clinic-atDCS-VRRS+Tele@H-VRRS group. No enhancement in episodic memory in other groups. Improvements in immediate free recall (FCSRT) and maintenance at follow-up. Improvements in executive functions (TMT, Raven's Matrices).

Marin et al. (2022)	USA	EG (10) CG (10)	1.5%	NR	RBANS	RBANS, NABM	ADLS	NR	CCT (constant therapy)	Long-term computerized cognitive training using Constant Therapy, spanning 24 weeks, proves feasible for patients with Alzheimer's disease in mild cognitive impairment and mild dementia stages. Patients exhibited greater adherence to Constant Therapy compared to paper-and-pencil training and showed progressive performance improvements over time.
McDougall et al. (2019)	USA	EG (19) CG (32)	14.02% 11.70%	71.74 73.35	MSEQ, RBMT, HVLT-R	MSEQ, RBMT, HVLT-R, MIA	DAFS	NR	VR + CT vs health education	Senior WISE Memory training delivered to individuals with MCI was able to forestall the participants' declining cognitive ability and sustain the benefit over two years in both subjective and objective memory function.
Montero-Odasso et al. (2023)	Canada	EG1(34) EG2(35) EG3(37) EG4(35) CG(34)	49,1%	73.1	MoCA	ADAS-Cog-13, ADAS-Cog-Plus	IADL, GDS-30	NR	Aerobic-resistance exercise, cognitive training, vitamin D	Exercise and cognitive training significantly improved cognition. No significant improvement was found with vitamin D. The multidomain intervention (exercise, cognitive training, vitamin D) showed the greatest improvement.
Moutoussamy et al. (2022)	France	YAG (37) OAG (37)	NR	25.68 66.54	NA	MHVS, MMSE, WL	HADS	NR	Physical activity	The benefits of physical activity on episodic memory vary by age and task type. Only free-recall performance, which depends on updating, appears to be influenced by physical activity.
Ngandu et al. (2015)	Sweden Finland Saudi Arabia	EG (591) CG (599)	45% 47%	69.5 69.2	NTB	NTB	ZSRDS	NR	MI (diet, exercise, individual computer-based cognitive training, and group cognitive training)	Findings from this large, long-term, randomised controlled trial suggest that a multidomain intervention could improve or maintain cognitive functioning in at-risk elderly people from the general population.

Nobari et al. (2021)	Spain Iran	EG (20) CG (20)	0%	71.4 71.7	NA	MMSE	NR	NR	RV (driving)	The six-week training period significantly improved cognitive status and dual-task performance in elderly men, compared to the control group. VR driving can enhance these cognitive abilities in elderly men.
Nousia et al. (2021)	Greece	EG(25) CG(21)	76%	71,2	MoCA	CDT, word recall, word recognition, BNT, SF, DSF, DSB, TMT A & B	GDS-15, IADL	sMRI	Computer-based cognitive training (CCT) with RehaCom	Improvement in delayed memory, word recognition, BNT, CDT, SF, TMT-A, and TMT-B in the EG; deterioration in delayed memory and executive function in the CG
Nousia et al. (2023)	Greece	EG (15) CG (15)	46.6% 45.6%	75.73 76.67	MoCA, Lawton & Brody IADL	DST, BNT, RWT, TMT A & B	GDI	NR	CCT (md-aMCI) vs psychotherapy + physiotherapy	The telerehabilitation intervention appears to be a useful method in improving or stabilizing cognitive decline in multi-domain amnestic Mild Cognitive Impairment individuals and was a particularly effective alternative approach during the period of the pandemic lockdown.
Park et al. (2020)	South Korea	EG (10) CG (11)	70% 64%	71,80	K-MMSE, CDR, Seoul-IADL	DSF, DSB, Stroop, CF, LF	Seoul-IADL	NR	VR (Virtual Reality)	There were no significant improvements found in K-MMSE scores, the digit span test, the Stroop test, and word fluency following the 12-week VR training program.
Park et al. (2021)	Korea	RA (45) TR (45) CG (45)	72.6% 71.1% 73.3%	75.9 75.5 76.7	MMSE	GDSSF-K, CERAD	SMCQ	NR	CCT (robot-assisted)	A 6-week robot-assisted, multi-domain cognitive training program can improve the efficiency of global cognitive function and depression during cognitive tasks in older adults with MCI, which is associated with improvements in memory and executive function.
Park (2022)	Korea	EG (25) CG (25)	56% 52%	68.27 70.05	SNSB, MMSE	WAIS-BDT, SVLT	NR	fNIRS - GADS	VR + CCT	These results suggest that the virtual reality-based spatial cognitive training might be clinically beneficial to enhance spatial cognition and episodic memory of older adults with MCI.

Pikouli et al. (2023)	Greece	EG(27) CG(28)	66.67%	70.63	MMSE, MoCA	EDMC, ADR	GDSSF-K, BDI, SAS, BAI, NPI	sMRI, CT	Metacognitive strategy training	Improvement in everyday decision-making based on analytical thinking; no significant improvement in the ability to apply decision rules; benefits maintained one month after post-test. Emotional variables (depression, anxiety) were assessed to exclude severe affective disorders.
Rebok et al. (2014)	USA	MG (702) RG (699) SPG (702) CG (698)	76.4%, 76.8% 76.6% 73.6%	73.5 73.5 73.4 74.1	NA	RAVLT, HVLT, KEFS	NR	NR	Active CCT focused on memory, reasoning, and processing speed	Each ACTIVE cognitive intervention resulted in less decline in self-reported activities of daily living compared with the control group. Reasoning and speed, but not memory, training resulted in improved targeted cognitive abilities for 10 years.
Rozzini et al. (2007)	Italy	CCT + ChEIs (15) ChEIs (22) CG (22)	NR	NR	CDR MMSE	CF, LF, RCPM, ROCF	NPI, GDI, ADLS	NR	CCT (multidimensional software)	A long-termNeuroPsychological Training in cholinesterase inhibitors-treated MCI subjects induces additional cognitive and mood benefits.
Satorres et al. (2023)	Spain	EG (17) CG (16)	47.5% 50%	76.6 73.4	MMSE GDS	TAVEC, M@T, DR, ROFC, TBR	NR	NR	tDCS	Significant effects were observed in general cognitive function, immediate and delayed memory, and learning ability, with increases in scores in the active tDCS group. However, no significant effects were found in executive function performance.
Thapa et al. (2020)	South Korea	EG (34) CG (34)	77%	72.6	CERAD	TMT A & B, SDST, MMSE	NR	EEG	VR (Virtual Reality)	Significant improvement in executive function and physical function (gait speed, 8-feet Up and Go test); positive changes in brain activity related to attention (EEG).
Tawfik et al. (2022)	Egypt Greece USA	N (10)	53.80%	90	NA	CERAD, BNT, DST, LPS, SMCQ	NR	NR	VR (joystick)	The results of this study suggested that Cognitive training exercises are feasible among Egyptian adults, especially those with MCI, and potentially effective in enhancing global cognition and after 12 weeks of training.

Tinello et al. (2023)	Switzerland Finland Canada	EG (19) CG (15)	78.9% 73.3%	70.78 70.92	NA	Stroop, Go/no go, Arrows	NR	nirHEG-NF	Neurofeedback	Hemoencephalography Neurofeedback potentially improve performance in certain subcomponents of inhibition (i.e., interference vs. response inhibition), it may also be beneficial for parasympathetic activity in participants with low Heart Rate and for increasing blood flow oxygenation on prefrontal areas during training.
Willis et al. (2006)	USA	MG (703) RG (699) SPG (702) CG (698)	76.4% 76.8% 76.6% 73.6%	73.5 73.5 73.4 74.1	MMSE	RAVLT, HVLT	NR	NR	Active CCT focused on memory, reasoning, and processing speed	Reasoning training led to less functional decline in self-reported daily functioning. Compared to the control group, cognitive training resulted in improved cognitive abilities specific to the skills trained, which persisted for 5 years after the intervention began.
Wong et al. (2022)	Taiwan	NC (40)	60%	65.18	NA	D-CAT, SAT, TMT A & B	NR	NR	CCT Calculation games (Cleverbrain)	The game showed a significant enhancement in both attention span and executive functions after training, and the difficulty factor and the pressure factor were shown to have an effect, but the competition factor was shown to have no effect.
Wu et al., (2023)	China	EG(29) CG (28)	52% 54%	67.68 65.52	MoCA GDS	MoCA, CAVLT, Stroop, ROCF	GDS, IADL	fMRI	Computerized Cognitive Training	Significant improvements in MoCA and Stroop in the experimental group. Increased SC-FC coupling in DMN and SOM, decreased in VIS. Improved clustering coefficients in DMN and SOM. Improvements in inhibition, processing speed, and attention.
Yuan et al. (2021)	China	EG (12) CG (12)	50% 58%	65.08 64.67	MoCA GDS	MoCA, GDS	HAMD	sMRI, fMRI	tDCS	These findings suggest that high-frequency rTMS can effectively improve cognitive function in aMCI patients and alter spontaneous brain activity in cognitive-related brain areas.

Zhang et al. (2022)	China	EG (15) CG (16)	40% 56.25%	66.4 73.75	MoCA	CAVLT, TMT A & B, SDMT, DST	HAMA, HAMD	EEG	tDCS	The study revealed that the functional brain connectivity between the right posterior cingulate gyrus and the right dorsal caudate nucleus was significantly reduced in MCI patients compared to normal controls.

Note: **Sample column:** EG = experimental group; CG = control group; MCI = mild cognitive impairment; NC = normal cognition; YAG = young adult group; OAG = older adult group; MdG = meditation group; MsG = music group; SSG = standard stimulation group; ACG= active control group; PCG = passive control group; MG = memory group; RG = reasoning group; SPG = speed of processing group; CCT = computerized cognitive training; ChEIs = cholinesterase inhibitors; MCI-t = mild cognitive impairment training; MCI-r = mild cognitive impairment rest; AD-t = Alzheimer's disease training; AD-r = Alzheimer's disease rest; NPS = neuropsychiatric symptoms; FP = fixed priority; VP = variable priority; VR = virtual reality; CPT = Combined Cognitive and Physical Training; RA = robot-assisted cognitive training; TR = traditional cognitive training; N = number. **Percentage of women and age columns:** NR = no report. **MCI diagnosis column:** MMSE = Mini Mental State Examination; GDS = Global Deterioration Scale; MoCA = Montreal Cognitive Assessment; CERAD = Consortium for the Establishment of a Registry of Alzheimer's Disease; MSEQ = Memory Self-Efficacy Questionnaire; RBMT = Rivermead Behavioral Memory Test; HVLT-R = Hopkins Verbal Learning Test–Revised; NA = not applicable; RBANS = Repeatable Battery for the Assessment of Neuropsychological Status; NTB = Neuropsychological Test Battery; MDRS = Mattis Dementia Rating Scale; MEB = Memory Efficiency Battery; Côte-des-Neiges CMB = Côte-des-Neiges Computerized Memory Battery; RL / RI = free recall / cued recall; ROCF = Rey–Osterrieth Complex Figure; SDMT = Symbol Digit Modalities Test; CDR = Clinical Dementia Rating; BADL = Brixton Activities of Daily Living; ACE-III = Addenbrooke Cognitive Examination; IADL = instrumental activities of daily living; MCE = Mini-Cognitive Examination; SNSB = Seoul Neuropsychological Screening Battery. **Cognitive tasks column:** TAVEC = Spain-Complutense Verbal Learning Test; M@T = Memory Alteration Test; DR = digit retention; TBR = Barcelona Test Revised; CAVLT = Children's Auditory Verbal Learning Test; TMT A & B = Trail-Making Test A and B; DST = Digit Span Task; RWT = Regensburger Word Fluency Test; MIA = memory in adulthood; MHVS = Mill Hill Vocabulary Scale; LCT = Letter Comparison Test; D-CAT = Digit Cancellation Test; SAT = Sustained Attention Task; WL = word list; d2 = d2 Test of Attention; LPS = language proficiency scale; MWT-B = Multiple-Choice Word Test; CVLT-II = California Verbal Learning Test-II; COWAT = Controlled Oral Word Association Test; BNT = Boston Naming Test; D-KEFS = Delis–Kaplan Executive Function Scale;

RAVLT = Rey Auditory-Verbal Learning Test; HVLT = Hopkins Verbal Learning Test; BEMSIDR = baseline episodic memory story immediate and delayed recall; DO-80 = naming test; CF = category fluency; LF = letter fluency; RCPM = Raven's Colored Progressive Matrices; SYDBAT = Sydney Language Battery; MMQ = Meta Memory Questionnaire; CNA = Computerized Neurocognitive Assessment; CANTAB = Cambridge Automated Neuropsychological Test Battery; RVP = rapid visual information processing; PAL = paired-associates learning; EXIT-25 = Executive Interview; GDSSF-K = Geriatric Depression Scale Short Form: Korean Version; CogSym = metacognition questionnaire; NeuroTrax = computerized cognitive assessment battery; CDR-SOB = Clinical Dementia Rating Sum of Boxes; CAIDE = Cardiovascular Risk Factors, Aging, and Incidence of Dementia; SMCQ = Subjective Memory Complaints Questionnaire; NABM = Neuropsychological Assessment Battery for Memory; CRIq = Cognitive Reserve Index Questionnaire; WAIS-BDT = Wechsler Adult Intelligence Scale - Block Design Test; SVLT = Seoul Verbal Learning Test. **Affective and activities of daily living questionnaires column:** HAMA = Hamilton Anxiety Rating Scale; HAMD = Hamilton Depression Rating Scale; PANAS = Positive and Negative Affect Schedule; WHOQOL = World Health Organization Quality of Life; DAFS = Direct Assessment of Functional Status; HADS = Hospital Anxiety and Depression Scale; POMS = Profile of Mood States; ZSRDS = Zung Self-Rating Depression Scale; GDI = Geriatric Depression Inventory; NPI = Neuropsychiatric Inventory; ADLS = Activities of Daily ; SGDS-K= Korean Geriatric Depression Scale-Short form); Seoul-IADL =Seoul Instrumental Activities of Daily Living, Digit Symbol Substitution Test = DSST; **CPTask**= Continuous Performance Task; **VITask**= Verbal Interference Task; **MRT**= Memory Recall Task, **MT**: Maze Task; **FCSRT**= Free and Cued Selective Reminding Test; **BADA**=Battery for Analysis of Aphasic Deficits Living Scale; GAI = Geriatric Anxiety Inventory; DASS = Depression Anxiety and Stress Scale; YSGD = Yesavage Scale for Geriatric Depression. **Neuroimaging column:** EEG = electroencephalogram; sMRI = structural magnetic resonance imaging; fMRI = functional magnetic resonance imaging; nirHEG-NF = Near Infrared Hemoencephalography Neurofeedback; CT = computed tomography; NIRS = Near-Infrared Spectroscopy; fVR = functional volumetric resonance; fNIRS = functional near-infrared spectroscopy; GADS = Goldberg Anxiety and Depression Scale. **Stimulation method column:** tDCS = transcranial direct current stimulation; OLM = Object Location Memory; CT = cognitive training; PPCT = paper-and-pencil cognitive training; MI = multidomain intervention; VSOP = vision-based speed of processing; EDMC = Everyday Decision-Making Competencetask; **ADAS-Cog-13**= Alzheimer's Disease Assessment Scale-Cognitive Subscale - 13 ítems; **ADAS-Cog-Plus**= Variante del ADAS-Cog-13; **SWF**= Semantic Word Fluency; **PWF**=Phonemic Word Fluency.

3.1 Effect of computerized cognitive training and virtual reality on executive functions and anxiety in people with mild cognitive impairment

The final sample for this research trend consisted of 31 studies, which comprised 7229 participants altogether. Overall, 53.73% were female and 68.91 years was the average age.

Although this article focuses on executive functions and anxiety, effects on other cognitive and affective variables have also been found, which are important to mention. This review included trials providing results related to the effect of computerized intervention on visuospatial skills (Barnes et al., 2009; Liao et al., 2020; Park, 2022) and on praxis (Kang et al., 2021a; Rozzini et al., 2007; Tawfik et al., 2022). There are significant differences between those who were part of the experimental group and those of the control group.

Moreover, seven studies document the effect of computerized training in the attention process (Barnes et al., 2009; Belleville et al., 2006; Finn & McDonald, 2011; Gajewski et al., 2020; Herrera et al., 2012; Rebok et al., 2014; Wong et al., 2022). Two of them account for significant improvement in sustained attention (Finn & McDonald, 2011; Herrera et al., 2012); three, in selective attention (Gajewski et al., 2020; Herrera et al., 2012; Wong et al., 2022); and one, in attention span (Barnes et al., 2009) after the intervention in the case of near transfer. However, one trial—which directly stimulated the memory process and assessed the effect on attention—reveals no far transfer (Belleville et al., 2006).

As for the effect of computerized interventions and VR on memory processes, ten trials were found (Bahar-Fuchs et al., 2017; Barban et al., 2016; Barnes et al., 2009; Belleville et al., 2006, 2011; Dwolatzky et al., 2021; Herrera et al., 2012; Park, 2022; Rebok et al., 2014; Rozzini et al., 2007). Some studies partially show that intervention processes favor semantic memory (Barnes et al., 2009; Belleville et al., 2006; Park, 2022; Tawfik et al., 2022) and episodic memory (Barban et al., 2016; Rozzini et al., 2007) upon intervention. However, only one trial studied the effect of this cognitive process ten years later and reveals no effect or improvement even when effort is applied (Rebok et al., 2014).

With regard to executive functions, the 31 papers of this trend applied tests to analyze a particular executive function, such as inhibitory control (Belleville et al., 2006; Gagnon & Belleville, 2012; P. D. Gajewski et al., 2020; Nousia et al., 2023), metacognition (Bampa et al., 2024; Dwolatzky et al., 2021), working memory (Baik et al., 2024; Belleville et al., 2006, 2011, 2022; Givon Schaham et al., 2024; Nousia et al., 2023; Zhang et al., 2022), verbal fluency

(Gajewski et al., 2020; Kang et al., 2021), categorization, and deductive reasoning (Dwolatzky et al., 2021), processing speed (Barnes et al., 2009; Liao et al., 2019; Willis et al., 2006) and cognitive flexibility (Bampa et al., 2024; Gajewski et al., 2020; Nousia et al., 2021; Wu et al., 2023). Furthermore, a study investigated the effects of virtual reality-based cognitive training on elderly individuals with mild cognitive impairment and normal cognition, finding improvements in global cognition, particularly in those with higher levels of cognitive reserve (Kim et al., 2021).

Finally, regarding affective aspects, although this article focuses on executive functions and anxiety, it is important to mention that most of the studies included in this review also measure affective variables. However, few specifically report the effect of cognitive interventions on anxiety. some articles assess depression (Bahar-Fuchs et al., 2017; Rozzini et al., 2007), apathy (Kang et al., 2021a), and anxiety (Bahar-Fuchs et al., 2017; Grimaud et al., 2021; Zhang et al., 2022).

Only a few studies specifically focused on the effect of interventions on anxiety in patients with mild cognitive impairment (MCI). One study (Finn & McDonald, 2011) specifically focused on the effect of computerized interventions on anxiety in patients with mild cognitive impairment (MCI). This study found significant improvements in anxiety following the intervention. Another study demonstrated the potential of VR training to improve cognitive function in patients with amnestic MCI, indicating a reduction in anxiety levels among participants (Thapa et al., 2020). However, most studies included in this review used anxiety as an exclusion criterion, limiting the available evidence on this topic.

Additionally, some studies that evaluated affective variables such as depression and apathy found positive effects. For example, improvements in depression were reported after the intervention (Bahar-Fuchs et al., 2017), and positive effects on reducing apathy were observed (Kang et al., 2021). Another study found beneficial effects on depression in adults who participated in home-based computerized cognitive training, compared to the control group, suggesting that this type of intervention may be a positive tool for cognitive improvement and depression reduction in adults with MCI (Baik et al., 2024). However, a study on the effects of a home-based computerized cognitive training program found no changes in the level of depression after cognitive intervention (Park et al., 2020)

These findings suggest that cognitive interventions might have a positive impact on various affective aspects, although more research is needed to fully understand their effect on anxiety.

3.2 Effect of emerging intervention strategies on executive functions and anxiety in people with mild cognitive impairment

The final sample for this trend included 19 trials comprising 2837 participants altogether. Overall, 59,44% were female and 73,61 years was the average age. Although this study focuses on executive functions and anxiety, it is important to note that the included studies, meeting the inclusion criteria, also reference outcomes related to other cognitive and emotional processes.

Concerning the memory process, the study by De Sousa et al. (2020) supports the positive impact of transcranial direct current stimulation for improving connectivity among different cortical regions, immediate memory, long-term memory, and learning ability. Additionally, Zhang et al. (2022) and Satorres et al. (2023) report significant improvement of memory by means of transcranial magnetic stimulation. This means that using programs or interventions based on non-invasive neurophysiological techniques impact brain activity and mnesic processes in patients with MCI.

Other emerging intervention strategies—such as visualization with relaxation plus cognitive training of memory, meditation, music programs, and gamification—show significant improvement of memory in patients with MCI, especially in experimental groups compared with control groups (Grimaud et al., 2021; Innes et al., 2021; McDougall et al., 2019). At the same time, these approaches provide evidence of the positive correlation between mnesic ability and physical-sports practice (Moutoussamy et al., 2022).

As for the effect of emerging intervention strategies on executive functions, trials reveal dissimilar results. On the one hand, some studies suggest a significant impact of comprehensive interventions with diet, exercise, individual computerized cognitive training, and group cognitive training (Ngandu et al., 2015). On the other hand, others find no significant changes or no effect of specific interventions when applying either transcranial current relaxation or stimulation techniques to people with MCI (Innes et al., 2021; Satorres et al., 2023) or neurofeedback to healthy population (Tinello et al., 2023). Lastly, others deny the effect of these approaches on specific executive functions such as flexibility and working memory (Grimaud et al., 2021). However, others do report changes in working memory, as demonstrated by the study of Antonenko et al., (2024) which found significant improvements in the N-back working memory task in the group with anodal transcranial direct current stimulation (tDCS).

In relation to decision-making ability, a study demonstrates that metacognitive strategy training improves decision-making skills in patients with amnestic mild cognitive impairment. This study included 55 older adults with amnestic MCI and showed that the experimental group, which received metacognitive strategy training, improved their ability to make decisions based on analytical thinking in everyday and health-related situations, maintaining this improvement one month after training (Pikouli et al., 2023).

Another study found significant improvements in executive functions after a dual-task exercise intervention. The SMARTfit Dual-Task Exercise program led to improvements in cognitive functions such as attention, task-switching, and inhibitory control in older adults with mild cognitive impairment (Jhaveri et al., 2023). Furthermore, the SYNERGIC Trial demonstrated that a multidomain intervention of progressive aerobic-resistance exercises with sequential cognitive training can improve executive functions such as cognitive flexibility, inhibition, and planning in older adults with MCI. This multidomain intervention effect was larger than the improvement from exercise alone (Montero-Odasso et al., 2023).

The SYNERGIC Trial also demonstrated significant improvements in anxiety levels among participants who underwent the multidomain intervention, highlighting its efficacy in addressing both cognitive and emotional aspects in older adults with MCI. This study specifically mentions the reduction of anxiety (Montero-Odasso et al., 2023). Another study found that a 12-week intensive program significantly reduced anxiety levels in MCI patients. Anxiety was measured using the Zung Self-Rating Anxiety Scale (SAS), and the results showed a notable decrease in participants who completed the program (Luo et al., 2024)

This second trend includes more studies reporting significant effects (compared to those reporting no significant effects) of emerging intervention strategies on overall cognition, and not on particular cognitive domain tasks (Belleville et al., 2022; Satorres et al., 2023; Yuan et al., 2021; Zhang et al., 2022), which is a limitation in the analysis of this trend. With regard to emotional processes, some researchers address mood in general (Innes et al., 2021) and self-esteem (Grimaud et al., 2021). However, it is notable that only in the past two years have studies started to measure the effect of cognitive interventions on anxiety (Luo et al., 2024; Montero-Odasso et al., 2023). Previously, anxiety was measured only as an exclusion criterion and not to assess the intervention's effect.

4. Discussion

Based on the methodology and the review of articles, this study achieves its research goal of identifying the effect of cognitive training on executive functions and anxiety in patients with MCI. We present two trends in this systematic review: the effect of computerized cognitive training and virtual reality on executive functions and anxiety in people with MCI and the effect of emerging intervention strategies on executive functions and anxiety in people with MCI.

The studies related to the first trend suggest that computerized cognitive training and VR impact the different cognitive processes such as memory, perceptual skills, and praxis (Barnes et al., 2009; Belleville et al., 2006; Gajewski et al., 2020; Herrera et al., 2012; Rebok et al., 2014).

Furthermore, changes are evidenced in executive functions such as inhibitory control, working memory, reasoning, and processing speed, offering however reduced results (Baik et al., 2024; Chen et al., 2022; Gajewski et al., 2020; Nousia et al., 2023; Zhang et al., 2022). Likewise, we identified that this type of training has an impact on affective processes such as depression, apathy, and anxiety. While there are few results regarding the effect on anxiety levels, we found that cognitive training reduces them, although not significantly (Finn & McDonald, 2011; Thapa et al., 2020) However, most studies included in this review used anxiety as an exclusion criterion.

The studies related to the second trend split into two perspectives. One focuses on the use of programs or interventions based on non-invasive neurophysiological techniques (Cilli et al., 2023; Chan et al., 2024). These techniques have an effect on brain activity and mnesic processes of patients with MCI (De Sousa et al., 2020; Satorres et al., 2023; Zhang et al., 2022).

The other perspective addresses emerging intervention strategies such as music, relaxation techniques, gamification, and physical activity. These strategies are reported to modify overall cognition (Belleville et al., 2022; Satorres et al., 2023; Yuan et al., 2021; Zhang et al., 2022) and, to a lesser extent, cognitive processes in detail (attention, memory, executive functions). No significant effects of a specific intervention on these cognitive processes are found (Innes et al., 2021; Satorres et al., 2023) or effect is denied (Grimaud et al., 2021). Regarding executive functions, some studies show significant impacts of comprehensive interventions including diet, exercise, and cognitive training on overall cognitive function (Ngandu et al., 2015), The SMARTfit Dual-Task Exercise program showed improvements in attention, task-switching, and inhibitory control (Jhaveri et al., 2023). The SYNERGIC Trial demonstrated that a multidomain intervention improved cognitive flexibility, inhibition, and planning more effectively than exercise alone (Montero-Odasso et al., 2023)

Regarding emotional processes, the SYNERGIC Trial and another study found significant reductions in anxiety levels following multidomain interventions (Luo et al., 2024; Montero-Odasso et al., 2023) Some authors in this trend also address mood in general (Innes et al., 2021) and self-esteem (Grimaud et al., 2021). However, most studies used anxiety primarily as an exclusion criterion rather than to assess the intervention's effects.

5. Strengths and limitations

This systematic review includes 37 studies that collectively provide a broad perspective on the effects of cognitive training interventions on executive functions and anxiety levels in patients with mild cognitive impairment. The included studies employ a variety of tests and questionnaires, offering a comprehensive assessment of different aspects of cognitive and emotional functioning. Additionally, the review identifies two main research trends: the effects of computerized cognitive training and virtual reality on executive functions and anxiety, and the effects of emerging intervention strategies. This helps to understand the current landscape of research in cognitive interventions.

However, the review presents several limitations. The lack of comparison regarding the duration of interventions limits the ability to establish specific recommendations on the optimal duration of cognitive training sessions. Therefore, it is important that future research not only considers the immediate effects of the interventions but also examines how different durations and frequencies of training can impact cognitive performance and emotional well-being in the long term.

Another limitation is the impact of the educational level of participants, which can affect their performance on cognitive tests and their response to interventions. Individuals with higher educational levels tend to have greater cognitive reserve, which could influence how they respond to cognitive training. Therefore, it is important for future studies to consider the educational level of participants when designing and evaluating cognitive interventions.

6. Conclusion

In summary, this study has identified two main trends in research on cognitive training in people with MCI: the effects of computerized cognitive training and virtual reality, and the effects of emerging intervention strategies. Although positive impacts on various cognitive and emotional processes have been found, the evidence on anxiety reduction remains limited and not significant. Future research should address these limitations and explore the underlying mechanisms and the influence of variables such as training duration and the educational level of participants. It is necessary to conduct longitudinal studies to understand the effect and underlying mechanisms of cognitive training in patients with MCI.

Conflict of interest statement

The authors declare that the research was conducted in the absence of any potential conflict of interest.

Author Contributions

María Alexandra Cardona Tangarife (MACT), from the University of Manizales, was the author of the review article, taking care of compiling relevant literature, synthesizing key findings, and drafting the text. Daniel Alfredo Landínez Martínez (DALM), also from the University of Manizales, provided conceptual guidance for the article, offering strategic direction in topic selection, analytical approach, and manuscript structuring. Both authors reviewed and approved the final version of the manuscript.

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