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Review

Cognitive stimulation and cognitive results in older adults: A systematic review and meta-analysis

Isabel Gómez-Soria [a,b], Isabel Iguacel [a,b,c,*], Alejandra Aguilar-Latorre [b], Patricia Peralta-Marrupe [a], Eva Latorre [c,d], Juan Nicolás Cuenca Zaldívar [e,f], Estela Calatayud [a,b]

[a] Department of Physiatry and Nursing, Faculty of Health Sciences, Universidad de Zaragoza, Zaragoza, Spain
[b] Institute for Health Research Aragón (IIS Aragón), Zaragoza, Spain
[c] Department of Biochemistry and Molecular and Cell Biology, Faculty of Sciences, Universidad de Zaragoza, Zaragoza, Spain
[d] Growth, Exercise, Nutrition and Development (GENUD) Research Group, Universidad de Zaragoza, Zaragoza, Spain
[e] Research Group in Nursing and Health Care, Puerta de Hierro Health Research Institute - Segovia de Arana (IDIPHISA), Madrid, Spain
[f] Primary Health Center "El Abajon", 28231 Las Rozas de Madrid, Spain

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ABSTRACT

Background and Purpose: The lack of cognitive activity accelerates age cognitive decline. Cognitive stimulation (CS) tries to enhance cognitive functioning. The purpose of this systematic review and meta-analysis was to evaluate the effects of CS on cognitive outcomes (general cognitive functioning and specific cognitive domains) in older adults (aged 65 years or older, cognitively healthy participants, or with mild cognitive impairment, or dementia).

Methods: PubMed, Scopus and Web of Science databases were examined from inception to October 2021. A total of 1,997 studies were identified in these databases, and. 33 studies were finally included in the systematic review and the meta-analysis. Raw means and standard deviations were used for continuous outcomes. Publication bias was examined by Egger's Regression Test for Funnel Plot Asymmetry and the quality assessment tools from the National Institutes of Health.

Results: CS significantly improves general cognitive functioning (mean difference=MD = 1.536, 95%CI, 0.832 to 2.240), memory (MD = 0.365, 95%CI, 0.300 to 0.430), orientation (MD = 0.428, 95%CI, 0.306 to 0.550), praxis (MD = 0.278, 95%CI, 0.094 to 0.462) and calculation (MD = 0.228, 95%CI, 0.112 to 0.343).

Conclusion: CS seems to increase general cognitive functioning, memory, orientation, praxis, and calculation in older adults.

1. Introduction

Cognitive function decline is a common phenomenon on that occurs with age (Mahncke et al., 2006). The cognitive alterations have received a lot of attention in aging by the scientific community, especially on memory alterations (Novoa et al., 2008). Late-life cognitive decline ranges from normal, mildest, through mild cognitive impairment (MCI), to dementia as most severe form (Millán-Calenti et al., 2012).

In fact, perception, processing speed, attention, memory (Burke & Barnes, 2006) and executive function (Kaido et al., 2020) deteriorate during aging, thus cognitively healthy elderly subjects also have complaints in the ability to acquire, consolidate and remember new information.

MCI describes a stage of intermediate cognitive dysfunction, where the risk of conversion to dementia is increased, however, it is also possible that people diagnosed with MCI could revert to a normal cognitive state without deterioration over time (Gauthier et al., 2006). Cognitive problems in MCI include difficulties in memory, language, attention, orientation, calculation, abilities visuospatial and executive functions while the language is preserved (Langa & Levine, 2014). The prevalence of MCI in adults above 65 years is estimated around 18,5% (). Memory failures are predictors of future dementia in MCI subjects and vary depending on the level of cognitive impairment (Wolfsgruber et al., 2014). The probability that an MCI patient will develop dementia within 10 years of initial MCI diagnosis is 4.35 times than a healthy subject (Zhu et al., 2001).

* Corresponding author at: Department of Physiatry and Nursing, Faculty of Health Sciences, Universidad de Zaragoza, Zaragoza, Spain.
E-mail addresses: isabelgs@unizar.es (I. Gómez-Soria), iguacel@unizar.es (I. Iguacel).

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Dementia is the supreme worldwide burden for welfare and the health care system in the 21st century. The estimated number of people with dementia will increase from 47 million in 2015 to more than 140 million in 2050. As deterioration increases in patients with dementia, the costs of daily activity assistance and medical care also increase (Alzheimer's Disease International. 2013). Expenditure on long-term care services for older people with cognitive impairment in 2031, it may range between 0.83% and 1.11% of the Gross Domestic Product; these figures do not include the costs of informal care (Comas-Herrera & Knapp, 2016).

ACE-III: The Addenbrooke's Cognitive Examination; AChEIs: acetylcholinesterase inhibitors; AD: Alzheimeŕs disease; ADAS-Cog: Alzheimer disease assessment scale-cognitive; ADL: activities of daily living; CS: Cognitive stimulation; GDS: Global deterioration scale; MCI: Mild cognitive impairment; MEC-35: Spanish version of Mini-Mental State Examination; MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment score; PDD: Parkinson's disease dementia; TAU: Treatment as usual.

Cognitive stimulation (CS) plays an important role in learning and memory (Mather, 2020) and could offer beneficial effects on cognitive reserve and dementia risk (Collins et al., 2021). Moreover, the lack of cognitive activity accelerates cognitive decline (Woods et al., 2012); being able to accelerate the deterioration of both cognitively healthy elderly subjects and patients with dementia (Salthouse, 2006), therefore it should be started the as soon as possible (Woods et al., 2012). CS was defined by Clare & Woods, (2004) as "engagement in a range of group activities and discussions (usually in a group), aimed at general enhancement of cognitive and social functioning". On the one hand, it differs from cognitive training, that is, guided practice on a set of standard tasks to improve a specific cognitive function, and, on the other hand, from cognitive rehabilitation, an individualized approach aimed at improving performance in the daily life to achieve preselected personal goals.

CS includes different types of approaches such as: (1) reality orientation, which involves constant repetition of everyday life facts, (basic but important information, referring to person, place and time (Cafferata et al., 2021; Massoud & Léger, 2011); (2) validation, focuses on the attitude of respect, empathic listening and the person's subjective experience as opposed to objective facts (Cafferata et al., 2021; Spector et al., 2001); (3) reminiscence, consists of talking about past events and reflecting on the person's life, often with the help of props such as photographs, music, videos and objects (Cafferata et al., 2021; Lobbia et al., 2019; Spector et al., 2001); (4) multisensory therapy, is based on stimulation of the sense organs (smell, touch, vision, taste, and hearing), and includes activities such as fruit tasting, singing, and dancing (Kor et al., 2022); (5) cognitive activities, are activities designed for the prevention of cognitive function impairments (Calatayud et al., 2020; De Oliveira et al., 2014; Gomez-Soria et al., 2020) and (6) implicit learning, focused on acquiring knowledge about the structure of the environment without conscious awareness (Spector et al., 2010).

CS programs, which combine cognitive, emotional, and physical activities using various elements, can stimulate various aspects of cognitive function, making them more effective than single component programs. Furthermore, they have the advantage of arousing more the interest of the participants and encouraging a more active participation (Reijnders et al., 2013). In the UK, CS was firstly recommended by the National Institute for Health and Clinical Excellence NICE SCIE Guidelines have been upgraded in the recent revision (Duff, 2018) to improve cognition in people with mild to moderate dementia. In addition, CS is explicitly recommended in three criteria of a standard for psychosocial interventions by the National Memory Services Accreditation Program (MSNAP) (Hodge et al. 2016). CS is a cost-effective psychosocial intervention, recommended by national guidance (Dickinson et al., 2017). Therefore, different reviews and meta-analyses have evaluated the impact of CS on general cognitive functioning (Aguirre et al., 2013; Cafferata et al. 2021; Kim et al., 2017; Lobbia et al., 2019; Saragih et al., 2022; Sun et al., 2022; Wong et al., 2021; Woods et al., 2012), and only two of them have evaluated the impact of CS on specific cognitive domains (Cafferata et al., 2021; Lobbia et al., 2019). Furthermore, all these studies included only dementia patients.

Therefore, this systematic review and meta-analysis aimed to evaluate the impact of CS (independently or together with pharmacological treatment, particularly acetylcholinesterase inhibitors (AChEIs)) on cognitive outcomes, general cognitive functioning and specific cognitive domains (such as memory, attention, orientation, executive functions, language, verbal fluency, praxis, visuospatial abilities and calculation) in cognitively healthy elderly individuals, or with MCI, or dementia.

2. Methods

This systematic review adheres to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) (Rethlefsen et al., 2021) (see supplementary file 1, Table S1) and was registered in the PROSPERO database (ID number: CRD42021238120).

2.1. Search strategy

The databases PubMed, Web of Science and Scopus were used in this study. The specific search parameters used in all online databases (see supplementary file 2, Table S2). The search terms were adjusted to each respective database. The search was conducted from inception to October 2021.

When possible, the search included a vocabulary thesaurus (list of MeSH terms in PubMed). First, the CS related terms were combined. Secondly, the mental and cognitive outcome related terms were combined as follows: "healthy aging" OR "cognitive impairment" OR "Alzheimer" OR "dementia" OR "Parkinson" OR "Lewy Body Disease" OR "Pick Disease" OR "Huntingtońs Disease". Finally, both the CS and the mental and cognitive outcome terms were combined with "AND.".

2.2. Eligibility criteria

A specific question was constructed according to the PICOS (Participants, Interventions, Control, Outcomes, Study Design) principle (Table 1).

The following inclusion criteria were applied: (1) original studies (randomized controlled trials, clinical trials, observational studies, and pre-post studies); (2) studies performed in humans; (3) studies written in English, Spanish (4) participants aged 65 years or older of mean age and (5) studies with (5.1) cognitively healthy elderly participants with normal levels of cognitive functioning, (that is, i.e., Mini-Mental State Examination (MMSE) score $>$ 24, Spanish version of Mini-Mental State Examination (MEC-35) score $>$ 27 or Montreal Cognitive Assessment score (MoCA) $\geq$ 26) or (5.2) participants diagnosed of MCI, that is i.e., MMSE $\geq$ 24, MEC-35 24-27; Clinical Dementia Rating score 0.5, and National Institute of Neurological and Communicative Criteria for Disorders and Stroke-AD and Related Disorders Association (NINCDS-

Table 1
PICOS criteria for inclusion and exclusion of studies.

Parameter	
Participants	Older adults aged 65 years or older cognitively healthy, or with mild cognitive impairment, or dementia.
Interventions	CS according to the classification of Clare & Woods (2003).
Control/comparator group	Passive (no intervention, treatment as usual) or active controls (same or different intervention than intervention group).
Outcomes	Evaluate psychosocial variables, at least one of them (activities of daily living, mood-depression, mood-anxiety, quality of life, well-being, loneliness).
Study design	Randomized controlled trials, clinical trials, observational and pre-post studies

ADRDA) (McKhann et al., 1984), Petersen (Petersen, 2004; Petersen et al., 1999) Winblad et al., 2004, Gauthier et al., 2006, Spector (Spector et al., 2006; Spector et al., 2003) Diagnostic and Statistical Manual of Mental Disorders 5 (DSM5) (American Psychiatric Association, 2013), or (5.3) criteria for dementia, that is probable AD, patients diagnosed of AD, vascular dementia, Parkinsonś Disease dementia and other types of dementia (e.g., assessed with by a neurologist or psychiatrist or neuropsychological tests, Statistical Manual of Mental Disorders DSM, the National Institute of Neurological Disorders and Stroke, Association International Neurosciences and the Association Internationale pour la Recherche et l'Enseignement en Neurosciences (NINDS-AIREN) (Román et al., 1993), or a MoCA score 12-25 and MMSE score 10-25). Parkinson's disease dementia (PDD) or mild cognitive impairment or dementia (PD-MCI) according to (Emre et al., 2007; Litvan et al., 2012) and dementia with Lewy bodies (DLB) according to (McKeith et al., 2017). Furthermore, cognitive decline ranging from MCI to dementia according to scores of the Global Deterioration Scale (GDS) between 3 and 5.

The following exclusion criteria were applied: (1) articles that did not provide original data (e.g., systematic reviews, meta-analyses, literature reviews); (2) participants diagnosed with other cognitive impairments different to MCI and dementia; (3) studies that included other types of cognitive intervention different than CS; (4) articles that did not provide a control group.

2.3. Study selection and data extraction

Two authors (IG-S, EC) independently searched each database to obtain publications. Agreement between the authors was found for 90% of the publications while the remaining discrepancies were resolved by discussion. Relevant articles were obtained in full and assessed against the inclusion and exclusion criteria. Disagreements between the reviewers were resolved by consensus, when consensus could not be reached, arbitration by a third reviewer was applied (AA).

2.4. Quality assessment and publication bias

Publication bias was examined by performing Egger's Regression Test for Funnel Plot Asymmetry (Egger et al., 1997). Further confirmation was obtained through visual inspection of funnel plot symmetry, plotting the effect size in relation to the standard error.

Funnel plots were created using JAMOVI (Jamovi, 2021) to investigate publication bias. Publication bias was assessed by the Egger linear regression test, following the guidelines provided by Peters et al., 2006. Thus, funnel plots were created and tests were carried out when the meta-analysis had more than 10 studies, as a small number of studies lowers the test power to a point where it is too low to distinguish chance from actual asymmetry (Sterne et al., 2011). Besides, trim and fill funnel plots according to Duval & Tweedie (Duval & Tweedie, 2000a, 2000b) were created using the R Ver. 3.5.1 program (R Foundation for Statistical Computing, Institute for Statistics and Mathematics, Welthandelsplatz 1, 1020 Vienna, Austria) and the meta and metaphor packages (Supplementary file 81, Fig. 10).

Additionally, National Heart, Lung, and Blood Institute website ("Quality Assessment Tool for Controlled Intervention Studies, Observational Cohort and Cross-Sectional Studies and Pre-Post Studies With No Control Group. NIH National Heart, Lung, and Blood Institute Website. [Online].," 2013) was used for the assessment of the quality of the studies included in the present systematic review and meta-analyses.

2.5. Statistical analyses to conduct the meta-analyses

All the studies included in the present meta-analysis and systematic review met the established inclusion criteria. However, when extracting the data, some information was missing. Although corresponding authors were contacted to collect the missing information to conduct the meta-analyses (Leroi et al., 2019; Lok et al., 2020; Marinho et al., 2021; Middelstadt et al., 2016, Oliveira et al., 2018; Vega Rozo et al., 2016) only two authors responded and gave us the required missing data (Leroi et al., 2019; Lok et al., 2020).

The following subgroups were analyzed: (1) cognitive status ("cognitively healthy elderly or "MCI"; or "dementia"); (2) age ("≤75 years/ ">75 years"); (3) "computerized CS"; or "traditional CS"; (4) "personalized-adapted CS" or "non-personalized/non-adapted CS"; (5) "individual CS" or "group CS"; (6) "short-term" (duration of the CS is less than 3 months); "maintenance or medium-term" (duration of the CS is between 3 and 6 months); or "long-term" (duration of the CS is more than 12 months) (Aguirre et al., 2010); (7) 30 min/session; < 45 min/session; or > 45 min/session; (8) subtype of control (active, passive or TAU); (9) "fair"; or "good" quality of studies; (10) "alone CS" or "CS + AChEIs"; (11) origin of the studies ("America", "Asia", or "Europe"); (12) "type of memory" (fixation memory, short-term, episodic memory, visuospatial memory, visual memory, or auditive memory); (13) type of orientation (temporal or spatial); (14) "type of verbal fluency" (semantic or phonemic); and (15) type of praxis (ideational or constructional) as long as the information was available. The gender of the participants could not be analyzed.

With the continuous variables "time of session", "number of sessions (min)", "total duration (weeks)" and "scores quality of studies (%"), heterogeneity was assessed through meta-regressions using the restricted maximum likelihood (REML), recommended as an estimator of heterogeneity to avoid bias (Tanriver-Ayder et al., 2021).

The standardized mean difference was chosen as the effect size metric to combine the results. When it was not directly provided by the authors, it was calculated from the mean, standard deviation, and sample size. When the Standard Deviation (SD) was not reported in the study, the authors were contacted. If no response was received, the following formula was applied: standard error = SD/ $\sqrt{n}$; SD = interquartile range/1.35. When the mean was not reported in the studies, the median was used. When possible, subgroup analyses were conducted. Several specific subgroup analyses were not performed because of a lack of studies (i.e., subgroups for which data could be obtained from only one study).

Then, all results were pooled using the DerSimonian-Laird method in a random-effects meta-analysis (DerSimonian & Kacker, 2007) with the OpenMetaAnalyst software (Wallace et al., 2012).

In addition, heterogeneity across studies using the I^2 statistic was estimated. Heterogeneity was considered as not important (0%–40%), moderate (30%–60%), substantial (50%–90%), or considerable (75%–100%) (Higgins & Thompson, 2002). Moreover, the corresponding p-values were also taken into account.

3. Results

3.1. Study selection

The initial search provided a total of 2,108 records. The process used to detect duplicates was carried out through Microsoft Excel and the process was repeated twice, with a final manual revision. After removing duplicates and including studies identified through reference scanning, 1,997 potentially relevant studies were found, which were further filtered based on their title and abstract, remaining 64. After reading the full texts, 33 articles were finally included in the systematic review and the meta-analysis. The PRISMA diagram for the study selection is detailed in Fig. 1 and studies excluded by text complete (see Supplementary file 3, Table S3).

32 studies evaluated general cognitive functioning (Fig. 2a.) (Alvares-Pereira et al., 2020; Alves et al., 2014; Calatayud et al., 2020; Capotosto et al., 2017; Carbone et al., 2021; Coen et al., 2011; Cove et al., 2014; Ciarmiello et al., 2015; Fernández Calvo et al., 2010; Folkerts et al., 2018; Gibbor, et al., 2020; Gómez-Soria et al., 2020; Gómez-Soria, Brandín-de la Cruz, et al., 2021; Gómez-Soria, Esteban,

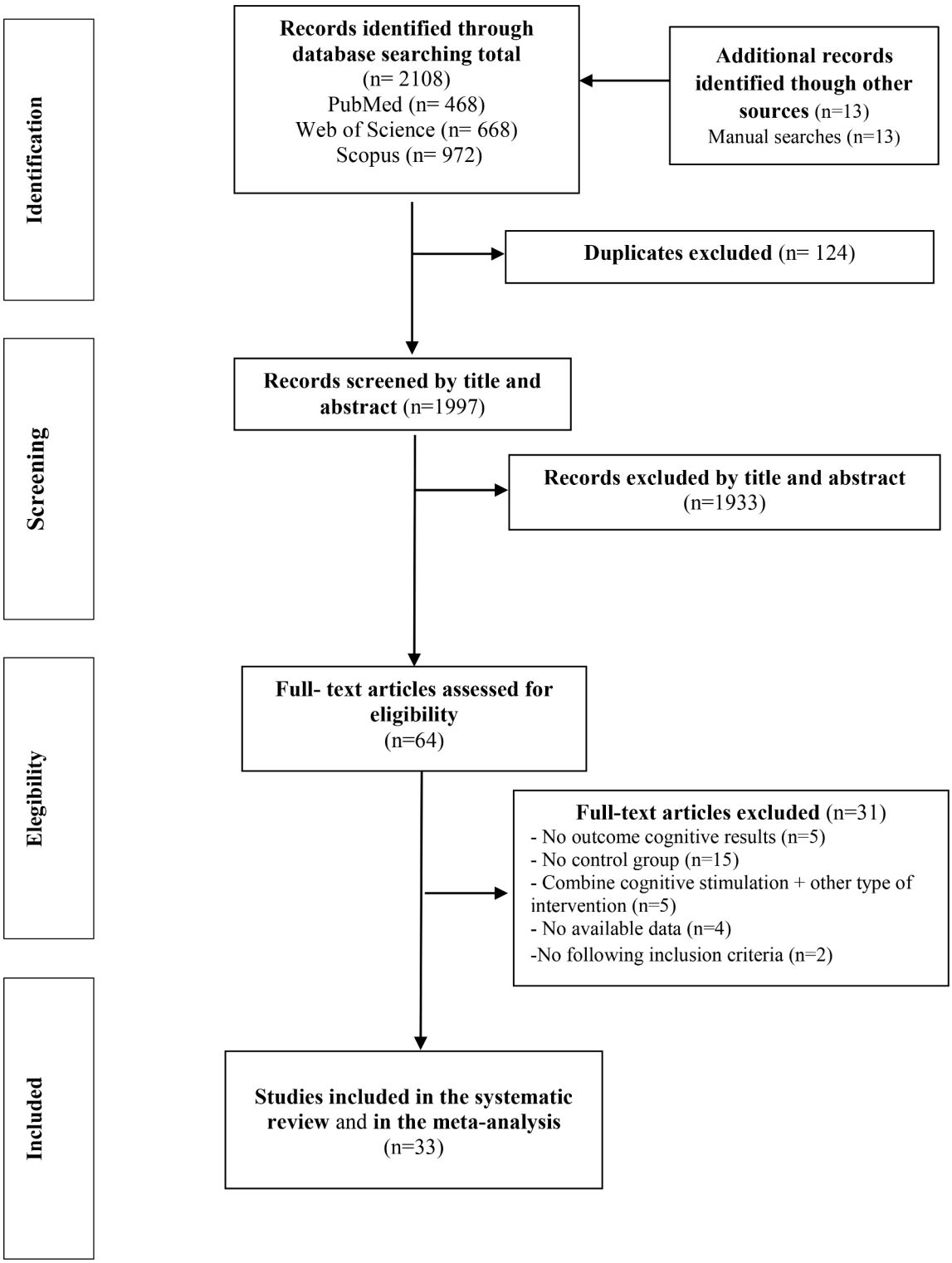

Fig. 1. PRISMA Diagram- the process of study selection. From: Rethlefsen, M. L., Kirtley, S., Waffenschmidt, S., Ayala, A. P., Moher, D., Page, M. J., & Koffel, J. B. (2021). PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews. *Systematic Reviews, 10*(1), 1-19. https://doi.org/10.1186/S13643-020-01542-Z.

et al., 2021; Juárez-Cedillo et al., 2020; Justo-Henriques et al., 2019, 2021; Leroi et al., 2019; Liu et al., 2021; Lok et al., 2020; López et al., 2020; Miranda-Castillo et al., 2013; Niu et al., 2010; Oliveira et al., 2021; Orgeta et al., 2015; Orrell et al., 2014; Piras et al., 2017; Polito et al., 2015; Spector et al., 2003; Tarnanas et al., 2014; Tsai et al., 2019), 18 studies evaluated specific cognitive domains (memory, attention, orientation, executive functions, language, verbal fluency, praxis, calculation and visuospatial abilities) (Alvares-Pereira et al., 2020; Alves et al., 2014; Calatayud et al., 2020; Capotosto et al., 2017; Carbone et al., 2021; Ciarmiello et al., 2015; Djabelkhir et al., 2017; Gómez-Soria, Brandín-de la Cruz, et al., 2021; Gómez-Soria, Esteban, et al., 2021; Juárez-Cedillo et al., 2020; Justo-Henriques et al., 2019; Leroi et al., 2019; Liu et al., 2021; López et al., 2020; Piras et al., 2017; Polito et al., 2015; Spector et al., 2010; Tarnanas et al., 2014) (Fig. 2b).

Authors, year	Participants	MMSE	ADAS-Cog	MoCA	MEC-35	MODA	CERAD	ACE-III
1-Spector et al. 2003	Dementia	■	■					
2-Fernández-Calvo et al. 2010	Dementia		■					
3-Niu et al. 2010	Dementia	■						
4-Coen et al. 2011	Dementia	■						
5-Miranda-Castillo et al. 2013	Dementia	■	■					
6-Alves et al. 2014	MCI and dementia	■	■					
7-Cove et al. 2014	Dementia	■	■					
8-Orell et al. 2014	Dementia	■	■					
9-Polito et al. 2014	Cognitively healthy elderly/MCI	■		■				
10-Tarnanas et al. 2014	MCI	■						
11-Ciarmiello et al. 2015	MCI	■				■		
12-Ortega et al. 2015	Dementia	■	■					
13- Capotosto et al. 2017	Dementia	■	■					
14-Djabelkhir et al. 2017	MCI	■						
15-Piras et al. 2017	Dementia	■	■					
16-Calatayud et al. 2018	Cognitively healthy elderly				■			
17-Folkerts et al. 2018	Dementia						■	
18-Justo-Henriques et al. 2019	MCI	■		■				
19-Leroi et al. 2019	PDD, PD-MCI, DLB							■
20-Lok et al. 2019	Dementia	■						
21-Tsai et al. 2019	MCI and dementia		■					
22-Alvares-Pereira et al. 2020	Dementia		■					
23-Gibbor et al. 2020	Dementia	■	■					
24-Gómez-Soria et al. 2020	MCI				■			
25-Juárez-Cedillo et al. 2020	Dementia	■	■					
26-López et al. 2020	Dementia	■	■					
27-Carbone et al. 2021	Dementia	■	■					
28-Gómez-Soria, Andrés-Esteban et al. 2021	MCI				■			
29-Gómez-Soria, Brandín-de la Cruz et al. 2021	MCI				■			
30-Justo-Henriques et al. 2021	MCI	■		■				
31-Liu et al. 2021	Dementia		■					
32-Oliveira et al. 2021	Dementia	■						

DLB: Dementia with Lewy bodies; MCI: Mild cognitive impairment; PD-MCI: Mild cognitive impairment or dementia; PDD: Parkinson's disease dementia.

Fig. 2a. General cognitive functioning.

In the Fernández Calvo et al., 2010 study, one group performs CS in format individual and other group CS in format group.

3.2. Study characteristics

The main characteristics of the participants and CS were extracted from the selected studies and can be consulted in Table 2. Additionally, the specific cognitive domains and activities of CS are shown (see

Authors, year	Participants	M	A	O	EF	L	VF	P	C	VA
1-Spector et al. 2010	Dementia	■		■		■		■		
2-Alves et al. 2014	MCI and Dementia	■			■					
3-Polito et al. 2014	Cognitively healthy elderly /MCI	■								
4-Tarnanas et al. 2014	MCI	■			■	■	■	■		■
5-Ciarmiello et al. 2015	MCI	■			■			■		
6- Capotosto et al. 2017	Dementia				■	■				
7-Djabelkhir et al. 2017	MCI	■	■		■		■			
8-Piras et al. 2017	Dementia	■			■	■				
9-Calatayud et al. 2018	Cognitively healthy elderly	■	■	■		■	■	■	■	
10-Justo-Henriques et al. 2019	MCI	■	■	■	■	■		■		■
11-Leroi et al. 2019	PDD, PDD-MCI; DLB	■	■			■	■			■
12-Alvares-Pereira et al. 2020	Dementia	■		■		■		■		
13-Juárez-Cedillo et al. 2020	Dementia						■			
14-López et al. 2020	Dementia	■			■	■	■			■
15-Carbone et al. 2021	Dementia				■					
16-Gómez-Soria, Andrés-Esteban et al. 2021	MCI	■	■	■				■	■	
17-Gómez-Soria, Brandín-de la Cruz et al. 2021	MCI	■	■	■				■	■	
18-Liu et al. 2021	Dementia	■				■		■		

A: Attention; C: Calculation; DLB: Dementia with Lewy bodies; EF: Executive functions; L: Language; M: Memory; MCI: Mild cognitive impairment; O: Orientation; PD-MCI: Mild cognitive impairment or dementia; PDD: Parkinson's disease dementia; P: Praxis; VA: Visuospatial abilities; VF: Verbal fluency.

Fig. 2b. Specific cognitive domains.

supplementary file 4, Table 4). Measurements and the observed effect included in psychosocial variables in each individual study is available (see supplementary file 5, Table 5.)

A total of 2.724 participants (63.8% females) were analyzed. The mean age of the participants was 78.8 years. Regarding the origin of the studies 81,8% were conducted in Europe, 12.1% in Asia, and 6.1% in America. 3% of studies included cognitively healthy elderly individuals, 3% of studies included both cognitively healthy elderly individuals and MCI, 24.2% of studies included participants with MCI, and 60.6% of the studies included participants with dementia and 9.1% of the studies included both, MCI and dementia.

The intervention provider was nurse ($n = 1$), neuropsychologist ($n = 5$), occupational therapist ($n = 5$), psychologist ($n = 3$), psychologist and therapeutic assistants ($n = 1$) therapist ($n = 3$), carer ($n = 2$), and team specially ($n = 2$). In 11 studies they did not specify which professional carried out the intervention. The study setting was residential care ($n = 7$), community ($n = 18$) and residential care together community ($n = 8$).

Interventions carried out were diverse: 30 studies included traditional interventions and 3 studies computerized interventions, 27 studies include group intervention, 5 studies included individual intervention and one study both (group and individual). Particularly, the studies included the following types of CS: 30 studies applied cognitive activities, 21 studies applied reality orientation, 12 studies administered multisensory stimulation, 7 studies applied reminiscence, 6 studies introduced implicit learning, 1 study applied validation therapy; in addition, 8 studies introduced external aids. Furthermore, in 16 studies adjusted the level of difficulty of the CS or personalized the intervention. Regarding the pharmacological treatment; in 4 studies participants did not take AChEIs, in 2 studies participants took AChEIs and 26 studies did not specify whether participants take or not AChEIs. In the study of Orrell et al. (2014), subgroup analyses were also carried out, differentiating between the participants who only took CS and those who, in addition to CS, took AChEIs.

There were some differences regarding the type of control used. Six studies included an active control group. Tarnanas et al. (2014), included an active and passive control group. Orrell et al. (2014) included treatment as usual (TAU) and in the subgroup also included AChEIs. In 24 studies participants received their TAU and in 2 studies the participants were in a waitlist for intervention.

3.3. Methodological quality assessment in Individual Studies

The risk of bias assessment for all included studies is summarized (see supplementary file 6-8, Tables S6.a-6.c). Overall, our analysis indicates that 14 studies had good methodological quality and 19 studies presented fair methodological quality.

On the one hand, the method of randomization was not reported in 9 studies and in the others 10 studies the treatment allocation concealed not reported. On the other hand, participants and providers were not blinded to treatment group assignment in 18 studies and in 6 studies people assessing the outcomes were not blinded to the participants' group assignments. Besides, there was no high adherence to the intervention protocols for each treatment group in 21 studies; the authors did not report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power in 7 studies. In addition, the outcomes not reported subgroups analyzed pre-specified in 7 studies, and in 22 studies, an intention-to-treat analysis was not performed.

3.4. Effects of CS in relation to cognitive variables in older adults

3.4.1. General cognitive functioning

As shown in Fig. 3a a significant improvement in general cognitive functioning was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS

Table 2
Main characteristics of the participants and cognitive stimulation.

Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country (Setting)	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
1- Spector et al. 2003 RCT	CS adapted: reminiscence, reality orientation and multisensory (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Dementia DSM–IV	201 (43/158) IG: 115 CG: 86	ns	UK (Day centers and residential care)	85.3 (7.0)	ns	MMSE 14.4 (3.8)	MMSE: sd.
2- Fernández-Calvo et al. 2010 Pre-post study	Multimodal CS: cognitive activities. (AChEIs not specified) (Individual/ Group)	TAU	60 min/session Three times a week 3 months, 36 sessions (Maintenance)	AD probably NINCDS-ADRDA; McKhann et al., 1984	45 (25/20) GI individual format: 15 GI group format: 15 GC: 15	ns	Spain (Association of Alzheimer's patients)	75.33 (4.76)	7.38 (2.93)	MMSE 18.97 (2.44)	ADAS-Cog; sd.
3- Niu et al. 2010 RCT	CS: reality orientation and cognitive activities. (AChEIs not specified) (Individual)	Active Communi-cation exercise.	45 min/session Twice a week 10 weeks, 20 sessions (Short-Term)	AD probably NINCDS-ADRDA McKhann et al., 1984	32 (25/7) GI:16 GC:16	Trained Therapists	China (Military sanatorium)	79.85 (4.31)	10.68 (1.88)	MMSE 17.12 (3.13)	MMSE: sd
4- Spector et al. 2010 RCT	CS: reality orientation, reminiscence, implicit learning and multisensory. (No specific if take AChEIs) (Group)	TAU	45 min/session Twice a week 7 weeks 14 sessions	Dementia DSM-IV MMSE 10- 24	201 (43/158) IG: 115 CG: 86	ns	UK (Day centers and residential care homes)	85.3 (7.0)	ns	MMSE 14.4 (3.8) ADAS-Cog 27 (7.5)	ADAS-Cog: sd. Language: sd.
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
5- Coen et al. 2011 RCT	CS: cognitive activities. (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia Spector et al. 2003	27 (13/14) IG: 14 CG: 13	Occupational Therapists	Ireland (Residential care)	79.85 (5.6)	ns	MMSE 16.9 (5.05)	MMSE: sd.
6- Miranda-Castillo et al. 2013 Pre-post study	CS: reality orientation, reminiscence, cognitive activities and multisensory. (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate AD DSM-IV-TR	22 (8/14) IG: 12 CG: 12	ns	Chile (Residential care)	83.65 (9.95)	91.9 % Basic	MMSE 19 (3.95)	IG MMSE: sd.
7- Alves et al. 2014 RCT	CS adapted: reminiscence, reality orientation, cognitive activities and multisensory. (AChEIs not specified) (Group)	TAU Wait-list/brief intervention	60 min/session Three times a week, except the last week twice a week 1.5 months, 17 sessions (Short-Term)	From MCI to mild to moderate dementia GDS 3-5	17 (4/13) IG:10 CG:7	Psychologist and therapeutic assistants	Portugal (Day centers and residential care)	78.65 (10.72)	1.98 (2.33)	MMSE 18.06 (4,64)	MMSE: no sd.
8- Cove et al. 2014 RCT	Home-based CS adapted: reality orientation and cognitive activities. (AChEIs not specified) (Individual)	TAU Wait-list	45 min/session Once a week 14 weeks, 14 sessions (Short-Term)	Dementia DSM IV MMSE 18-24	59 (36/32) IG: 24 CG: 13	Carer Using the guiding principles of CS	UK (Community)	76.37 (6.55)	ns	MMSE 22.65	MMSE: no sd ADAS-Cog: no sd Sub-scalas ADAS-Cog: no sd

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Table 2 (*continued*)

Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country (Setting)	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
9- Orrell et al. 2014 RCT	Alone CS (reality orientation, cognitive activities and multisensory) and CS + AChEIs (Group)	TAU AChEIs	45 min/session Once a week 24 weeks, 24 sessions (Maintenance)	Dementia DSM-IV	236 (86/150) Alone CS: 81 CS+AChEIs:42 TAU:79 AChEIs: 34	ns	London (Residential care, and community)	83.1 (7.55)	ns	MMSE 17.8 (5.5)	CS + AChEIs MMSE: sd (three and six months) ADAS-Cog: no sd
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
10- Polito et al. 2014 RCT	CS: reality orientation, implicit learning and cognitive activities. (No specific if take AChEIs) (Group)	Active Two interactive 60-min meetings	90 min/session Twice a week 10 weeks 20 sessions	HA and MCI Petersen's criteria 2004 and Guaitas criteria et al.,2013	77 CHA (29/48) IG: 38 CG: 39 44 MCI (31/13) IG:22 CG:22	Trained Neuropsychologist	Italy (Community and residential care home)	HA 73.8 (1.25) MCI 74.15 (1.55)	HA 7.65 (3.0) MCI 7.45 (3.2)	HA MMSE 28.05 (1.55) MCI MMSE 25.75 (1.95)	Cognitive healthy elderly and MCI: MMSE and MoCA sd Cognitive healthy elderly and MCI: MMSE: no sd.
11- Tarnanas et al. 2014 RCT	CCS cognitive activities, implicit learning, virtual reality and external aids. (AChEIs not specified) (Group)	Active Learning-based memory training. Passive No-contact	90-min session Twice a week 5 months, 40 sessions (Maintenance)	MCI Petersen's criteria 1999, 2004 Winblad 2004 Gauthier et al. 2006	95 (41/54) IG: 32 CAG: 39 CG: 34	Psychologists	Greece (Day Clinic)	70.37 (4.4)	ns	MMSE 26.4 (3.43)	.MMSE: sd. RAVLT delayed recall, ROCF inmediate recall BNT, digit span forward, letter fluency and Trail B: sd
12- Ciarmiello et al. 2015 Observa-tional study	CS: multisensory and cognitive activities. (Group)	Active Informal meeting	45 min/session Twice a week 4 months, 32 sessions (Maintenance)	MCI MMSE ≥ 24	30 (12/17) IG: 15 CG: 15	Experienced Neuropsychologists	Italy (Hospitals Neurology Unit)	71.59 (7.13)	8.56 (2.82)	MMSE 27.85 (1.84)	Prose memory: sd
13- Orgeta et al. 2015 RCT	Home-based CS (reality orientation, reminiscence, validation, implicit learning, multisensory and cognitive activities) + AChEIs (Individual)	TAU	30 min/session Three times weekly 25 weeks, 75 sessions (Maintenance)	Dementia DSM-IV MMSE > 10	356 (191/165) IG: 180 CG: 176	Family carers Carer training and support was provided by the research (team mental health nurses, clinical psychologists, occupational therapists or research assistants)	UK (Community)	78.2	Highest level of education School leaver (14–16 years) 60%	MMSE 21.22 (4.30)	MMSE, ADAS-Cog: no sd
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
14- Capotosto et al. 2017 RCT	CS adapted: reality orientation, implicit learning, and cognitive activities.(Group)	Active Educational activities.	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia Spector et al. 2006	39 (12/27) IG: 20 CG: 19	ns	Italy (Residential care)	88.25 (5.15)	6.15 (2.60)	MMSE 18.25 (3.39)	ADAS-Cog: sd.
15- Djabelkhir et al. 2017	CCS: cognitive activities and external aids.	Active CCE and stimulate	90 min/session Once a week 3 months, 12	MCI Petersen 2004 and Winbland 2004.	20 (6/14)	Neuropsychologist	France (Community)	76.7 (6.7)	52.2% Degree or higher	MMSE 27.55 (1.95)	MMSE: no sd. Trail Making Test and self-esteem: sd

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Table 2 (*continued*)

Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country (Setting)	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
RCT	(AChEIs not specified) (Group)	social interaction.	sessions (Maintenance)		IG: 10 CG: 10						
16- Piras et al. 2017 RCT	CS: reality orientation and cognitive activities. (Group)	Active Educational activities.	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Vascular dementia NINDS-AIREN Roman et al. 1993	35 (7/28) IG: 21 CG: 14	ns	Italy (Residential care)	84.62 (8.06)	5.27 (2.46)	MMSE 19.66 (4.04)	MMSE, ADAS-Cog, Backward digit span: sd
17- Calatayud et al. 2018 RCT	CS personalized and adapted: reality orientation, cognitive activities and external aids. (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	Cognitive healthy participants ME-35 > 27	201 (69/132) IG: 100 CG: 101	Trained Occupational Therapist	Spain (Health Center)	72.91 (5.69)	51% Complete primaries	MEC-35 31.34 (2.14)	MEC-35: sd.
18- Folkerts et al. 2018 Randomi-zed crossover trial	CS: cognitive activities. (AChEIs not specified) (Group)	TAU	60 min/session Twice a week 8 weeks, 16 sessions (Short-Term)	PDD By neurologist or psychiatrist MMSE 10–25	12 (10/2) IG: 6 CG: 6	Trained Psychologist	Netherlands (Residential care)	76.59 (7.26)	9.84 (1.08)	MMSE 17.84 (5.55)	CERAD: no sd.
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
19- Justo Henriques et al. 2019 Pre-post study	CS: reality orientation and cognitive activities. (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 44 weeks, 88 Sessions (Long-Term)	Mild Neurocog-nitive disorder DSM 5	30 (8/22) IG: 15 CG: 15	Experienced Therapist	Portugal (Day center and community)	78.8 (11.6)	66.6% > 4 years	MMSE 19.95 (3.55)	MoCA: sd. Language: sd
20- Leroi et al. 2019 RCT	Home-based adapted, CS: cognitive activities. (AChEIs not specified) (Individual)	TAU	30 min/session Two to three times per week. 10 weeks (Short-term)	PD-MCI (Level 1), PDD (probable or possible) Litvan et al. 2012, Emre et al. 2007, or DLB Mckeith et al. 2017	76 (60/16) IG:38 CG:38	A specially trained implementer (eg, nurse, therapist or researcher) visit the dyad at home and provide intervention	UK (Community)	74.75	Up to 18-year-old schooling Further education and higher	ACE-III 63.24	ACE-III: no sd
21- Lok et al. 2019 RCT	CS adapted (cognitive activities and implicit learning) + AChEIs. (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	AD By Internatio-nal Working Group MMSE 13-24	60 (30/30) GI: 30 GC: 30	Nurse	Turkey (Neurology Polyclinic)	ns	60.05% Higher	MMSE 17.05	MMSE: sd.
22- Tsai et al. 2019 Pre-post study	CS adapted: reality orientation, multisensory and cognitive activities. (Group)	TAU	90 min/session Once a week, 14 weeks, 14 sessions (Short-term)	MCI and mild moderate dementia MMSE 14-27	25 (6/19) IG: 12 CG:13	Occupational therapists, social workers, nurse, day care center supervisors, and occupational therapist students.	Taiwan (Day center)	77.71 (5.66)	Illiterates 19.55% Literates with no schooling 8% Primary school 20.2% Secondary school 32.05%	MMSE 20.26	ADAS-Cog: sd

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Table 2 (*continued*)

Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country (Setting)	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
									High school 11.85% College 4.15% Unknown 4.15%		
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
23- Alvares-Pereira et al. 2020 RCT	CS: cognitive activities. (AChEIs not specified) (Group).	TAU	45-60 min/ session Twice a week 7 weeks, 14 sessions (Short-Term)	Neurocognitive disorder (dementia) DSM5	100 (9/91) IG: 50 CG: 50	ns	Portugal (Residential care, psycho-geriatric and rehabilitation center)	83.60 (7.64)	55.65% ≤4 years	ns	ADAD-Cog: sd.
24- Gibbor et al. 2020 RCT	CS adapted: reality orientation, multisensory and cognitive activities. (AChEIs not specified) (Individual)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia DSM-IV	33 (17/16) IG 17 CG: 16	ns	UK (Residential care)	81.85 (10.31)	ns	MMSE 21.70 (3.51)	MMSE: no sd. ADAS-Cog: sd.
25 -Gómez-Soria et al. 2020 RCT	CS personalized and adapted: reality orientation, cognitive activities and external aids. (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24-27	122 (28/94) IG: 54 CG: 68	Trained Occupational Therapist	Spain (Health Center)	74.99 (6.02)	Primary 88.78% Secondary 11.05%	MEC-35 25.91 (1.03)	Short and médium term MEC-35: sd.
26- Juárez-Cedillo et al. 2020 RCT	Multicom-ponent CS adapted (reality orientation, multisensory, cognitive activities and external aids) + AChEIs (Group)	TAU	90 min/session Twice a week 8 weeks, 16 sessions (Short-Term)	Mild neurocognitive disorder DSM5 and NINCDS-ADRDA	67 (21/46) IG: 39 CG: 28	Neuropsychologist	Mexico (Institute of Social Security)	77.7 (8.15)	14.5 % None 24% 4 years 61.5 <3 years	MMSE 22.4 (0.8)	MMSE, ADAS-Cog, Semantic and Phonemic Verbal Fluency: sd
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
27- López et al. 2020 Pre-post study	CS 'review notebooks' adapted (reality orientation and cognitive activities) (AChEIs not specified) (Group)	TAU	60 min/session Three times a week 6 months	Mild-moderate dementia type Alzheimer's Stage 4-5 on the GDS scale.	30 (5/15) GI: 15 15	ns	Spain (/Center for Attention to people with AD and other dementias)	81.9 (5.47)	ns	MMSE 17.84 (3.73)	MMSE, ADAS-Cog: no sd WCST-Errors: sd
28- Carbone et al. 2021 Controlled clinical trial	CS adapted:reality orientation and cognitive activities. (AChEIs not specified) (Group)	Active Educational activities.	45 min/session. Twice a week 7 weeks, 14 sessions (Short-Term)	Major neurocogni-tive disorder. DSM 5 Mild-to-moderate Dementia. Spector et al., 2003	225 (76/149) IG: 123 CG: 102	Trained Psychologists	Italy (Residential care or day centers)	83.66 (8.10)	6.47 (3.67)	MMSE 20.04 (4.19)	Short and long term MMSE: sd Shor-term ADAS-Cog y Narrative Language Test

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Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/ week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country (Setting)	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
29- Gómez-Soria, Andrés-Esteban et al. 2021 RCT	CS personalized and adapted:reality orientation, cognitive activities and external aids. (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24-27	29 (6/23) IG: 15 CG: 14	Trained Occupational Therapist	Spain (Health Center)	72.7 (5.05)	Primary 48.3% Secondary 51.7%	MEC-35 26.14 (0,92)	Short, médium and long-term MEC-35: s.d. Spatial orientation: s.d.
30- Gómez-Soria, Brandín-de la Cruz et al. 2021 RCT	CS personalized and adapted: reality orientation, cognitive activities and external aids (AChEIs not specified) (Group)	TAU	45 min/session Once a week 10 weeks, 10 sessions (Short-Term)	MCI MEC-35: 24-27	50 (11/39) IG: 23 CG: 27	Trained Occupational Therapist	Spain (Health Center)	74.32 (5.47)	Primary complete 44%	MEC.35 25.87 (1.058)	Long-term MEC-35, global orientation and spatial orientation: s.d.
Study (Author, year and design)	Type of CS (AChEIs) (Individual or group)	Control group	Frequency (duration, session/week, duration)	Cognitive status (Diagnosis criteria)	N (male/ female)	Professionals that administered the intervention	Country Setting	Mean age (Standard deviation)	Education (Standard deviation)	Baseline score general cognitive functioning	Main Results
31- Justo-Henriques et al. 2021 Pre-post study	CS: reality orientation and cognitive actitivities. (AChEIs not specified) (Individual)	TAU.	45 min/session Twice a week 44 weeks, 88 sessions (Long-Term)	Mild neurocognitive disorder DSM 5	82 (24/58) IG: 41 CG: 41	Trained Therapists	Portugal (Psychosocial support organization)	79.3 (10)	76.8 % 1-4 years	MMSE 19.9 (3.3)	MMSE and MoCA: sd
32- Liu et al. 2021 Observa-tional study	CS adapted:cognitive activities. (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 7 weeks, 14 sessions (Short-Term)	Mild to moderate dementia. Clinical diagnosis MMSE > 18	29 (10/19) IG: 16 CG: 13	ns	China (Community)	80.29 (6.16)	4.78 (4.67)	ADAS-Cog 21.54 (8.29)	ADAS-Cog: no sd.
33- Oliveira et al. 2021 Pilot RCT	CCS cognitive activities, exteranal aids and virtual reality. (AChEIs not specified) (Group)	TAU	45 min/session Twice a week 6 weeks, 12 sessions (Short-Term)	Major neurocogni-tive disorders due to AD by a psychologist	17 (5/12) IG: 10 CG: 7	Clinical Neuropsycholo-gist	Portugal (Residential care)	83.24 (5.66)	23.5% Higher	MMSE 15.8 (7.01)	MMSE: sd.

ACE-III: The Addenbrooke's Cognitive Examination; AChEIs: Acetylcholinesterase Inhibitors; AD: Alzheimer's disease; ADAS-Cog: Alzheimer's Disease Assessment Scale; BADL: Basic ADLs; CAG: Control active group; CDR: Clinical Dementia Rating; CCE: Computerized Cognitive Engagement; CCS: Computerized Cognitive stimulation; CG: Control Group; DLB: Dementia with Lewy bodies; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders (4th ed); DSM-IV-TR: Diagnostic and Statistical Manual of Mental Disorders (4th edn) (Text Revision) ; DSM5: Neurocognitive Disorder Diagnostic and Statistical Manual of Mental Disorders, 5th edition: IADL: Instrumental ADLs;; ICD-10: International Classification of Diseases 10th Revision; IG: Intervention Group; MEC-35: Spanish version of the MMSE; MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment; NINCDS-ADRDA: National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association; NINDS-AIREN: National Institute of Neurological Disorders and Stroke - Association International Neurosciences; PDD: Parkinson's disease dementia; PD-MCI: mild cognitive impairment or dementia; RCT: Randomized controlled trial; TAU: Treatment as usual. ns: not specified.
sd: significant differences.

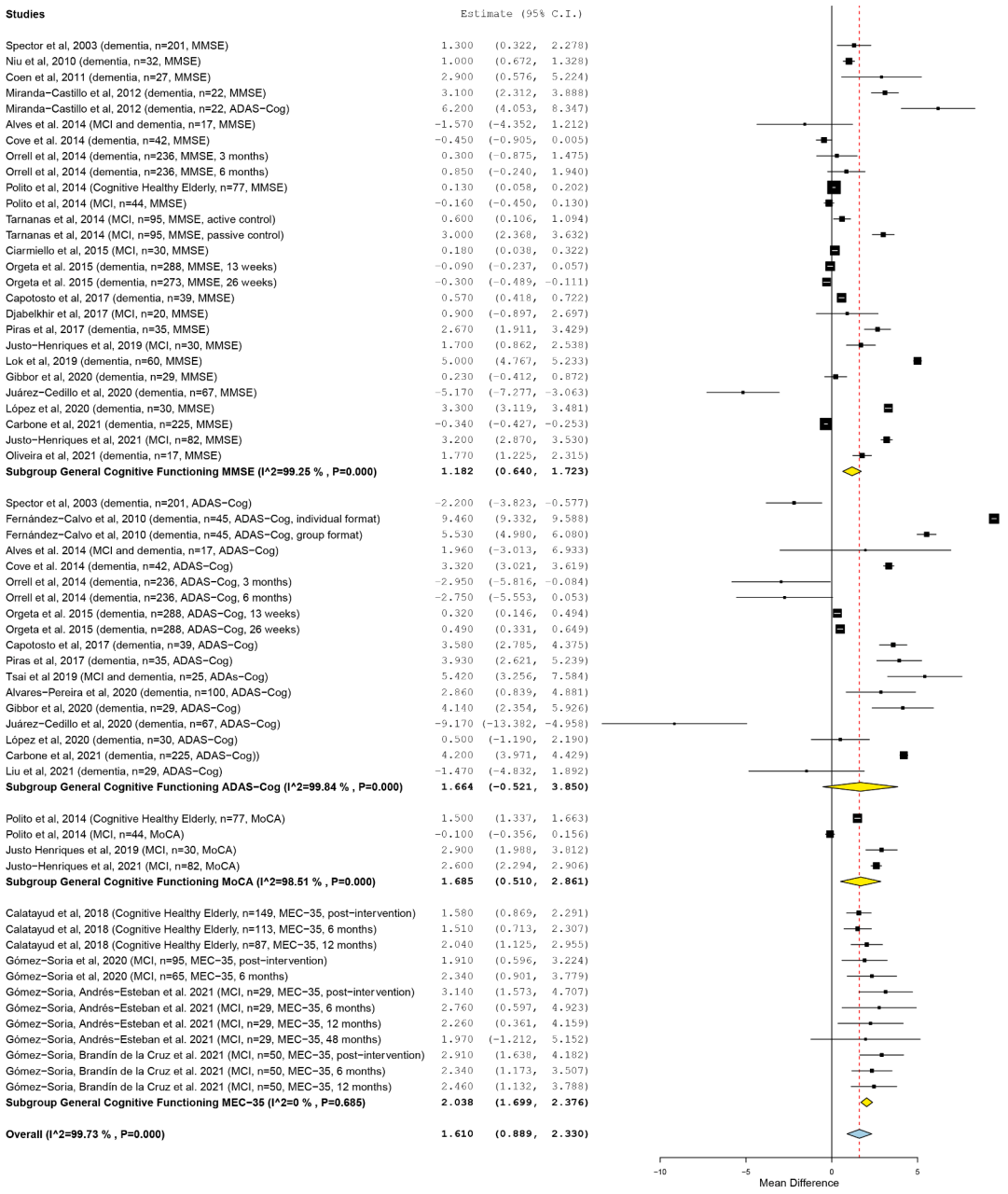

Fig. 3a. Forest plot of effect sizes (ESs) from the studies that assessed general cognitive functioning.

(control groups) (MD = 1.536 95%CI, 0.832 to 2.240). Heterogeneity among studies for general cognitive functioning was very high (I^2 = 99.72; $p < 0.001$).

Subgroup analysis showed statistically significant improvements in general cognitive functioning in MMSE (MD = 1.182; 95%CI, 0.640 to 1.723; see supplementary file 9, Fig. S1.a.), in MoCA (MD = 1.685; 95% CI, 0.510 to 2.861; file S9, Fig. S1.a.), in MEC-35 (MD = 2.038; 95%CI, 1.699 to 2.376; file S9, Fig. S1.a.), active control (MD = 1.245; 95%CI, 0.686 to 1.803; file S10, Fig. S1.b.), TAU control (MD = 1.691; 95%CI, 0.516 to 2.866; file S10, Fig. S1.b.), those cognitively healthy elderly individuals (MD = 1.312; 95%CI, 0.422 to 2.202; file S11, Fig. S1.c.), with Mild Cognitive Impairment (MD = 1.836; 95%CI, 1.184 to 2.488; file S11, Fig. S1.c.), and Dementia (MD = 1.266; 95%CI, 0.116 to 2.416; file S11, Fig. S1.c.), ≤ 75 years (MD = 1.335; 95%CI, 0.953 to 1.717; file S12, Fig. S1.d.), > 75 years (MD = 1.397; 95%CI, 0.341 to 2.453; file S12, Fig. S1.d.), 45 min/session (MD = 1.869; 95%CI, 1.252 to 2.485; file S13, Fig. S1.e.), group CS (MD = 1.535; 95%CI, 0.936 to 2.134; file S14, Fig. S1.f.), short-term CS (MD = 1.612; 95% CI, 1.094 to 2.131; file S15, Fig. S1.g.), long-term CS (MD = 2.669; 95% CI, 2.132 to 3.207; file S15, Fig. S1.g), traditional CS (MD = 1.443; 95%CI, 0.700 to 2.187; file S16, Fig. S1.h), studies with personalized/adapted CS (MD = 1.446; 95% CI, 0.614 to 2.279; file S17, Fig. S1.i.), studies with non-personalized/ non-adapted CS (MD = 1.657; 95%CI, 0.537 to 2.776; file S17, Fig. S1.i.), studies with Fair quality assessment scores (MD = 1.842; 95% CI, 1.162 to 2.522; file S18, Fig. S1.j.), alone CS (MD = 1.207; 95%CI, 0.360 to 2.055; file S19, Fig. S1.k.), and studies with origin Europe (MD = 1.590; 95%CI, 0.844 to 2.337; file S20, Fig. S1.l.).

However, the CS+AChEIs subgroup (file S19, Fig. S1.k.) showed significantly worse scores in general cognitive functioning (MD = -1.854; 95%CI, -3.521 to -0.187; file S19, Fig. S1.k.).

Publication bias was detected for the estimation of the mean change of general cognitive functioning (Egger test, $p < .001$) (file S21, Fig. S1. ll.).

3.4.2. Specific cognitive domains

3.4.2.1. Memory. As shown in Fig. 3b a significant improvement in memory was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.365, 95%CI, 0.300 to 0.430). Heterogeneity among studies for memory was very high ($I^2 = 99.86$; $p < 0.001$).

Subgroup analysis revealed statistically significant improvements in episodic memory (MD = 1.497; 95%CI, 0.940 to 2.054; file S22, Fig. S2.a.), visual memory (MD = 0.758; 95%CI, 0.415 to 1.101; file S22, Fig. S2.a.), active control (MD = 0.639; 95%CI, 0.296 to 0.982; file S23, Fig. S2.b.), TAU control (MD = 0.125; 95%CI, 0.046 to 0.203; file S23, Fig. S2.b.), those cognitively healthy elderly individuals (MD = 0.166; 95%CI, 0.111 to 0.220; file S24, Fig. S2.c.), and with Mild Cognitive Impairment (MD = 0.301; 95%CI, 0.260 to 0.341; file S24, Fig. S2.c.), ≤ 75 years (MD = 0.232; 95%CI, 0.202 to 0.263; file S25, Fig. S2.d.), 45 min/session (MD = 0.118; 95%CI, 0.095 to 0.141; file S26, Fig. S2.e.), > 45 min/session (MD = 0.698; 95%CI, 0.370 to 1.026; file S26, Fig. S2.e.), Short-term CS (MD = 0.200; 95% CI, 0.170 to 0.231; file S27, Fig. S1.f.), Maintenance CS (MD =0.435 ; 95%CI, 0.026 to 0.845; file S27, Fig. S1.f.), studies with non-personalized/non-adapted CS (MD = 0.978; 95%CI, 0.681 to 1.275; file S28, Fig. S1.g.), studies with computerized CS (MD = 1.213; 95%CI, 0.711 to 0.715; file S29, Fig. S2.h.), studies with traditional CS (MD = 0.215; 95%CI, 0.144 to 0.285; file S29, Fig. S2.h.), and studies with Fair quality assessment scores (MD = 0.209; 95%CI, 0.179 to 0.239; file S30, Fig. S1.i.).

Publication bias was detected for the estimation of the mean change of general cognitive functioning (Egger test, $p < .001$) (file S31, Fig. S1.j.).

3.4.2.2. Attention. As shown in Fig. 3c no significant improvement in attention was found in the group that received CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.044, 95%CI, -0.142 to 0.229). Heterogeneity among studies for attention was very high ($I^2 = 98.17$; $p < 0.001$).

Subgroup analysis (file S32-S34, Fig.s S3.a.-S3.c.) showed no significant difference in attention.

Publication bias was detected for the estimation of the mean change

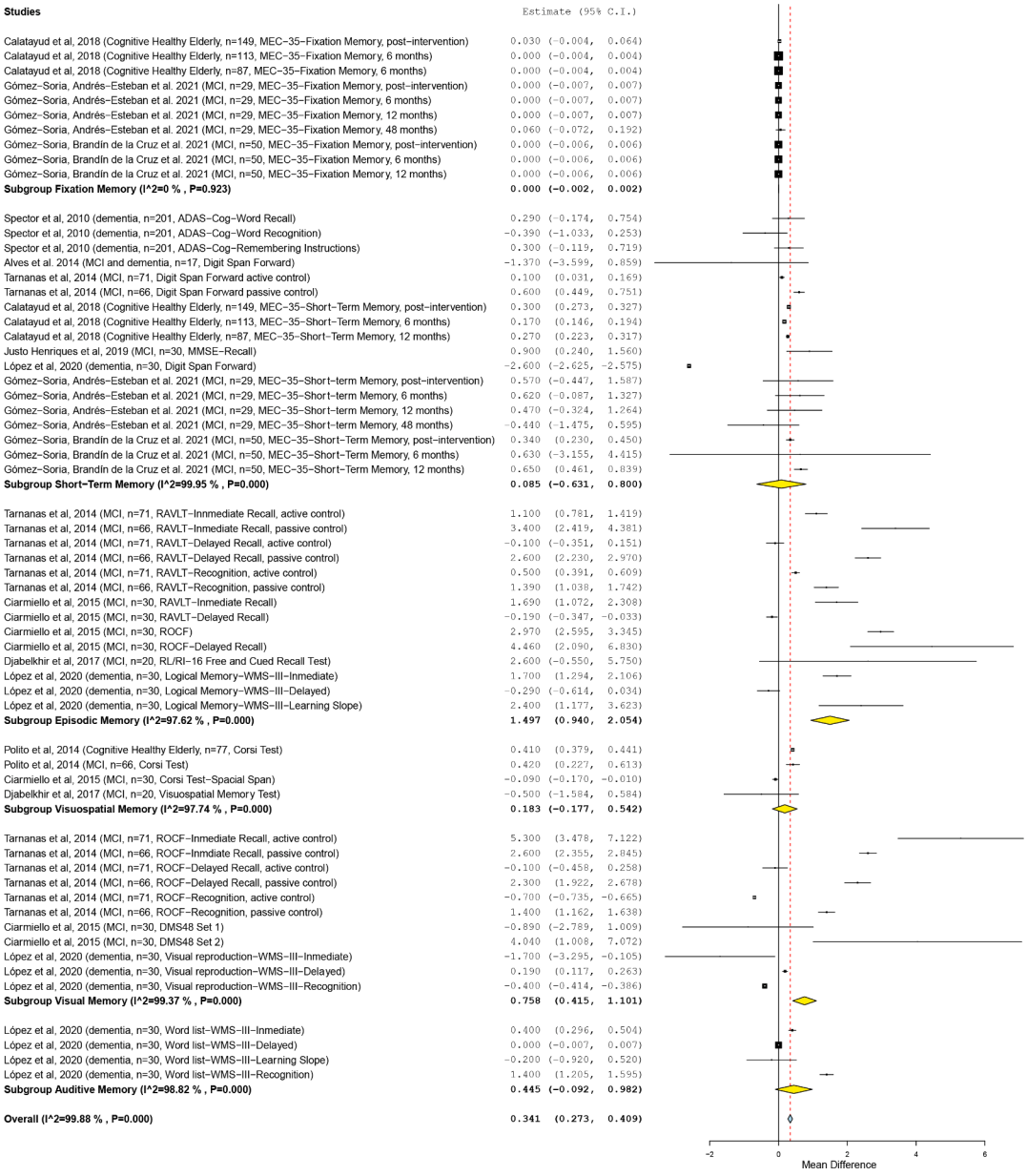

Fig. 3b. Forest plot of effect sizes (ESs) from the studies that assessed memory.

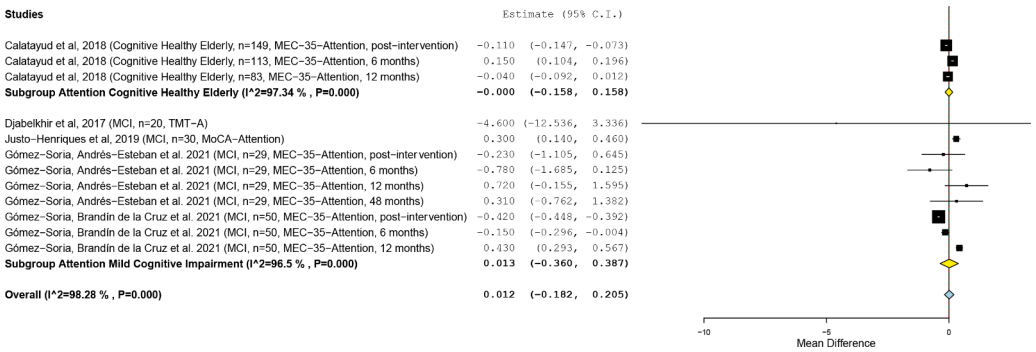

Fig. 3c. Forest plot of effect sizes (ESs) from the studies that assessed attention.

of attention (Egger test, $p < .001$) (file S35, Fig. S3.d.).

3.4.2.3. Orientation. As shown in Fig. 3d significant improvement in orientation was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.428, 95%CI, 0.306 to 0.550). Heterogeneity among studies for orientation was very high ($I^2 = 95.1$; $p < 0.001$).

Subgroup analysis found statistically significant increases in temporal orientation (MD = 0.363; 95%CI, 0.257 to 0.468; file S36, Fig. S4.a.), spatial orientation (MD = 0.491; 95%CI, 0.294 to 0.688; file S36, Fig. S4.a.), those cognitively healthy elderly individuals (MD = 0.197; 95%CI, 0.076 to 0.319; file S37, Fig. S4.b.), and Mild Cognitive Impairment (MD = 0.488; 95%CI, 0.307 to 0.669; file S37, Fig. S4.b.), ≤ 75 years (MD = 0.419; 95%CI, 0.294 to 0.544; file S38, Fig. S4.c.), studies with personalized/adapted CS (MD = 0.404; 95%CI, 0.281 to 0.527; file S39, Fig. S4.d.), Short-term CS (MD = 0.419; 95% CI, 0.294 to 0.544; file S40, Fig. S4.e.), and studies with Fair quality assessment scores (MD = 0.419; 95%CI, 0.294 to 0.544; file S41, Fig. S4.f.).Publication bias was detected for the estimation of the mean change of orientation (Egger test, $p < .001$) (file S42, Fig. S4.g.).

3.4.2.4. Executive functions. As shown in Fig. 3e no significant improvement in executive functions was found in the group that received CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = -0.019 95%CI, -0.263 to 0.225). Heterogeneity among studies for executive functions was very high ($I^2 = 95.45$; $p < 0.001$).

Subgroup analysis showed statistically significant increases in executive function scores in 45 min/session (MD = 0.186; 95%CI, 0.151 to 0.220; see supplementary file 46, Fig. 5.d.). Other subgroup analyses did not show statistical differences in executive functions (files S43-S45 and S47-S50, files S5.a.-S5.c., S5.e.-S5.h.)

Publication bias was detected for the estimation of the mean change of executive functions (Egger test, $p < .001$) (file S51, Fig. S5.i.).

3.4.3.5. Language. As shown in Fig. 3f a significant improvement in language was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.097, 95%CI, -0.128 to 0.322). Heterogeneity among studies for language was very high ($I^2 = 98.37$; $p < 0.001$).

Subgroup analysis revealed statistically significant increases in language in those participants with MCI (MD = 0.330; 95%CI, 0.030 to 0.629; file S52, Fig. S6.a.), ≤ 75 years (MD = 0.154; 95%CI, -0.09 to 0.298; file S53, Fig. S6.b.), and studies with non-personalized/non-adapted CS (MD = 0.494; 95%CI, 0.086 to 0.901; file S54, Fig. S6.c.) and Long-term CS (MD = 0.753; 95% CI, 0.459 to 1.047; file S55, Fig. S6.d.). The other subgroups (files S56-S57, Figs. S6.e.-S6.f.) did not show significant differences in language domain.

Publication bias was detected for the estimation of the mean change of language (Egger test, p = 0.012) (file 58, Fig. S6.g.).

3.4.3.6. Verbal fluency. The group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.519, 95%CI, -0.386 to 1.425) did not showed differences in verbal fluency (Fig. 3g). Heterogeneity among studies for verbal fluency was very high ($I^2 = 98.1$; $p < 0.001$).

Subgroup analysis revealed statistically significant increases in phonemic verbal fluency (MD = 2.145; 95%CI, 0.875 to 3.415; file S59, Fig. S7.a.), participants with Mild Cognitive Impairment (MD = 1.192; 95%CI, 0.183 to 2.201; file S60, Fig. S7.b.), 45 min/session (MD = 0.466; 95%CI, 0.014 to 0.919; file S62, Fig. S7.d.), Maintenance CS (MD = 1.834; 95%CI, 0.576 to 3.092; file S63, Fig. S7.e.), non-personalized/

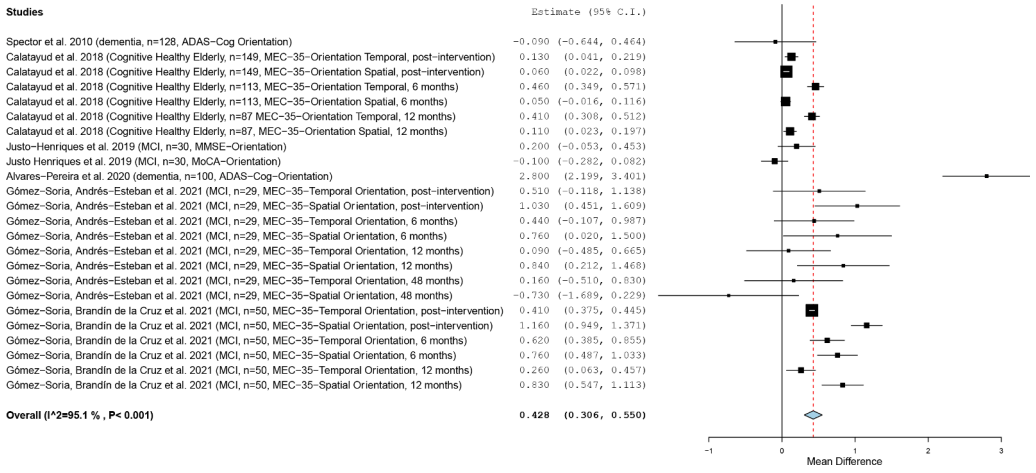

Fig. 3d. Forest plot of effect sizes (ESs) from the studies that assessed orientation.

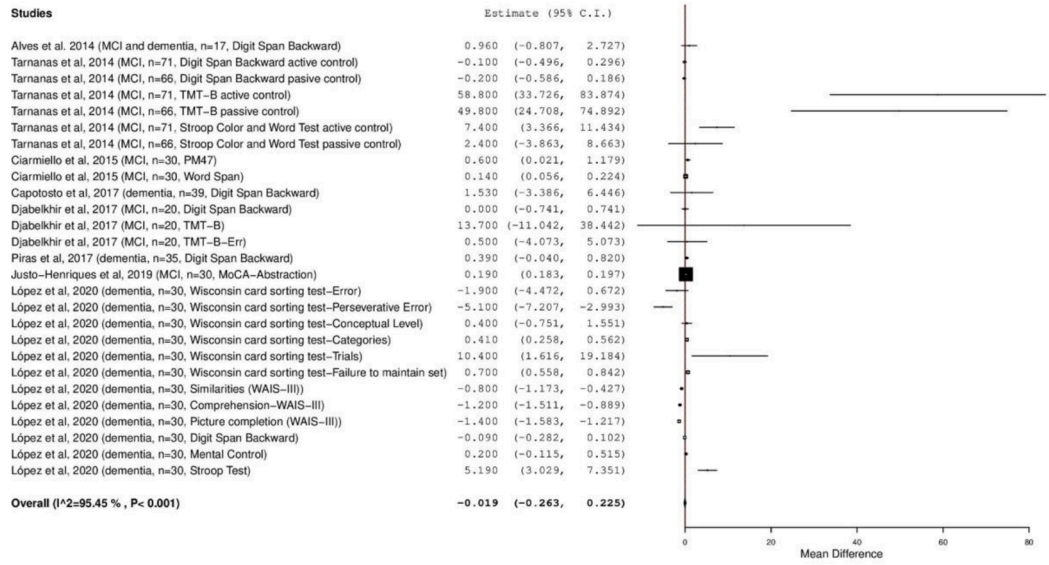

Fig. 3e. Forest plot of effect sizes (ESs) from the studies that assessed executive functions.

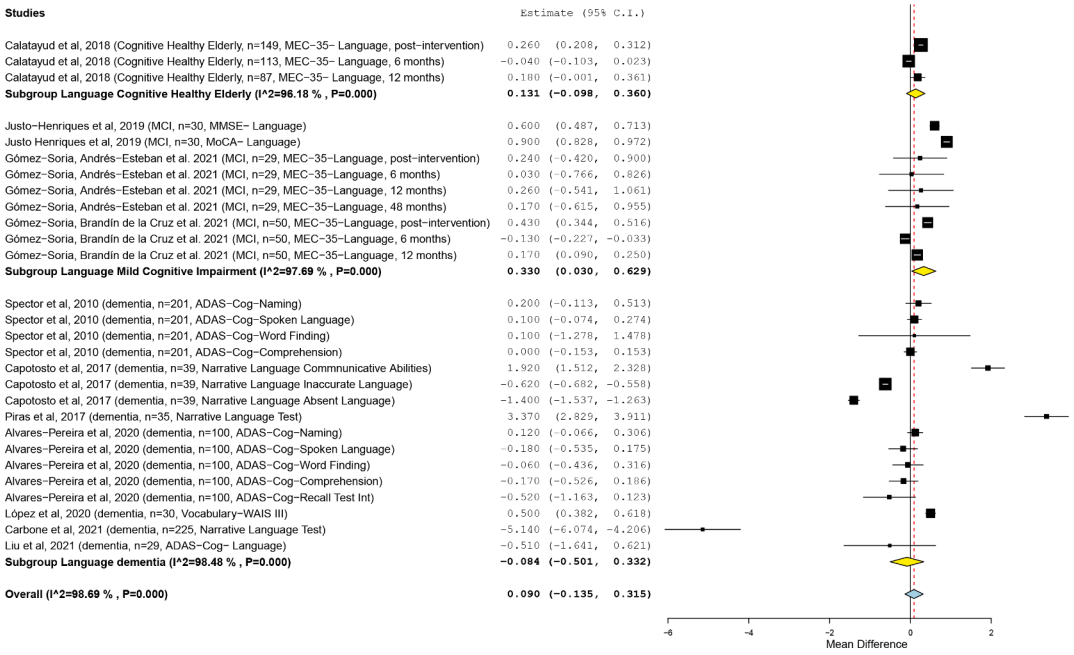

Fig. 3f. Forest plot of effect sizes (ESs) from the studies that assessed language.

non-adapted CS (MD = 2.367; 95%CI, 1.029 to 3.706; file S64, Fig. S7. f.), computerized CS (MD = 2.367; 95%CI, 1.029 to 3.706; file S65, Fig. S7.g.). The other subgroups did not show a statistically significant difference in verbal fluency (file S62, Fig. S7.c., and file S66, Fig. S7.h.).

Publication bias was detected for the estimation of the mean change of verbal fluency (Egger test, $p < .001$) (file S67, Fig. S7.i.).

3.4.3.7. Praxis. As shown in Fig. 3h a statistically significant improvement in praxis was found in the group that received CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.278, 95%CI, 0.094 to 0.462). Heterogeneity among studies for praxis was very high ($I^2 = 97.86$; $p < 0.001$).

Subgroup analysis indicated statistically significant increases in praxis in those cognitively healthy elderly individuals (MD = 0.371; 95%CI, 0.195 to 0.548; file S69, Fig. S8.b.), TAU control (MD = 0.212; 95%CI, 0.052 to 0.371; file S70, Fig. S8.c.), ≤ 75 years (MD = 0.356; 95%CI, 0.157 to 0.555; file S71, Fig. S8.d.), personalized/adapted CS (MD = 0.472; 95%CI, 0.285 to 0.659; file S74, Fig. S8.g.), Fair quality (MD = 0.356; 95%CI, 0.157 to 0.555; file S75, Fig. S8.h.). The other subgroups did not show a statistically significant (files S68, S72 and S73, Figs. S8.a., S8.e. and S8.f.).

Publication bias was not detected for the estimation of the mean change of praxis (Egger test, $p = 0.459$) (file S76, Fig. S8.i.).

3.4.3.8. Calculation. As shown in Fig. 3i a statistically significant improvement in calculation was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 0.228, 95%CI, 0.112 to 0.343). Heterogeneity among studies for calculation was very high ($I^2 = 94.68$; $p < 0.001$).

Subgroup analysis revealed statistically significant increases in calculation in participants with Mild Cognitive Impairment (MD =

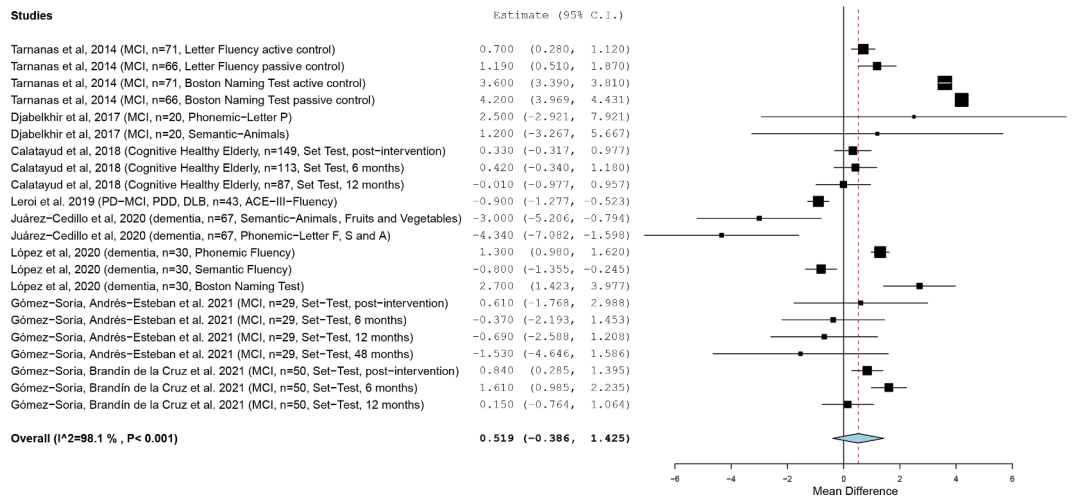

Fig. 3g. Forest plot of effect sizes (ESs) from the studies that assessed verbal fluency.

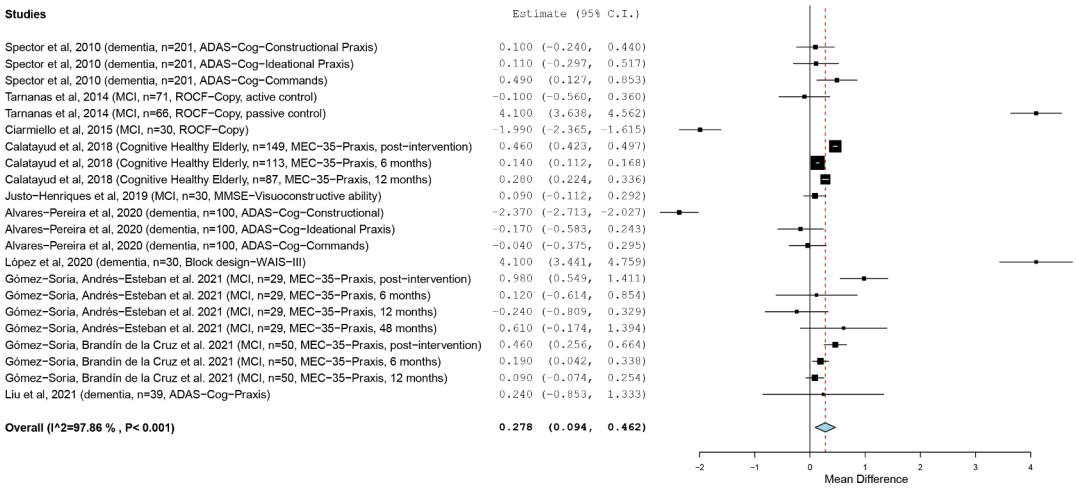

Fig. 3h. Forest plot of effect sizes (ESs) from the studies that assessed praxis.

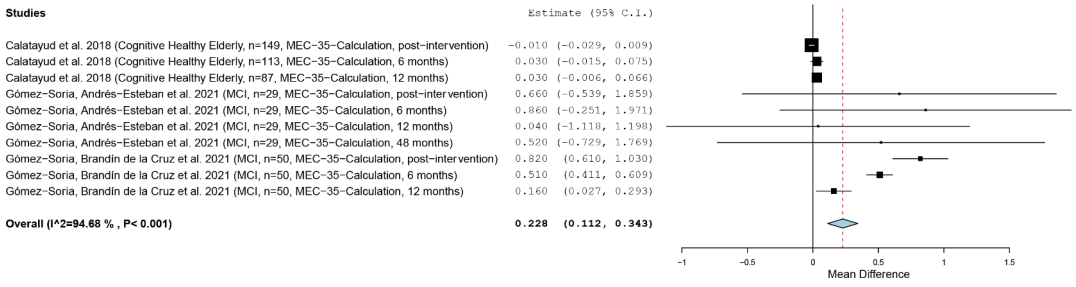

Fig. 3i. Forest plot of effect sizes (ESs) from the studies that assessed calculation.

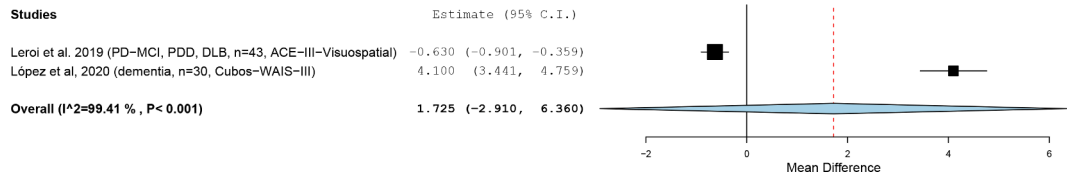

Fig. 3j. Forest plot of effect sizes (ESs) from the studies that assessed visuospatial abilities.

0.228, 95%CI, 0.112 to 0.34). (file S78, Fig. S9.a.). Publication bias was not detected for the estimation of the mean change of calculation (Egger test, p =.078) (**file S79,** Fig. S**9.b.**).

3.4.3.9. Visuospatial abilities. As shown in Fig. 3j a statistically significant improvement in visuospatial abilities was found in the group receiving CS (independently or together with AChEIs) compared to those who did not receive CS (control groups) (MD = 1.725; 95%CI, -2.910 to 6.360). Heterogeneity among studies for visuospatial abilities was very high ($I^2 = 99.56$; $p < 0.001$).

3.4.2.10. Summary the effects of CS in relation to cognitive variables in older adults. The effects observed through the analysis in the different subgroups of the different variables analyzed are shown (file S80, table S7).

Regarding the risk of bias, using Trim and fill' method, funnel plots showed that in all the variables used in the meta-analysis, a high publication bias was observed, with most of the studies located outside the significance bands (file S81, Fig. S10).

3.6. Meta-regression

The meta-regression shows how in the variable Executive Functions the Total duration (weeks), in the variable Language the Number of sessions (min) and the Total duration (weeks) and in the variable Verbal Fluency, Total duration (weeks) and Scores quality of studies (%) significantly influence heterogeneity (file S82, table S8).

In the variable Executive Functions, the Total duration (weeks) significantly influences the heterogeneity (0.117 (SE = 0.036), 95%CI (0.042, 0.192), $p = 0.004$), increasing it (I^2 = 96.907% vs I^2 original=95.45%) with a coefficient R^2 that explains the 6.034% of the variance caused by heterogeneity. Cochrane's Q test indicates that the unexplained heterogeneity is significant ($p < 0.001$) while the significant moderation test ($p = 0.004$) indicates that this covariate does not influence the effect sizes of the studies.

In the variable Language, the Number of sessions (min) significantly influences the heterogeneity (0.088 (SE = 0.028), 95%CI (0.03, 0.146), $p = 0.005$), although almost without modifying it (I^2 = 98.596% vs I^2original=98.37%) with a coefficient R^2 that explains the 30.541% of the variance caused by heterogeneity. Cochrane's Q test indicates that unexplained heterogeneity is significant ($p < 0.001$) while the significant moderation test ($p = 0.005$) indicates that this covariate has no influence on effect sizes. of the studies. Total duration (weeks) also significantly influences heterogeneity (0.075 (SE = 0.02), 95%CI (0.033, 0.117), $p = 0.001$), although again almost without modifying it (I^2 = 98.445% vs I^2original=98.37%) with a coefficient R^2 that explains the 37.474% of the variance caused by the heterogeneity. Cochrane's Q test indicates that the unexplained heterogeneity is significant ($p < 0.001$) while the significant moderation test ($p = 0.001$) indicates that this covariate does not influence effect sizes. of the studies.

In the variable Verbal Fluency, the Total duration (weeks) significantly influences the heterogeneity (0.141 (SE = 0.041), 95%CI (0.055, 0.227), $p = 0.003$), reducing it (I^2 = 97.639% vs I^2 original=98.1%) with a coefficient R^2 that explains the 38.811% of the variance caused by heterogeneity. Cochrane's Q test indicates that the unexplained heterogeneity is significant ($p < 0.001$) while the significant moderation test ($p = 0.003$) indicates that this covariate does not influence the effect sizes of the studies. Also, the Scores quality of studies (%) significantly influences the heterogeneity (-0.11 (SE = 0.045), 95%CI (-0.204, -0.016), $p = 0.024$), although almost without modifying it (I^2 = 98.158% vs I^2original=98.1%) with a coefficient R^2 that explains the 21.18% of the variance caused by heterogeneity. Cochrane's Q test indicates that unexplained heterogeneity is significant ($p < 0.001$) while the significant moderation test ($p = 0.024$) indicates that this covariate has no influence on effect sizes of the studies.

The bubble plots show how the covariates have a positive relationship with the effects, the greater the Total duration (weeks) or Number of sessions (min), the greater the effect size reported in the intervention group versus the control group for the variables Executive Functions, Language and Verbal Fluency except in the covariate Scores quality of studies (%) where, the higher the percentage of quality, the lower it is the effect reported in the intervention group versus the control group for the domain Verbal Fluency.

In any case, the percentage of heterogeneity and variance not explained by the models is very high and only the covariate Total duration (weeks) in the Verbal Fluency shows a higher value R^2 38.811% and best fit of studies to the regression line (file S83, Fig. 11).

4. Discussion

This systematic review and meta-analysis aimed to assess the impact of CS (independently or together with pharmacological treatment, particularly AChEIs) on general cognitive functioning and some specific cognitive domains such as memory, orientation, praxis, and calculation in older adults cognitively healthy, with MCI, or dementia.

In contrast to previously published studies, our research has assessed the impact of CS on general cognitive functioning and different cognitive functions not only in older adults with dementia, but also in cognitively healthy elderly participants and patients with MCI.

In addition, we have analysed different subgroups that previous studies have not evaluated, such as cognitive status, age of participants, duration of the CS session, tailored or personalised intervention/non-personalised or non-tailored intervention, traditional intervention/computerised intervention, origin of the studies (according to the origin of the participants by continent), and types of memory, orientation and praxis.

Our results show improvements in general cognitive functioning in cognitive healthy elderly participants, those with MCI, and those with dementia. In agreement, other authors also found similar results in general cognitive functioning (Aguirre et al., 2013; Cafferata et al., 2021; Kim et al., 2017; Saragih et al., 2022; Sun et al., 2022; Wong et al., 2021; Woods et al., 2012) in participants with dementia. Cafferata et al. (2021) describes important improvements in memory for participants with dementia; however they did not find differences in language. In contrast, Kim et al. (2017), did not find variations in cognition for dementia patients.

We have shown significant better scores in MMSE, MoCA y MEC-35 assessments. Similarly, Kim et al. (2017) and Woods, et al., 2013 found significant benefits in MMSE and ADAS-Cog. In addition, (Cafferata et al., 2021,; Aguirre et al., 2013) also showed benefits in ADAS-Cog. The results of Aguirre et al. (2013) support the hypothesis that CS is effective regardless of whether AChEIs are not prescribed, and any effects are in addition to those associated with medications.

Based on the type of control, significant differences were found in both active control and TAU control in general cognitive functioning and memory, and in TAU control as well as in praxis. Wong et al. (2021) describes apositive treatment effect through CS on general cognitive functioning in dementia participants, compared with inactive controls (including no active treatment, waitlisted for intervention, and treatment as usual).

Regarding cognitive status, we can observe improvements with significant differences in general cognitive functioning. Cognitive healthy elderly participants showed better scores in memory, orientation, praxis and calculation. In addition, in MCI participants we also describe improvements in ~~in~~ language and verbal fluency. In our study, we have differentiated between sub-groups "individual CS" versus "group CS" in general cognitive functioning, finding statistically significant improvements in group CS. Orfanos et al. (2021) found therapeutic advantages inherent in the group of CS and Devita et al. (2021) suggested that by including the social component, the group CS had more beneficial effects on neuroplasticity compared to pharmacological interventions.

However, the study of Wong et al. (2021), did not find differences between individual CS and group CS.

Regarding the duration of CS programs, our meta-analysis showed that "short-term CS" or "long-term CS", could improve the level of general cognitive functioning. "Short-term CS", or "maintenance CS", seem to improve memory, "short-term CS" seem to increase orientation, "long-term CS" seen to improve language and "maintenance CS" seem to increase verbal fluency. On the one hand, Chen et al. (2019) concluded that "CS and AChEIs" were effective in AD, regardless of whether short, maintenance, or long-term CS were applied; although the latter appears to be more effective on cognitive function. On the other hand, Brown et al. (2019), showed that maintenance CS might be cost-effective compared to standard treatment for participants who lived alone and those with higher levels of cognitive functioning. However, Wong et al. (2021) performed a subgroup analysis based on the CS duration and did not find significant differences between $\leq$3 months and >3 months. Besides, Jean et al. (2010) found that applying fewer sessions (between 6 and 20) was more cost-effective for clinical purposes. In terms of duration, CS programs with more than 12 weeks showed no extra benefits compared to shorter programs. Therefore, the 12-week programs seem to be a good option, especially to reduce the risks of attrition. In addition, personalized CS may be more effective in the short and long-term than a standard CS (Calatayud et al., 2022).

Concerning the duration of the CS sessions, our meta-analysis showed that "45 min/session" improves general cognitive functioning, memory, executive functions, and verbal fluency. However, ">45min/session" also show higher scores in general cognitive functioning. Different authors recommend 45 min by session (Abraha et al., 2017; Aguirre et al., 2013; Aguirre et al., 2014; Clare & Woods, 2004; Comas-Herrera & Knapp, 2016; Knapp et al., 2006; Orrell et al., 2014; Spector et al., 2006; Woods et al., 2012; Yamanaka et al., 2013).

Our results indicate that a "personalized/adapted CS" significantly improves general cognitive functioning, orientation, and praxis. However, "non-personalized/adapted CS" also significantly improves general cognitive functioning, memory, language, and verbal fluency. Despite these contradictory results, we suggest adapting the activities to participants' specific cognitive levels (Gómez-Soria et al., 2021; Calatayud et al., 2022), personal preferences and limitations of the participants (Félix et al., 2020). Satisfactory sessions are essential to achieve an adequate selection of CS tasks, which it can be by adapting the cognitive level, being interesting avoiding boredom, and being meaningful for the person who performs them and to be close to the issues of everyday life (Muñoz Marrón, 2009).

Our study found that "traditional CS" obtained better results than "computerized CS" in general cognitive functioning. However, we found contradictory results in verbal fluency, as significant differences were found in "computerized CS". In memory, we have described important improvements in both "traditional CS" and "computerized CS". Acosta et al. (2022), found that computerized CS can offer a more personalized and flexible approach compared to traditional CS.

Furthermore, our results indicated that "participants aged 75 years or younger" significantly increased their levels of general cognitive functioning, memory, orientation, language, and praxis when using CS. However, in "participants aged 75+", even if CS improved levels of general cognitive functioning there were no improvements in the other cognitive functions analysed. The study by Tesky et al. (2011), based on cognitive stimulating leisure activities, describes significant differences attention in older adults ($\geq$ 75 years) and in subjective memory decline in younger participants (< 75 years). Besides, Park et al. (2019), found differences in visuospatial/executive functions, language skills, and memory between the 65-79 years age group and the aged over 80 group in participants older adults through multicomponent CS. Further, regarding the relationship between the multicomponent CS and age, it was found that their interaction was significant only regarding visuospatial/executive ability.

Consistent with these results, Fernández-Ballesteros et al. (2012), showed that younger participants had greater changes in cognitive function due to greater neural plasticity. Therefore, the earlier psychosocial intervention is initiated, the more likely it is that cognitive functions will be preserved (Vernooij-Dassen et al., 2010).

Regarding participants that received "alone CS", we found that it was associated with better general cognitive functioning. However, the participants that received "CS+AChEIs" display worse levels in general cognitive functioning. The CS+AChEIs subgroup included just the results of three randomized controlled trials to evaluate the benefits in general cognitive functioning. Also, important characteristics such as lower baseline cognitive level, lower educational level and higher mean age of the participants were observed in the subgroup in which drugs (AChEIs) plus CS were combined compared to the subgroup in which only CS was conducted. These differences can explain the lack of additional effect combining drug and CS and therefore, results should be taken with caution. In other studies, the combination of CS and AChEIs, had more benefits than "alone CS" or "alone AChEIs" in memory (Devita et al., 2021), and cognition (D'Amico et al., 2015). Besides, "alone CS" showed significant improvements compared with "alone AChEIs" (Devita et al., 2021). Other investigations have suggested that CS was effective irrespective of whether or not AChEIs were prescribed (Aguirre et al., 2013; Streater et al., 2016; Woods et al., 2012).

About the quality of the selected studies, our results showed that CS was associated with improvements in general cognitive functioning, memory, orientation and praxis in the subgroup "Fair quality". In Lobbia et al. (2019) study, moderate levels of evidence were found for general cognitive functioning, comprehension and production of language in participants with dementia. However, the levels of evidence were weakest for short-term memory, orientation, and praxis in participants with dementia. Furthermore, in Sun et al. (2022), compared with the control group, maintenance CS (low-quality evidence) and group CS (very low-quality evidence) could significantly improve general cognitive functioning in participants with dementia.

In reference to the origin of the studies, we observed that participants from Europe showed improvements in general cognitive functioning in those who received CS. However, there are limited studies from Asia and America.

To date, no previous systematic reviews or meta-analyses based on CS have been carried out including cognitively healthy participants or with MCI besides dementia. Moreover, a high number of subgroup analyses were conducted to analyse the effect that cognitive status, type of assessments in general cognitive functioning, type of memory, type of orientation, type of verbal fluency, type of praxis, age, number of sessions and duration, type of CS, individual or group CS, type of control, treatment and personalization or adaptation, the quality of studies, and origin of the studies, could have on the cognitive outcomes assessed.

Concerning the limitations of the present systematic review and meta-analysis. Firstly, the overall quality of the evidence was limited due to the poor methodological quality of the included studies (Sun et al., 2022; Wong et al., 2021). Some studies lacked details in their methods of blinding participants (Sun et al., 2022). The absence of randomization in some studies was particularly problematic (Chao et al., 2020). Secondly, heterogeneity could not be explained by the results of subgroup analyses (Wong et al., 2021). Thirdly, the sample size of most of the studies was relatively small in some studies, although this is also common in other meta-analyses (Sun et al., 2022).

Futures studies are needed to study what are the most beneficial contents, frequencies, durations, formats, number of sessions, strategies and activities of CS (Spector et al., 2012). Future research regarding the long-term effects of CS should be investigated (Cafferata et al., 2021; Chao et al., 2020) especially in cognitively healthy elderly participants and MCI (La rue, 2010). In addition, it would be necessary to know if the participants with CS take any pharmacological treatment to better differentiate between (1) those who are taking pharmacological drugs and receive CS, (2) those who only receive CS and (3) those who only take drugs. Moreover, the differences in function of gender of the

participants and age should be considered.

4.1. Implications for clinical practice

Our findings suggest that personalized and tailored CS programmes in older adults (both institutionalized and non-institutionalized) improve general cognitive functioning, orientation, and praxis. Although, by applying any CS, benefits in older adults are obtained, some types of CS appear to be more effective, specially, reminiscence therapy, reality orientation and multisensory stimulation. In addition, short-term (less than 3 months) CS programmes applied to older adults (cognitively healthy participants, with MCI or dementia) could improve the level of general cognitive functioning and memory. Due to neuroplasticity, participants aged 75 years or younger could benefit more than older participants in different cognitive functions such as memory, orientation, language, and praxis when performing CS. For this reason, it would be advisable to administer CS programmes at younger ages.

5. Conclusions

Our findings suggest that CS improves general cognitive functioning, memory, orientation, and praxis in older adults. Moreover, conducting traditional CS and CS alone in short- and long-term with a duration of 45 min per session seem to be the best option to improve general cognitive functioning in the elderly.

Both, traditional and computerized CS, in short-term and maintenance with a duration of 45 min or more per session could improve "memory" in cognitively healthy participants or with MCI. Regarding other cognitive areas, we have described contradictory results on personalized-adapted/non-personalized-non-adapted. Nevertheless, it has been observed that in executive functions and verbal fluency the interventions with a duration of 45 min per session get better results. In addition, in verbal fluency the maintenance CS and the computerized CS are more effective. In relation to quality of studies, "fair quality" has obtained better results in general cognitive functioning, memory, orientation and praxis. Finally, younger participants ($\leq$ 75 years) seem to obtain more benefits in general cognitive functioning, memory, orientation, language, and praxis compared to older participants.

Disclosure statement

The authors declare no conflicts of interest.

IRB protocol/human subjects approval

Not applicable.

CRediT authorship contribution statement

Isabel Gómez-Soria: Conceptualization, Methodology, Investigation, Resources, Data curation, Writing – original draft, Project administration. **Isabel Iguacel:** Investigation, Data curation, Writing – review & editing, Supervision. **Alejandra Aguilar-Latorre:** Investigation, Formal analysis, Resources, Data curation. **Patricia Peralta-Marrupe:** Investigation, Writing – review & editing. **Eva Latorre:** Investigation, Writing – review & editing, Supervision. **Juan Nicolás Cuenca Zaldívar:** Formal analysis, Data curation, Supervision. **Estela Calatayud:** Conceptualization, Methodology, Resources, Data curation.

Declaration of Competing Interest

The Authors declare that there is no conflict of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2022.104807.

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