Experimental Gerontology 196 (2024) 112568

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

Analysis of the effectiveness of a computerized cognitive stimulation program designed from Occupational Therapy according to the level of cognitive reserve in older adults in Primary Care: Stratified randomized clinical trial protocol

Estela Calatayud [a,b], Bárbara Oliván-Blázquez [b,c,*], Alejandra Aguilar-Latorre [b,d], Juan Nicolás Cuenca-Zaldivar [e,f,g], Rosa Mª. Magallón-Botaya [b,h], Isabel Gómez-Soria [a,b]

[a] Department of Physiatry and Nursing, Faculty of Health Sciences, University of Zaragoza, 50009 Zaragoza, Spain
[b] Institute for Health Research Aragón (IIS Aragón), CIBA building, Avda. San Juan Bosco, 13, 50009 Zaragoza, Spain
[c] Department of Psychology and Sociology, Faculty of Social and Labor Sciences, University of Zaragoza, 50009 Zaragoza, Spain
[d] Department of Psychology and Sociology, Faculty of Human Sciences and Education of Huesca, University of Zaragoza, 22003 Huesca, Spain
[e] Research Group in Nursing and Health Care, Puerta de Hierro Health Research Institute - Segovia de Arana (IDIPHISA), 28222 Majadahonda, Madrid, Spain
[f] Primary Health Center "El Abajon", 28231 Las Rozas de Madrid, Spain
[g] Universidad de Alcalá, Facultad de Medicina y Ciencias de la Salud, Departamento de Enfermería y Fisioterapia, Grupo de Investigación en Fisioterapia y Dolor, 28801 Alcalá de Henares, Spain
[h] Department of Medicine, Psychiatry and Dermatology, Faculty of Medicine, University of Zaragoza, 50009 Zaragoza, Spain

A R T I C L E I N F O

Section Editor: Marzetti Emanuele

Keywords:
Cognitive reserve
Cognitive stimulation
Occupational therapy
Healthy aging

A B S T R A C T

Normal aging presents subtle cognitive changes that can be detected before meeting the criteria for Mild cognitive impairment (MCI). Older people with low cognitive reserve and who receive limited cognitive stimulation are at greater risk of deterioration. In this regard, cognitive stimulation (CS) has been identified as an intervention that reduces this risk, provided that its design takes into account the differences in the level of cognitive reserve (CR) acquired throughout life and the baseline level of cognitive functioning. The general objective of this study is to evaluate, through a randomized clinical trial, the effectiveness of a computerized cognitive stimulation program, designed and adapted from Occupational Therapy based on the level of cognitive reserve in older adults in Primary Care. 100 participants will be randomized in a stratified manner according to the level of cognitive reserve (low/moderate/high), assigning 50 participants to the control group and 50 participants to the intervention group. The intervention group will carry out a computerized cognitive stimulation intervention designed and adapted from occupational therapy according to the level of cognitive reserve, through the "stimulus" platform. The main result expected to be achieved is the improvement of higher brain functions. As secondary results, we expect that those cognitive aspects most vulnerable to aging will decrease more slowly (in areas such as memory, executive function, attention and processing speed), and that the cognitive reserve of the participants will increase, in addition to being able to balance gender differences in these aspects. We think that these results can have a positive impact on the creation of adapted, meaningful and stimulating CS programs in older adults to prevent MCI and experience healthier aging.

1. Introduction

Promoting active aging is a global priority. Cognitive impairment and dementia, whose incidence is expected to triple by 2050, are currently the leading cause of disability and death in old age (WHO, 2023). In addition, health care expenditure in primary care in individuals with mild cognitive impairment (MCI) is 16 % higher than in people with normal cognition (NC). For the elderly population, the most significant aspects linked to their health that impact their quality of life include interpersonal relationships, functional autonomy and maintaining an active life (Parra-Rizo, 2017; Zhu et al., 2013).

Normal aging presents subtle cognitive changes which influence the

* Corresponding author at: Department of Psychology and Sociology, Faculty of Social and Labor Sciences, University of Zaragoza, 50009 Zaragoza, Spain.
E-mail address: bolivan@unizar.es (B. Oliván-Blázquez).

https://doi.org/10.1016/j.exger.2024.112568
Received 16 April 2024; Received in revised form 29 August 2024; Accepted 30 August 2024
Available online 3 September 2024

degree of satisfaction with the state of health in the elderly (Agustí et al., 2023), and can be detected before MCI criteria are met and may be related to future dementia (Gates et al., 2019). These cognitive aspects that are most vulnerable in aging are memory, executive function (EF), attention and processing speed (MacAulay et al., 2018). It has been suggested that two cognitive levels can be considered within the NC range and that their differences may be due in part to the cognitive reserve (CR) that older adults have acquired over the course of a lifetime (Opdebeeck et al., 2018).

The term CR refers to the adaptability (i.e., efficiency, capacity, flexibility) of cognitive processes that helps explain the differential susceptibility of cognitive abilities to aging, pathology, or brain injury (Stern et al., 2020). This concept suggests that CR involves a greater capacity to produce new or greater interneuronal activation as cognitive demand increases (Ducharme-Laliberté et al., 2022).

Evidence suggests that low CR and limited cognitive stimulation (CS) may be associated with an increased risk of dementia (Gates et al., 2019). CR is a theoretical concept that can explain the different cognitive trajectories of old age (Cabeza et al., 2018; Stern et al., 2020), that may enable some people to cope better than others with brain changes (Steffener and Stern, 2012; Stern et al., 2020). Thus, in older people with NC, a higher CR would allow the use of compensatory cognitive processes, increasing frontal activity versus memory performance (Hall et al., 2007).

High CR is associated with better global cognitive function and higher EF in old age (Lojo-Seoane et al., 2020; Opdebeeck et al., 2018). This is why cognitive aging researchers point to the importance of baseline cognitive assessment and the need for interventions to maintain this cognitive function (Kelly et al., 2017; Lenze et al., 2022; Rabbitt et al., 2008).

In this regard, CE has been identified as an intervention that reduces the risk of MCI (Anstey et al., 2013; Fisher et al., 2024; Gómez-Soria et al., 2023b), provided that the design takes into account differences in the level of CR acquired throughout life and the level of baseline cognitive functioning (Stern et al., 2020). In addition, it is recommended that CE, be multidomain (Chen et al., 2017), but emphasize the cognitive aspects most vulnerable to aging (MacAulay et al., 2018).

Among the factors that influence the level of CR, one of the most important is the level of education. CR acquired through years of education may contribute to better EF and memory in older adults (Loftus et al., 2021). However, with CE, and the presentation of challenges and novel materials, the level of CR could be increased, and the same cognitive benefits achieved with educational attainment could be attained (Clark et al., 2016; Mičič et al., 2019). In this regard, a recent study proposes a strategic shift in the less educated and the development of expertise in those with higher education, thus restoring the differences related to initial education (Belleville et al., 2023).

Another factor that influences the level of CR is the occupational factor, considering not only the occupational complexity of the work stage, but also the level of the work environment (Hyun et al., 2022), but the level of participation in post-retirement leisure, intellectual, social and physical activities (Su et al., 2022). Thus, it has been shown that subjects with a lot of leisure activity have a 38 % lower risk of developing dementia after controlling for educational, occupational and ethnic factors (Scarmeas et al., 2001; Wajman et al., 2018).

Regarding the level of baseline cognitive functioning, there is no consensus in the literature. Some authors argue that adults with high cognitive functioning may show greater gains with CE, as a result of their higher level of plasticity (Stine-Morrow et al., 2006). Conversely, an alternative hypothesis is that individuals with low cognitive functioning will have greater benefits after training because they have greater potential and room for improvement (Clark et al., 2016; López-Higes et al., 2018). In either case, it is recommended to consider the initial level of basal functioning, since it modulates the results of cognitive training (Shaw and Hosseini, 2020).

In the design of cognitive tasks, previous experience with the task should be taken into account (Belleville et al., 2014). In this sense, CE could be considered as a form of "education for old age" that can provide neuroprotection (Belleville et al., 2023). According to the triarchic model of learning (Belleville et al., 2023), cognitive interventions, to be effective, must be mentally challenging according to the person's CR level (Chan et al., 2016; Shaw and Hosseini, 2020).

Therefore, it is of interest to the health professional, such as the Occupational Therapist (OT), the selection and design of adapted cognitive programs that graduate the complexity of the activities so that their results are transferred to the functional sphere (Chan et al., 2016; Lampit et al., 2014). Activities called "productive engagement" activities should be promoted as they are cognitively demanding for the older person, as opposed to "receptive engagement" activities, which contain more familiar and familiar activities and are of low cognitive demand (Park et al., 2014).

Although CE can include traditional pencil-and-paper tasks, computerized cognitive tasks are now often used because they are easier to administer and adapt, as well as being more interactive (Gates et al., 2011). Computerized cognitive stimulation (CCT) is a complex mental activity, performed using an individual electronic device (usually tablet/iPad) that requires a simple physical response, such as pressing a button, or dragging a finger across the screen (Lampit et al., 2014). It is a promising, safe, and cost-effective strategy to prevent MCI, which can increase the level of CR (Ten Brinke et al., 2017).

However, older adults with a fear of MCI and high CR may consume a large number of computerized products, including stimulating leisure activities (Ferreira et al., 2015) not prescribed by health professionals (Lampit et al., 2014). On the contrary, people with lower CR have a lower rate of use of new technologies (Stronge et al., 2006).

The relationship between age and technology adoption is mediated by cognitive skills, computer anxiety (Czaja et al., 2006) and the digital divide (Quinde Barcia et al., 2020). Training is therefore an important objective to ensure that older adults can take advantage of the benefits of these devices by increasing their digital literacy (Mitzner et al., 2016; Tsai et al., 2017).

Some studies have shown that CCT produces improvements in general cognitive performance in older adults and specifically, in verbal and nonverbal memory, working memory, processing speed and visuospatial skills; however, no significant effects have been found in attention and EF (Chan et al., 2016; Cheng et al., 2012; Grotz et al., 2018; Lampit et al., 2014; Laver et al., 2015; Vaportzis et al., 2018). On the other hand, no studies have been identified in whose intervention designs CR has been taken into account; moreover, some even exclude participants with primary education or who do not have a very high level of instrumental activities of daily living (IADLs) (Ten Brinke et al., 2018).

The literature refers that more high quality studies, with sample size calculation, the use of cognitive tests that are reliable and sensitive to change, and a training dose appropriate to baseline proficiency levels, are needed to confirm the benefits of CCT programs on cognition (Oh et al., 2021; Ten Brinke et al., 2017; Whitfield et al., 2021).

2. Objectives and hypotheses

2.1. Objectives

The general objective of this study is to analyze through a randomized clinical trial the effectiveness of a computerized cognitive stimulation program, designed and adapted according to the level of cognitive reserve in older adults in Primary Care.

2.2. Specific objectives

1- To evaluate the effect of the intervention, on global cognitive functions, and on the cognitive domains most vulnerable to impairment (EF, attention,episodic memory and processing speed).
2- To analyze the effect of the intervention on CR.
3- To analyze and describe the effect of the intervention, by sex, according to CR level.

2.3. Hypotheses

1- At the global cognitive level: the older adults of the IG will improve cognitively, equally, independent of their initial level of cognitive reserve, when the cognitive stimulation program is adapted according to the level of cognitive reserve. The CG with high CR will be maintained, and the CG with low CR will worsen.
2- In cognitive areas vulnerable to cognitive impairment (episodic memory, information processing speed and executive functions): the CG with high CR will improve in these aspects and the CG with low CR will be maintained; on the other hand, the CG with high CR will be maintained, and the CG with low CR will worsen.
3- At the level of cognitive reserve: older adults in the IG will improve their level of cognitive reserve. In the CG, however, this level of reserve will not be modified.
4- By sex, at baseline we think that men will have a higher level of cognitive reserve than women, especially in the educational and occupational areas, and will start from a higher cognitive level. However, after the intervention these results will be balanced both at the cognitive level and at the cognitive reserve level.

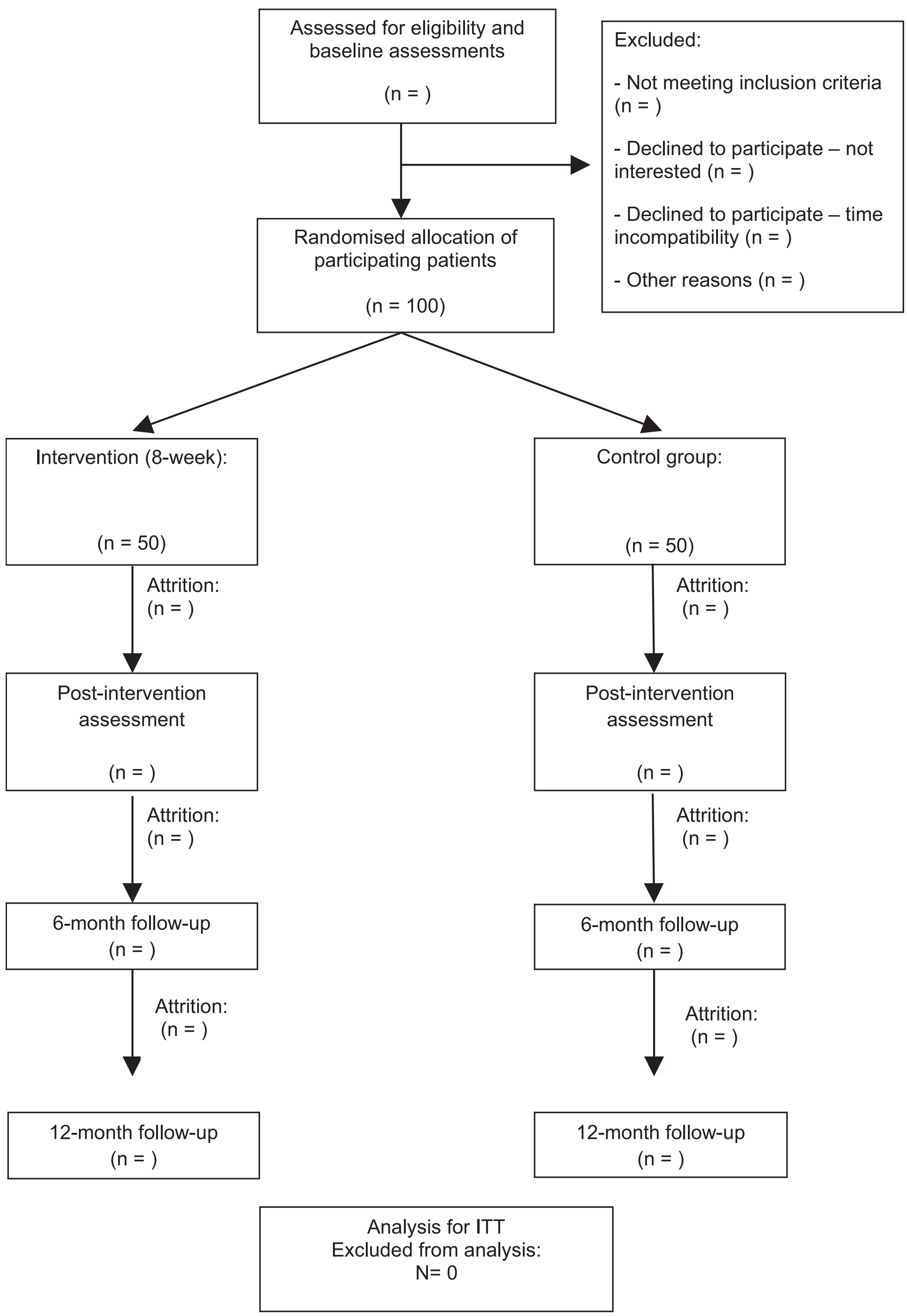

Fig. 1. Protocol of the randomized controlled trial.

3. Methods

3.1. Study design

Randomized clinical trial (RCT) according to the CONSORT group guidelines. (see Fig. 1) (Cobos-Carbo and Augustovski, 2011). The population of interest is made up of elderly people (65 years of age and older) with NC and without MCI recruited at a primary care center.

3.2. Participants

The population of interest will consist of elderly individuals aged 65 years and older with NC and without MCI, recruited from a Primary Care center. To recruit 100 participants, we will collaborate with coordinators at various health centers and place information posters at the entrances of medical offices. Given that the role of Occupational Therapist is not yet widely recognized in Primary Care, a multifaceted approach will be employed to boost participation: This will include conducting informative sessions for medical and nursing staff to raise awareness about the study, distributing leaflets to the elderly and their families with detailed information—along with a QR code and email address for further inquiries—and personally informing individuals in the waiting rooms of medical consultations.

3.3. Eligibility criteria (inclusion and exclusion criteria)

3.3.1. Inclusion criteria

- Age: $\geq$ 65 years.
- With score in Lobo's Mini-cognitive Examination (MEC-35) (Lobo et al., 1979) between: 28–35 points (Friedman et al., 2012; Vinyoles Bargalló et al., 2002).
- Non-institutionalized persons, belonging to the health centers where the study was conducted.
- With a minimum educational level (knowing how to read and write).
- Who do not present hearing, visual or communication difficulties that would prevent them from completing the cognitive training.

3.3.2. Exclusion criteria

- People with mild cognitive impairment or Alzheimer's disease (AD).
- People with significant functional impairment.
- People who have received any type of professionalized cognitive stimulation therapy in the last year.
- People with significant psychiatric conditions, such as major depressive disorder or schizophrenia.
- People who are taking medications that may adversely affect cognitive function, such as anticholinergics, tranquilizers and anticonvulsants.

3.4. Sample size

The sample size was calculated with the MEC-35 data reported in Table 3 of the article by Calatayud et al. (Calatayud et al., 2020) using a Student's *t*-test for independent samples for the 6-month posttreatment difference between the two groups. Accepting a risk <0.05 and a minimum power of 80 % with 15 % loss, 100 subjects (50) are needed for a calculated effect size of Cohen's d = 0.611.

3.5. Randomization

Once the sample size (100 participants) has been reached, applying the inclusion and exclusion criteria, participants will be randomized in a stratified manner according to CR level. Participants will be initially classified into those with Low Cognitive Reserve (LCR) (7–9 points), moderate-high (10–14 points) and High Cognitive Reserve (HCR) (15–25 points). Randomization cards will be generated to assign participants to the three cognitive reserve groups using the opaque sealed envelope method. Subsequently, using the excel randomization program, half of each stratum will be randomly selected to the CG and the other half to the IG, so that 50 participants will be from the CG and 50 from the IG.

3.6. Intervention

The IG will receive a cognitive intervention according to his/her identified CR level; previously he/she will receive digital literacy classes according to his/her previously assessed level.

The CG will undergo a group and face-to-face training-explanatory session, where the importance of maintaining the usual level of cognitive activity will be emphasized.

3.6.1. Program design

- The CS program, for the IG, will be previously designed by 2 TO of the team, and adapted to the computerized format through a platform specialized in cognitive neurorehabilitation. The activities will be designed under TO models: human occupation model and cognitive-perceptual model, so that the different professions, interests and roles are represented, and allow to express different levels of complexity, according to the level of CR.
- The cognitive aspects to be worked on are: memory, orientation, language, praxis, gnosis, calculation, perception, logical reasoning, attention-concentration and executive functions.
- In addition, reinforcement, EF, episodic memory, attention and information processing speed activities will be designed, also according to the CR level.

3.6.2. Intervention sessions and program development.

Participants assigned to the intervention group will receive an 8-week treatment plan, structured as follows:

- **Week 1:** Participants will attend digital literacy training sessions at the health center, tailored to their initial skill levels. These sessions, conducted in subgroups of 15, will focus on teaching tablet use, the Stimulus platform, and the intervention structure based on their cognitive reserve levels. Participants with high training levels will attend one 1.5-h session, while those with lower levels will attend three 1.5-h sessions.
- **Weeks 2–6:** Participants will complete cognitive stimulation exercises at home using their tablets. These exercises will target 10 cognitive aspects (memory, orientation, language, praxis, gnosis, calculation, perception, logical reasoning, attention-concentration, and executive functions), with two aspects covered each week. The difficulty levels will be adjusted based on the participant's cognitive reserve.
- **Week 7:** Group video calls will be conducted via Google Meet to discuss progress. During these calls, instructions will be given on accessing reinforcement activities for vulnerable cognitive aspects (attention, episodic memory, processing speed, and executive functions) through the Stimulus platform.
- **Week 8:** Participants will perform the reinforcement exercises at home. After completing the 8-week intervention, they will return for a follow-up evaluation, using the same assessment tools as in the initial evaluation.

The control group will not require tablets. For the intervention group, participants will be asked if they had access to a tablet, mobile phone, or computer. The program will be adaptable to all devices. For those without access to these tools, two tablets will be purchased through grant funding and loaned to participants as needed.

3.7. Assessments

An initial evaluation (pre), after the intervention (post) and two follow-up evaluations (at 6 and 12 months) will be carried out.

In the initial interview, data related to sociodemographic variables will be collected: sex, age, marital status, level of education, living arrangements and main occupation.

For the description of clinical variables, the existence of pathologies related to MCI: arterial hypertension, diabetes, cholesterol, obesity and cardiovascular and Alzheimer's disease history will be collected in a self-reported manner.

3.7.1. Instruments

To determine the level of cognitive reserve (Landenberger et al., 2019) the most suitable questionnaire is the Cognitive Reserve Questionnaire (CRQ) (Rami et al., 2011). It has eight items with between three and six response options. Each item relieves a CR factor: schooling, parental schooling, courses, occupation, musical training, languages, reading and intellectual games. The maximum score is 25 points. Between 7 and 9 points is considered a low range of CR. Between 10 and 14 points moderate-high range, and ≥ 15 points, high CR. It is an instrument with high reliability and acceptable convergent validity (Martino et al., 2021).

The primary outcome variable is MEC-35 (Spanish version of Folstein's Mini-Mental): the most widely used cognitive test in Primary Care, adapted by Lobo to the Spanish population (Lobo et al., 1979). It evaluates 8 components: temporal orientation, spatial orientation, fixation memory, attention, calculation, short-term memory, language and praxis. Its sensitivity is 85–90 % and its specificity 69 % (Lobo et al., 1999). Although its cut-off point for detecting cognitive impairment is 24, in NC, scores between 28 and 35 points are considered (Friedman et al., 2012; Vinyoles Bargalló et al., 2002). The MEC-35 is internationally recognized as the instrument with the highest diagnostic accuracy, offering superior sensitivity and specificity compared to other shorter tests (Carrie D. Patnode et al., 2020).

The secondary outcome variables are:

- **Set-Test** (Pascual et al., 1990): measures verbal fluency of categorical type: colors, animals, fruits and cities, asking the patient to say elements of the 4 categories in one minute. It presents a sensitivity of 87 % and a specificity of 67 %.
- **The SDMT or Symbols and Digits Test** measures EF, processing speed and attention. It is a test with good accuracy, sensitivity and specificity, useful for predicting future MCI. The SDMT card consists of a header with a key that relates the numbers from 1 to 9 with different symbols; the participant has 90 s to match a specific number with a particular geometric figure. The response can be written or verbal, and the maximum total response time is five minutes. The ideal cut-off point is 44 points, although 38 points can be used for a more specific result (Baudouin et al., 2009).
- **Color Word Stroop Test (CWST)** (Cheng et al., 2012) assesses perseveration, cognitive flexibility, EF and attention (Uttl and Graf, 1997). It consists of naming a color with and without the presence of conflicting or incongruent stimuli. The test consists of three sheets: in the first one, colors written in black ink are repeated, in the second one colors with their geometric figure, and in the third one colors written in different ink. The correct answers in the three sheets are collected. This test shows a decrease by age and gender (the most impaired EF in men) (Periáñez et al., 2021; Van der Elst et al., 2008). The limits considered normal are 35–65 points (Graf et al., 1995).
- **Verbal Learning Test (TAVEC)** Spanish version of the California Verbal Learning Test (CVLT). It evaluates learning and episodic memory capacity. The test consists of memorizing a list of 16 words (list A), belonging to four semantic categories, and their subsequent recall. Five trials are repeated and a second list of 16 words (list B) is administered. Subsequently, recall of list A and recall by semantic categories is requested. After about 20 min, free recall of word list A and recall by semantic categories is requested again. Both Spearman's coefficient and Cronbach's α indicate high reliability (Nieto Barco et al., 2014).
- **Mobile Device Proficiency Questionnaire in Short Form (MDPQ-16).** Tests experience and aptitude for using mobile devices in eight domains: mobile device basics, communication, data and file storage, Internet, calendar, entertainment, privacy, troubleshooting, and software management. Each of the domains is scored on a 5-point scale (e.g., 1 = never tried, 2 = not at all, 3 = not very easily, 4 = somewhat easily, 5 = very easily). The total score ranges from 8 to 40, with higher scores reflecting greater competence. Internal consistency is excellent (Cronbach's α = 0.96) (Roque and Boot, 2018).

3.8. Statistical analysis

Statistical analysis will be performed with the program R Ver. 3.5.1. (R Foundation for Statistical Computing, Institute for Statistics and Mathematics, Welthandelsplatz 1, 1020 Vienna, Austria).

The significance level will be set at $p < 0.05$.

Quantitative variables will be described with mean and standard deviation and qualitative variables with absolute and relative (%) values. The Shapiro-Wilk test will be applied to determine the distribution of quantitative variables.

Outcome variables with non-normal distribution will be analyzed using a robust repeated measures model with two factors, between (groups) and within (measurements) with means truncated at 20 %. For post hoc tests, the Mann-Whitney *U* test between groups and the Wilcoxon signed-rank test within groups will be applied, applying the Bonferroni correction in both cases. Outcome variables with normal distribution will be analyzed with a parametric mixed Anova, after checking the assumption of homogeneity of variances using the Mauchly test. For post hoc tests, a *t*-test will be applied for independent samples between groups and a t-test for dependent samples within groups, applying in both cases the Bonferroni correction.

The effect size will be calculated with the statistic η^2 (bootstrapped partial eta squared), defining it as small (<0.06), moderate (0.06–0.14) and large (>0.14).

3.9. Ethical aspects and data protection

This study has been approved by the Research Ethics Committee of the Autonomous Community of Aragón, protocol number (CEICA PI23/637), by the manager of the health area corresponding to the primary care centers and is registered in ClinicalTrials.gov (identifiers NCT06279325). Participants will be informed of the study objectives, and they signed a written informed consent form. The protocol will comply with the ethical principles of the 1964 Declaration of Helsinki, as revised in 2013 at the 64th WMA General Assembly in Fortaleza, Brazil (World Medical Association Declaration of Helsinki Ethical Principles for Medical Research, 2013) and standards of good clinical practice and the study will comply with current legislation. The protocol will follow the CONSORT 2010 recommended guidelines (Schulz et al., 2010).

For the processing of personal data, the provisions of the RGPD 2016/679 and the LO 3/2018 on the processing of personal data will be complied with. The data will be pseudonymized to prevent patients from being recognized in the data analysis (This project has been approved by the Data Protection Unit of the University of Zaragoza (RAT 2024–3).

4. Discussion

The results of this trial are expected to demonstrate the effectiveness of a computerized CE intervention at two different levels of cognitive reserve (low vs. medium-high), raising the hypothesis, added to the expected cognitive benefits, that, by adapting the intervention, the program can be equally effective in both groups. On the other hand, they aim to equalize gender differences, and differences in educational and work opportunities. Finally, the aim is to delay or prevent MCI, thanks to the reinforcement of the cognitive activities most vulnerable to aging.

CS is a non-pharmacological intervention intended to promote the maintenance of memory and global cognition. It is increasingly common for the professional who designs and administers these treatments to be an Occupational Therapist, as it is an individualized intervention based on person-centered care models (Clare et al., 2019; Regier et al., 2016; Tulliani et al., 2023).

Primary Health Care (PHC) focuses on comprehensive health care, offering preventive and curative services (Fong, 2008). The person-centered approach that Starfield (Starfield, 2011) pointed to regarding PHC is fully consistent with the models of OT (Duncan, 2022).

Furthermore, the CR hypothesis is in line with one of the most common statements in OT: meaningful and purposeful activities or occupations have a greater effect on health (Hammell, 2017; Mendoza-Holgado et al., 2021; Pettigrew and Soldan, 2019) and improve occupational balance (Anaby et al., 2010).

The CR model suggests that a person's lifestyle and occupations will determine their CR (Mendoza-Holgado et al., 2021). Socially active people who have engaged in intellectual activities such as reading books, learning languages, and who have had cognitively demanding jobs will have increased CR and were associated with more favorable cognitive aging trajectories (Amanollahi et al., 2021; Fallahpour et al., 2016) (Li et al., 2020).In addition, digital literacy is related to improving communication and promoting physical and mental well-being among older adults (Oh et al., 2021).

The theoretical implications that this study could have for scientists and colleagues in this field would be the importance of personalizing interventions and the work of cognitive stimulation by levels previously published (Calatayud et al., 2022; Gómez-Soria et al., 2023a), but adding in this case, technological means that are more attractive and mouldable in practice for users and professionals. On the other hand, anticipate cognitive challenges prior to retirement, at an occupational level, and promote a culture that promotes cognitive reserve through social participation to reach old age in more optimal cognitive conditions. Finally, the fact of equalizing educational and occupational opportunities, which affect cognitive reserve, especially in women.

The strengths of this study include the personalization and adaptation of the computerized stimulation program (CCS) to two levels of reserve acquired throughout life; This implies equality of opportunities, even more so, when recent studies consider that CR can be promoted and increased after retirement, and that in that case, CCE could be considered a form of "education for old age"(Belleville et al., 2023). These interventions help the elderly to use more efficient brain networks, in the face of the demands of the environment (Jones et al., 2011).

Another of the strengths of the study is that the digital divide has been taken into account, which involves moving from a traditional CE model (pencil and paper) to an ECC model, taking into account the evaluation of digital literacy and training, before the start of the intervention. This way the elderly person will be able to receive the treatment in the comfort of their home. The dominance of mobile devices is imposed by the need for social participation. However, today, the existence of a digital divide between young and older adults can be perceived, especially with respect to mobile devices (i.e., tablets and smartphones) (Quinde Barcia et al., 2020). The relationship between age and technology adoption is mediated by cognitive abilities and computer anxiety (Czaja et al., 2006) A recent study associates the use of social networks, and independence in the use of technological advances and the level of digital competence with successful aging (Betlej, 2023).

A key strength of this study, in contrast to similar ones, is its focus on measuring long-term effects (Gates et al., 2020). Not only does it analyze cognitive functions, but it also examines whether cognitive reserve levels increase over time, despite aging. This increase could enhance both quality of life and self-perception of health, supported by the digital literacy provided beforehand.

As previously mentioned, some studies have demonstrated that ECC improves overall cognitive performance in older adults, particularly in areas such as verbal and non-verbal memory, working memory, processing speed, and visuospatial skills. However, no significant effects have been observed in attention and executive functions (Grotz et al., 2018; Lampit et al., 2014). To address these vulnerable areas, our study includes reinforcement sessions specifically designed to target these aspects of cognitive deterioration.

A limitation of the study could be that only those older people with high digital literacy are encouraged to participate, as they seem safer, or even that those with high cognitive abilities decide not to participate, because they find free downloadable tools on mobile devices, which can fulfill this function. It has been found in the literature that older adults consume this type of computerized leisure activities, without prescription from a health professional (Ferreira et al., 2015; Lampit et al., 2014); Furthermore, people with lower CR are the ones who use these technologies the least (Stronge et al., 2006).

The purpose of this study is to balance these differences in a Primary Care environment that, according to the definition given in the Declaration of Alma-Ata (WHO, 2007), approved by the 1978 International Conference on Health PC convened by the WHO: "It is essential health care based on practical, scientifically sound and socially acceptable methods and technologies, made available to all individuals and families in the community through their full participation." (WHO, 2007).

Future research will focus on exploring the transfer of cognitive improvements to functional abilities and overall quality of life in older adults. Additionally, we aim to investigate whether digital literacy enhances self-perception of cognitive health and self-esteem, as well as the impact on social participation through the use of social networks, following their adaptation to using tablets or mobile devices.

CRediT authorship contribution statement

Estela Calatayud: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Bárbara Oliván-Blázquez:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Alejandra Aguilar-Latorre:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Juan Nicolás Cuenca-Zaldivar:** Writing – review & editing, Validation, Supervision, Software, Methodology. **Rosa Mª. Magallón-Botaya:** Writing – review & editing, Supervision, Resources. **Isabel Gómez-Soria:** Writing – review & editing, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

No data was used for the research described in the article.

Acknowledgements

Thanks to the Arrabal and Barrio Jesús Health Centres, Zaragoza (Spain), for their collaboration, to all of the participants who collaborated in this study and professional who will carried out the evaluations. We wish to thank the Aragonese Primary Care Research Group (GAIAP, B21_23R) for providing us with their facilities to carry out the study.

Funding

This article has been funded by a research grant from the Colegio Oficial de Terapeutas Ocupacionales de la Comunidad de Madrid (COPTOCAM) awarded for the development of the study in 2024.

References

Agustí, A.I., Guillem-Saiz, J., González-Moreno, J., Cantero-García, M., Cigarroa, I., Parra-Rizo, M.A., 2023. Predictors of health satisfaction in Spanish physically active older adults: a cross-sectional observational study. Geriatrics 8 (1), 27. https://doi.org/10.3390/geriatrics8010027.

Amanollahi, M., Amanollahi, S., Anjomshoa, A., Dolatshahi, M., 2021. Mitigating the negative impacts of aging on cognitive function; modifiable factors associated with increasing cognitive reserve. In: European Journal of Neuroscience, Vol. 53, Issue 9. Blackwell Publishing Ltd., pp. 3109–3124. https://doi.org/10.1111/ejn.15183

Anaby, D.R., Backman, C.L., Jarus, T., 2010. Measuring occupational balance: a theoretical exploration of two approaches. Can. J. Occup. Ther. 77 (5), 280–288. https://doi.org/10.2182/cjot.2010.77.5.4.

Anstey, K.J., Cherbuin, N., Herath, P.M., 2013. Development of a new method for assessing global risk of Alzheimer's disease for use in population health approaches to prevention. Prev. Sci. 14 (4), 411–421. https://doi.org/10.1007/s11121-012-0313-2.

Baudouin, A., Clarys, D., Vanneste, S., Isingrini, M., 2009. Executive functioning and processing speed in age-related differences in memory: contribution of a coding task. Brain Cogn. 71 (3), 240–245. https://doi.org/10.1016/j.bandc.2009.08.007.

Belleville, S., Mellah, S., de Boysson, C., Demonet, J.-F., Bier, B., 2014. The pattern and loci of training-induced brain changes in healthy older adults are predicted by the nature of the intervention. PloS One 9 (8), e102710. https://doi.org/10.1371/journal.pone.0102710.

Belleville, S., Cuesta, M., Bieler-Aeschlimann, M., Giacomino, K., Widmer, A., Mittaz Hager, A.G., Perez-Marcos, D., Cardin, S., Boller, B., Bier, N., Aubertin-Leheudre, M., Bherer, L., Berryman, N., Agrigoroaei, S., Demonet, J.F., 2023. Pre-frail older adults show improved cognition with StayFitLonger computerized home–based training: a randomized controlled trial. GeroScience 45 (2), 811–822. https://doi.org/10.1007/s11357-022-00674-5.

Betlej, A., 2023. Social networks, new technologies, and wellbeing—an interview study on factors influencing older adults' successful ageing. Int. J. Environ. Res. Public Health 20 (7). https://doi.org/10.3390/ijerph20075279.

Cabeza, R., Albert, M., Belleville, S., Craik, F.I.M., Duarte, A., Grady, C.L., Lindenberger, U., Nyberg, L., Park, D.C., Reuter-Lorenz, P.A., Rugg, M.D., Steffener, J., Rajah, M.N., 2018. Maintenance, reserve and compensation: the cognitive neuroscience of healthy ageing. In: Nature Reviews Neuroscience, Vol. 19, Issue 11. Nature Publishing Group, pp. 701–710. https://doi.org/10.1038/s41583-018-0068-2.

Calatayud, E., Plo, F., Muro, C., 2020. Analysis of the effect of a program of cognitive stimulation in elderly people with normal aging in primary care: randomized clinical trial. Aten. Primaria 52 (1), 38–46. https://doi.org/10.1016/j.aprim.2018.09.007.

Calatayud, E., Lozano-Berges, G., Peralta-Marrupe, P., Latorre, E., Gomez-Soria, I., 2022. Job demands may determine cognitive and physical aging after retirement. Journal of Applied Gerontology: The Official Journal of the Southern Gerontological Society 41 (12), 2435–2446. https://doi.org/10.1177/07334648221120080.

Chan, M.Y., Haber, S., Drew, L.M., Park, D.C., 2016. Training older adults to use tablet computers: does it enhance cognitive function? Gerontologist 56 (3), 475–484. https://doi.org/10.1093/geront/gnu057.

Chen, Y., Denny, K.G., Harvey, D., Farias, S.T., Mungas, D., DeCarli, C., Beckett, L., 2017. Progression from normal cognition to mild cognitive impairment in a diverse clinic-based and community-based elderly cohort. Alzheimer's and Dementia 13 (4), 399–405. https://doi.org/10.1016/j.jalz.2016.07.151.

Cheng, Y., Wu, W., Feng, W., Wang, J., Chen, Y., Shen, Y., Li, Q., Zhang, X., Li, C., 2012. The effects of multi-domain versus single-domain cognitive training in non-demented older people: a randomized controlled trial. BMC Med. 10 https://doi.org/10.1186/1741-7015-10-30.

Clare, L., Kudlicka, A., Oyebode, J.R., Jones, R.W., Bayer, A., Leroi, I., Kopelman, M., James, I.A., Culverwell, A., Pool, J., Brand, A., Henderson, C., Hoare, Z., Knapp, M., Morgan-Trimmer, S., Burns, A., Corbett, A., Whitaker, R., Woods, B., 2019. Goal-oriented cognitive rehabilitation for early-stage Alzheimer's and related dementias: the GREAT RCT. Health Technol. Assess. 23 (10), 1–242. https://doi.org/10.3310/hta23100.

Clark, D.O., Xu, H., Unverzagt, F.W., Hendrie, H., 2016. Does targeted cognitive training reduce educational disparities in cognitive function among cognitively normal older adults? Int. J. Geriatr. Psychiatry 31 (7), 809–817. https://doi.org/10.1002/gps.4395.

Cobos-Carbo, Albert, Augustovski, F., 2011. CONSORT 2010 declaration: updated guideline for reporting parallel group randomised trials. Medicina Clinica (Barc) 137, 213–215.

Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.A., Sharit, J., 2006. Factors predicting the use of technology: findings from the center for research and education on aging and technology enhancement (create). Psychol. Aging 21 (2), 333–352. https://doi.org/10.1037/0882-7974.21.2.333.

Ducharme-Laliberté, G., Mellah, S., Boller, B., Belleville, S., 2022. More flexible brain activation underlies cognitive reserve in older adults. Neurobiol. Aging 113, 63–72. https://doi.org/10.1016/j.neurobiolaging.2022.02.001.

Duncan, E.A.S., 2022. Fundamentos para la práctica en terapia ocupacional, 6th ed. Elsevier.

Fallahpour, M., Borell, L., Luborsky, M., Nygård, L., 2016. Leisure-activity participation to prevent later-life cognitive decline: a systematic review. Scand. J. Occup. Ther. 23 (3), 162–197. https://doi.org/10.3109/11038128.2015.1102320.

Ferreira, N., Owen, A., Mohan, A., Corbett, A., Ballard, C., 2015. Associations between cognitively stimulating leisure activities, cognitive function and age-related cognitive decline. Int. J. Geriatr. Psychiatry 30 (4), 422–430. https://doi.org/10.1002/gps.4155.

Fisher, E., Venkatesan, S., Benevides, P., Bertrand, E., Brum, P.S., El Baou, C., Ferri, C.P., Fossey, J., Jelen, M., Laks, J., Liu, L., Mograbi, D.C., Natarajan, N., Naylor, R., Pantouli, D., Ramanujam, V., Rangaswamy, T., Santos de Carvalho, R.L., Stoner, C., Spector, A., 2024. Online cognitive stimulation therapy for dementia in Brazil and India: acceptability, feasibility, and lessons for implementation. JMIR Aging 7, e55557. https://doi.org/10.2196/55557.

Fong, K., 2008. Occupational therapy in primary health care: a new area for involvement and contributions in the new health care system in Hong Kong. https://www.healthbureau.gov.hk/beStrong/files/individuals/I0755.pdf.

Friedman, T.W., Yelland, G.W., Robinson, S.R., 2012. Subtle cognitive impairment in elders with mini-mental state examination scores within the "normal" range. Int. J. Geriatr. Psychiatry 27 (5), 463–471. https://doi.org/10.1002/gps.2736.

Gates, N.J., Sachdev, P.S., Fiatarone Singh, M.A., Valenzuela, M., 2011. Cognitive and memory training in adults at risk of dementia: a systematic review. BMC Geriatr. 11 (1), 55. https://doi.org/10.1186/1471-2318-11-55.

Gates, N.J., Rutjes, A.W., Di Nisio, M., Karim, S., Chong, L.-Y., March, E., Martínez, G., Vernooij, R.W., 2019. Computerised cognitive training for maintaining cognitive function in cognitively healthy people in midlife. Cochrane Database Syst. Rev. https://doi.org/10.1002/14651858.CD012278.pub2.

Gates, N.J., Rutjes, A.W., Di Nisio, M., Karim, S., Chong, L.Y., March, E., Martínez, G., Vernooij, R.W., 2020. Computerised cognitive training for 12 or more weeks for maintaining cognitive function in cognitively healthy people in late life. Cochrane Database Syst. Rev. 2 (2) https://doi.org/10.1002/14651858.CD012277.pub3.

Gómez-Soria, I., Ferreira, C., Oliván-Blázquez, B., Aguilar-Latorre, A., Calatayud, E., 2023a. Effects of cognitive stimulation program on cognition and mood in older adults, stratified by cognitive levels: a randomized controlled trial. Arch. Gerontol. Geriatr. 110, 104984 https://doi.org/10.1016/j.archger.2023.104984.

Gómez-Soria, I., Iguacel, I., Cuenca-Zaldívar, J.N., Aguilar-Latorre, A., Peralta-Marrupe, P., Latorre, E., Calatayud, E., 2023b. Cognitive stimulation and psychosocial results in older adults: a systematic review and meta-analysis. Arch. Gerontol. Geriatr. 115, 105114 https://doi.org/10.1016/j.archger.2023.105114.

Graf, P., Uttl, B., Tuokko, H., 1995. Color- and picture-word stroop tests: performance changes in old age. J. Clin. Exp. Neuropsychol. 17 (3), 390–415. https://doi.org/10.1080/01688639508405132.

Grotz, C., Meillon, C., Amieva, H., Andel, R., Dartigues, J.F., Adam, S., Letenneur, L., 2018. Occupational social and mental stimulation and cognitive decline with advancing age. Age Ageing 47 (1), 101–106. https://doi.org/10.1093/ageing/afx101.

Hall, C.B., Derby, C., LeValley, A., Katz, M.J., Verghese, J., Lipton, R.B., 2007. Education delays accelerated decline on a memory test in persons who develop dementia. Neurology 69 (17), 1657–1664. https://doi.org/10.1212/01.wnl.0000278163.82636.30.

Hammell, K.W., 2017. Précis – Discours commémoratif Muriel Driver 2017 Possibilités en matière de bien-être: Le droit à la participation occupationnelle. Can. J. Occup. Ther. 84 (4–5), E1–E14. https://doi.org/10.1177/0008417417753374.

Hyun, J., Hall, C.B., Katz, M.J., Derby, C.A., Lipnicki, D.M., Crawford, J.D., Guaita, A., Vaccaro, R., Davin, A., Kim, K.W., Han, J.W., Bae, J. Bin, Röhr, S., Riedel-Heller, S., Ganguli, M., Jacobsen, E., Hughes, T.F., Brodaty, H., Kochan, N.A., Lipton, R.B., 2022. Education, occupational complexity, and incident dementia: a COSMIC collaborative cohort study. J. Alzheimers Dis. 85 (1), 179–196. https://doi.org/10.3233/jad-210627.

Jones, R.N., Manly, J., Glymour, M.M., Rentz, D.M., Jefferson, A.L., Stern, Y., 2011. Conceptual and measurement challenges in research on cognitive reserve. J. Int. Neuropsychol. Soc. 17 (4), 593–601. https://doi.org/10.1017/S1355617710001748.

Kelly, M.E., Duff, H., Kelly, S., McHugh Power, J.E., Brennan, S., Lawlor, B.A., Loughrey, D.G., 2017. The impact ofsocial activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. Syst. Rev. 6 (1) https://doi.org/10.1186/s13643-017-0632-2.

Lampit, A., Hallock, H., Valenzuela, M., 2014. Computerized cognitive training in cognitively healthy older adults: a systematic review and Meta-analysis of effect modifiers. PLoS Med. 11 (11), e1001756 https://doi.org/10.1371/journal.pmed.1001756.

Landenberger, T., Cardoso, N. de O., de Oliveira, C.R., Argimon, I.I. de L., 2019. Instruments for measuring cognitive reserve: a systematic review. Psicologia - Teoria e Prática 21 (2), 58–74. https://doi.org/10.5935/1980-6906/psicologia.v21n2p58-74.

Laver, K., Hamilton, C., Mccluskey, A., 2015. Computerised cognitive training programs improved the cognitive performance of healthy older adults on some cognitive tests including memory, speed of information processing and visuospatial skills. Aust. Occup. Ther. J. 62 (3), 223–224. https://doi.org/10.1111/1440-1630.12209.

Lenze, E.J., Voegtle, M., Miller, J.P., Ances, B.M., Balota, D.A., Barch, D., Depp, C.A., Diniz, B.S., Eyler, L.T., Foster, E.R., Gettinger, T.R., Head, D., Hershey, T., Klein, S., Nichols, J.F., Nicol, G.E., Nishino, T., Patterson, B.W., Rodebaugh, T.L., Wetherell, J. L., 2022. Effects of mindfulness training and exercise on cognitive function in older adults: a randomized clinical trial. JAMA 328 (22), 2218–2229. https://doi.org/10.1001/jama.2022.21680.

Li, H., Li, C., Wang, A., Qi, Y., Feng, W., Hou, C., Tao, L., Liu, X., Li, X., Wang, W., Zheng, D., Guo, X., 2020. Associations between social and intellectual activities with cognitive trajectories in Chinese middle-aged and older adults: a nationally representative cohort study. Alzheimer's Research and Therapy 12 (1), 115. https://doi.org/10.1186/s13195-020-00691-6.

Lobo, A., Escolar, V., Ezquerra, J., Seva Díaz, A., 1979. El Mini-Examen Cognoscitivo: Un test sencillo, práctico, para detectar alteraciones intelectuales en pacientes psiquiátricos. Actas Luso Esp. Neurol. Psiquiatr. 3, 189–202.

Lobo, A., Saz, P., Marcos, G., Dia, J., Ventura, T., 1999. Revalidación y normalización del Mini-Examen Cognoscitivo (primera versión en castellano del Mini-Mental Status Examination) en la población general geriátrica. MEDICINA CLINICA 112 (20), 767–774.

Loftus, A.M., Gasson, N., Lopez, N., Sellner, M., Reid, C., Cocks, N., Lawrence, B.J., 2021. Cognitive reserve, executive function, and memory in parkinson's disease. Brain Sci. 11 (8) https://doi.org/10.3390/brainsci11080992.

Lojo-Seoane, C., Facal, D., Guàrdia-Olmos, J., Pereiro, A.X., Campos-Magdaleno, M., Mallo, S.C., Juncos-Rabadán, O., 2020. Cognitive reserve and working memory in cognitive performance of adults with subjective cognitive complaints: longitudinal structural equation modeling. Int. Psychogeriatr. 32 (4), 515–524. https://doi.org/10.1017/S1041610219001248.

López-Higes, R., Martín-Aragoneses, M.T., Rubio-Valdehita, S., Delgado-Losada, M.L., Montejo, P., Montenegro, M., Prados, J.M., de Frutos-Lucas, J., López-Sanz, D., 2018. Efficacy of cognitive training in older adults with and without subjective cognitive decline is associated with inhibition efficiency and working memory span, not with cognitive reserve. Frontiers in Aging Neuroscience 10 (FEB). https://doi.org/10.3389/fnagi.2018.00023.

MacAulay, R.K., Calamia, M.R., Cohen, A.S., Daigle, K., Foil, H., Brouillette, R., Bruce-Keller, A.J., Keller, J.N., 2018. Understanding heterogeneity in older adults: latent growth curve modeling of cognitive functioning. J. Clin. Exp. Neuropsychol. 40 (3), 292–302. https://doi.org/10.1080/13803395.2017.1342772.

Martino, P., Cervigni, M., Caycho-Rodríguez, T., Valencia, P., Politis, D., 2021. Cognitive reserve questionnaire: the psychometric properties in an Argentinian population. Rev. Neurol. 73 (6), 194–200. https://doi.org/10.33588/RN.7306.2021200.

Mendoza-Holgado, C., Lavado-García, J., López-Espuela, F., Roncero-Martín, R., Canal-Macías, M.L., Vera, V., Aliaga, I., Rey-Sánchez, P., Pedrera-Zamorano, J.D., Moran, J. M., 2021. Cognitive reserve characteristics and occupational performance implications in people with mild cognitive impairment. Healthcare 9 (10), 1266. https://doi.org/10.3390/healthcare9101266.

Mičič, S., Horvat, M., Bakracevic, K., 2019. The impact of working memory training on cognitive abilities in older adults: the role of cognitive reserve. Curr. Aging Sci. 13 (1), 52–61. https://doi.org/10.2174/1874609812666190819125542.

Mitzner, T.L., Rogers, W.A., Fisk, A.D., Boot, W.R., Charness, N., Czaja, S.J., Sharit, J., 2016. Predicting older adults' perceptions about a computer system designed for seniors. Univ. Access Inf. Soc. 15 (2), 271–280. https://doi.org/10.1007/s10209-014-0383-y.

Nieto Barco, A., Hernández Rodríguez, E., Hernández Torres, A., Velasco Rodríguez-Solís, P., Hess Medler, S., Machado Fernández, A., Molina Rodríguez, Y., Barroso Ribal, J., 2014. Versión paralela del test de aprendizaje verbal España-Complutense (TAVEC). Réplica. Revista de Neurología 59 (10), 480. https://doi.org/10.33588/rn.5910.2014432.

Oh, S.S., Kim, K.-A., Kim, M., Oh, J., Chu, S.H., Choi, J., 2021. Measurement of digital literacy among older adults: systematic review. J. Med. Internet Res. 23 (2), e26145 https://doi.org/10.2196/26145.

Opdebeeck, C., Matthews, F.E., Wu, Y.T., Woods, R.T., Brayne, C., Clare, L., 2018. Cognitive reserve as a moderator of the negative association between mood and cognition: evidence from a population-representative cohort. Psychol. Med. 48 (1), 61–71. https://doi.org/10.1017/S003329171700126X.

Park, D.C., Lodi-Smith, J., Drew, L., Haber, S., Hebrank, A., Bischof, G.N., Aamodt, W., 2014. The impact of sustained engagement on cognitive function in older adults: the synapse project. Psychol. Sci. 25 (1), 103–112. https://doi.org/10.1177/0956797613499592.

Parra-Rizo, M.A., 2017. Most valued components of the quality of life in older people than 60 years physically active. European Journal of Investigation in Health, Psychology and Education 7 (3), 135–144. https://doi.org/10.30552/ejihpe.v7i3.202.

Pascual, L., Martinez, J., Modrego, P., Mostacero, E., Lopez del Val, J., Morales, F., 1990. El Set-test en el diagnóstico de la demencia. Neurología 5, 82–85.

Patnode, Carrie D., Perdue, Leslie A., Rossom, Rebecca C., Rushkin, Megan C., Redmond, Nadia, Thomas, Rachel G., Lin, Jennifer S., 2020. Screening for cognitive impairment in older adults: an evidence update for the U.S. preventive services task force. In: Evidence Synthesis, Vol. 189. https://www.ncbi.nlm.nih.gov/books/NBK554654/.

Periáñez, J.A., Lubrini, G., García-Gutiérrez, A., Ríos-Lago, M., 2021. Construct validity of the stroop color-word test: influence of speed of visual search, verbal fluency, working memory, cognitive flexibility, and conflict monitoring. Arch. Clin. Neuropsychol. 36 (1), 99–111. https://doi.org/10.1093/arclin/acaa034.

Pettigrew, C., Soldan, A., 2019. Defining cognitive reserve and implications for cognitive aging. Curr. Neurol. Neurosci. Rep. 19 (1), 1. https://doi.org/10.1007/s11910-019-0917-z.

Quinde Barcia, B., Mosquera, M., Vázquez-Martínez, A., 2020. Brecha Digital en Adultos Mayores: Accesibilidad Tecnológica y Redes Sociales. GIGAPP Estudios Working Papers 7 (180), 744–757.

Rabbitt, P., Lunn, M., Wong, D., Cobain, M., 2008. Age and ability affect practice gains in longitudinal studies of cognitive change. Journals of Gerontology - Series B Psychological Sciences and Social Sciences 63 (4). https://doi.org/10.1093/geronb/63.4.P235.

Rami, L., Valls-Pedret, C., Bartrés-Faz, D., Caprile, C., Solé-Padullés, C., Castellví, M., Olives, J., Bosch, B., Molinuevo, J.L., 2011. Cognitive reserve questionnaire. Scores obtained in a healthy elderly population and in one with Alzheimer's disease. Rev. Neurol. 52 (4), 195–201. https://doi.org/10.33588/rn.5204.2010478.

Regier, N.G., Hodgson, N.A., Gitlin, L.N., 2016. Characteristics of activities for persons with dementia at the mild, moderate, and severe stages. Gerontologist gnw133. https://doi.org/10.1093/geront/gnw133.

Roque, N.A., Boot, W.R., 2018. A new tool for assessing Mobile device proficiency in older adults: the Mobile device proficiency questionnaire. J. Appl. Gerontol. 37 (2), 131–156. https://doi.org/10.1177/0733464816642582.

Scarmeas, N., Levy, G., Tang, M.X., Manly, J., Stern, Y., 2001. Influence of leisure activity on the incidence of Alzheimer's disease. Neurology 57 (12), 2236–2242. https://doi.org/10.1212/WNL.57.12.2236.

Schulz, K.F., Altman, D.C., Moher, D., 2010. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ (Clinical research ed.) 340, c332. https://doi.org/10.1136/bmj.c332.

Shaw, J.S., Hosseini, S.M.H., 2020. The effect of baseline performance and age on cognitive training improvements in older adults: a qualitative review. J. Prev Alzheimers Dis. 1–10 https://doi.org/10.14283/jpad.2020.55.

Starfield, B., 2011. Is patient-centered care the same as person-focused care? Perm. J. 15 (2), 63. https://doi.org/10.7812/TPP/10-148.

Steffener, J., Stern, Y., 2012. Exploring the neural basis of cognitive reserve in aging. In: Biochimica et Biophysica Acta - Molecular Basis of Disease, Vol. 1822, Issue 3. Biochim Biophys Acta, pp. 467–473. https://doi.org/10.1016/j.bbadis.2011.09.012.

Stern, Y., Arenaza-Urquijo, E.M., Bartrés-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., Ewers, M., Franzmeier, N., Kempermann, G., Kremen, W.S., Okonkwo, O., Scarmeas, N., Soldan, A., Udeh-Momoh, C., Valenzuela, M., Vemuri, P., Vuoksimaa, E., 2020. Whitepaper: defining and investigating cognitive reserve, brain reserve, and brain maintenance. Alzheimers Dement. 16 (9), 1305–1311. https://doi.org/10.1016/j.jalz.2018.07.219.

Stine-Morrow, E.A.L., Shake, M.C., Miles, J.R., Noh, S.R., 2006. Adult age differences in the effects of goals on self-regulated sentence processing. Psychol. Aging 21 (4), 790–803. https://doi.org/10.1037/0882-7974.21.4.790.

Stronge, A.J., Rogers, W.A., Fisk, A.D., 2006. Web-based information search and retrieval: effects of strategy use and age on search success. Hum. Factors 48 (3), 434–446. https://doi.org/10.1518/001872006778606804.

Su, S., Shi, L., Zheng, Y., Sun, Y., Huang, X., Zhang, A., Que, J., Sun, X., Shi, J., Bao, Y., Deng, J., Lu, L., 2022. Leisure activities and the risk of dementia: a systematic review and meta-analysis. Neurology 99 (15), E1651–E1663. https://doi.org/10.1212/WNL.0000000000200929.

Ten Brinke, L.F., Davis, J.C., Barha, C.K., Liu-Ambrose, T., 2017. Effects of computerized cognitive training on neuroimaging outcomes in older adults: a systematic review. BMC Geriatr. 17 (1) https://doi.org/10.1186/s12877-017-0529-x.

Ten Brinke, L.F., Best, J.R., Crockett, R.A., Liu-Ambrose, T., 2018. The effects of an 8-week computerized cognitive training program in older adults: a study protocol for a randomized controlled trial. BMC Geriatr. 18 (1) https://doi.org/10.1186/s12877-018-0730-6.

Tsai, H.Y.S., Shillair, R., Cotten, S.R., 2017. Social support and playing around: an examination of how older adults acquire digital literacy with tablet computers. J. Appl. Gerontol. 36 (1), 29–55. https://doi.org/10.1177/0733464815609440.

Tulliani, N., Bye, R., Bissett, M., Coutts, S., Liu, K.P.Y., 2023. The feasibility and acceptability of an app-based cognitive strategy training programme for older people. Pilot and Feasibility Studies 9 (1), 109. https://doi.org/10.1186/s40814-023-01334-x.

Uttl, B., Graf, P., 1997. Color-word stroop test performance across the adult life span. J. Clin. Exp. Neuropsychol. 19 (3), 405–420. https://doi.org/10.1080/01688639708403869.

Van der Elst, W., Van Boxtel, M.P.J., Van Breukelen, G.J.P., Jolles, J., 2008. Detecting the significance of changes in performance on the stroop color-word test, Rey's verbal learning test, and the letter digit substitution test: the regression-based change approach. J. Int. Neuropsychol. Soc. 14 (1), 71–80. https://doi.org/10.1017/S1355617708080028.

Vaportzis, E., Clausen, M.G., Gow, A.J., 2018. Older adults experiences of learning to use tablet computers: a mixed methods study. Front. Psychol. 9 (SEP) https://doi.org/10.3389/fpsyg.2018.01631.

Vinyoles Bargalló, E., Vila Domènech, J., Argimon Pallàs, J.M., Espinàs Boquet, J., Abos Pueyo, T., Limón Ramírez, E., 2002. Concordance among Mini-Examen Cognoscitivo and Mini-mental state examination in cognitive impairment screening. Atencion Primaria / Sociedad Española de Medicina de Familia y Comunitaria 30 (1), 5–13. https://doi.org/10.1016/S0212-6567(02)78956-7.

Wajman, J.R., Mansur, L.L., Yassuda, M.S., 2018. Lifestyle patterns as a modifiable risk factor for late-life cognitive decline: a narrative review regarding dementia prevention. Curr. Aging Sci. 11 (2), 90–99. https://doi.org/10.2174/1874609811666181003160225.

Whitfield, T., McConnell, B., Renouf, P., Mansour, H., Zabihi, S., Aguirre, E., Walker, Z., Cooper, C., Marchant, N.L., 2021. The effect of remotely delivered lifestyle interventions on cognition in older adults without dementia: a systematic review and meta-analysis. In: Ageing Research Reviews, Vol. 72. Elsevier Ireland Ltd. https://doi.org/10.1016/j.arr.2021.101505

WHO, 2007. Declaration of Alma-Ata 1978. Social Medicine. https://www.who.int/teams/social-determinants-of-health/declaration-of-alma-ata.

WHO, 2023. Dementia. https://www.who.int/news-room/fact-sheets/detail/dementia.

World Medical Association Declaration of Helsinki Ethical Principles for Medical Research, 2013. Information, involving human subjects world medical association article. JAMA 310 (20), 2191–2194. https://doi.org/10.1001/jama.2013.28105.

Zhu, C.W., Sano, M., Ferris, S.H., Whitehouse, P.J., Patterson, M.B., Aisen, P.S., 2013. Health-related resource use and costs in elderly adults with and without mild cognitive impairment. J. Am. Geriatr. Soc. 61 (3), 396–402. https://doi.org/10.1111/jgs.12132.