Journal of Aging & Gerontology Research
Volume 2 | Issue 1

Case Report Open Access

Mobile Based Cognitive Retraining In Mild Cognitive Impairment: A Single Case Study

Amala Paul*, Keshav Kumar

Department of Clinical Psychology, NIMHANS, Bengaluru, India

***Corresponding Author:** Keshav Kumar, Department of Clinical Psychology, NIMHANS, Bengaluru, India, Tel.: 0802699-5910, E-mail: keshavjkapp@gmail.com

Citation: Amala Paul, Keshav Kumar (2024) Mobile Based Cognitive Retraining in Mild Cognitive Impairment: A Single Case Study, J Aging Gerontology Res 2(1): 101

Received Date: November 28, 2023 **Accepted Date:** December 28, 2023 **Published Date:** January 06, 2024

Abstract

Objective: The present study aims to explore the benefits of using D-CAP, an android based cognitive training app in Mild Cognitive Impairment(MCI).

Background: Mild cognitive impairment (MCI) is a transient phase between normal age related cognitive decline and dementia, with deficits in memory, executive function and speed of processing. D-CAP is an app-based cognitive retraining program provided by downloading an application that can be installed on an android phone, developed by Prof Keshav Kumar. Patients were self trained on the app. Weekly contact with the patient along with the caregiver is made to ensure adherence to the program.

Materials and Methods: The study adopted a single case design.The patient is a 55 - year-old female diagnosed with MCI. She was evaluated, before and after the treatment, with NIMHANS Neuropsychological battery for Elderly.The patient was given 30 sessions of app-based cognitive retraining activities using D- CAP. The program included tasks targeting to enhance attention, working memory, visual learning, and memory and response inhibition. Informant Questionnaire on Cognitive Decline in Elderly (IQCODE), and NIMHANS Cognitive complaint scale were also used to assess cognitive functions, Mild Behavioral impairment checklist was used to assess behavioral and psychological symptoms of dementia, Quality of life in Alzheimer's disease (QOL-AD) was used to assess quality of life and

Instrumental activities of daily living -IADL-EDR was used to assess instrumental activities of daily living before and after the intervention.

Results: The results showed that post-intervention improvements were found in verbal learning and memory, visual learning and memory, verbal and visual working memory, verbal fluency, reduced symptoms and increased quality of life.

Conclusion: D-CAP-based cognitive retraining can help in improving not only cognitive functions, but also reduction of

symptom and quality of life in Mild cognitive impairment indicating generalization of cognitive retraining to other psychological functioning.

Keywords: Mild Cognitive Impairment; App-Based Cognitive Retraining; D-CAP

List of Abbreviations: MCI: Mild cognitive impairment; DCAP: Digital Cognitive Augmentation Programme.

Introduction

Mild cognitive impairment (MCI) is a transient phase between normal age related cognitive decline and dementia, with deficits in memory, executive function and speed of processing [1]. MCI can be present with a number of cognitive symptoms, subsumed under amnestic with predominant memory disturbance and non amnestic MCI with primarily executive functions deficits.Prevalence rate of MCI among elder adults is estimated to be 3% to 42 % [2]; conversion rate of MCI to dementia have ranged from 2-31% [3];14-40% of those with MCI return to normal cognitive function(4,5); and many individuals also exhibit a persistent form of MCI without converting to dementia [5, 6].

Research suggests that individuals with MCI experiences changes in psychological functioning, daily functioning and quality of life [7-9]. Behavioural and psychological symptoms of dementia such as depression, anxiety, irritability, apathy, agitation, sleep disorders are very common in MCI with prevalence rate of 35% -85% [10-13]. Individuals with multi domain MCI have greater functional limitations than those with single domain MCI. Appointment scheduling, transportation issues, financial issues are some areas of daily living frequently impacted in MCI [8]. Research also shows that individuals with MCI report reduced QOL compared to other elderly without MCI [9].

Cognitive retraining can be defined as a systematic therapeutic approach designed to improve cognitive functioning after central nervous system insult. Studies shows that cognitive based intervention are helpful for people with MCI to improve different cognitive modalities such as language, memory, attention, visuospatial functions, anxiety, depression, quality of life, activities of daily living etc [14-18]. This suggests that cognitive interventions underlie a neurobiological mechanism in which cognitive stimulation facilitates neuroplasticity resulting in cognitive reserve enhancement [19-20]. Neuroplasticity refers to the brain's ability to undergo structural and functional alterations in response to internal and external stimulation [21]. Research on multi domain training suggests that the training increases within-network connectivity predominantly in the Default Mode Network. The degree of anti--correlation between networks, in particular between the Fronto Parietal Network and Default Mode Network is augmented, which has been related to better cognitive functioning in age related diseases [22, 23]. The current case described in this paper is an attempt to explore the benefits of app-based cognitive retraining using D-CAP in Mild Cognitive Impairment. Digital Cognitive Augmentation Programme (D-CAP) is a cognitive neuroscience informed android based app with tasks designed to improve attention, processing speed, verbal memory, visual memory, working memory, and response inhibition. It was developed at the neuropsychology unit, NIMHANS, by Prof Keshav Kumar. It was hypothesized that app-based cognitive retraining would lead to observable changes in neuropsychological measures of sustained attention, working memory, verbal learning and memory and visual learning and memory. Improvement following training was also excepted on secondary outcome measures such as quality of life, behavioural and psychological symptoms, and instrumental activities of daily living.

Materials and Methods

Subject

The participant was a 55 year old woman, who is a home maker. She was referred in 2022 for neuropsychological assessment and cognitive retraining. There was history of gradual decline in her memory over past few years including difficulty in concentration,

misplacing things, forgetting conversation, repeatedly asking the same questions and making errors in simple calculation. She continued to function independently managing the household activities and other instrumental activities of daily living. Medical history included cholesterol, blood pressure, diabetes .She had no history of any of head injury, stroke or any other neurological or psychiatric illness and there was no family history of dementia. Neuropsychological testing revealed impaired performance in verbal learning and memory. Other areas of concern included attention, verbal working memory, visual working memory, fluency and visual learning & memory in which her performance is in the below average range. MRI shows mild diffuse cerebral atrophy with grade 1, microangiopathic changes. She was diagnosed with MCI.

A diagnosis of Mild cognitive impairment was determined per the DSM V criteria and 1.5 standard deviation below the mean on standard neuropsychological test (Peterson's Criteria for. MCI). The diagnosis of MCI was also confirmed by the consultant psychiatrist from the geriatric clinic, NIMHANS. The patient was evaluated before and after cognitive training on NIMHANS Neuropsychological battery for elderly [24]. A parallel form of Neuropsychological test for elderly - Parallel Form was used for post cognitive training assessment to minimise the practice effects on the tests. NIMHANS Neuropsychological battery for elderly (NNBE) is a comprehensive battery developed for assessing cognitive functions in Indian elderly population. It is a brief battery which takes 60 minutes to administer. It includes measures of attention, memory, executive functions, language, visuospatial construction and parietal focal signs. Word list test, story recall test, stick construction test, digit span, corsi block tapping test, category fluency, Go/No-Go, Picture cancellation and parietal focal signs.

The other outcome measures includes Informant Questionnaire on Cognitive Decline in Elderly (IQCODE) [25], NIMHANS Cognitive complaint scale (Sowparnika & Kumar et al 2021).(ref),. Mild Behavioural impairment checklist [26] was used to assess behavioural and psychological symptoms of dementia, Quality of life in Alzheimer's disease(QOL-AD) was used to assess quality of life and Instrumental activities of daily living -IADL-EDR [27]was used to assess instrumental activities of daily living. The participant was rated on all the outcome measures both before and after the intervention.

Treatment

Digital Cognitive Augmentation Programme

D-CAP is a cognitive neuroscience informed android based app designed to improve multidomain cognitive deficits. It was developed by Prof Keshav Kumar at the neuropsychology unit. It's provided by downloading an application in an android phone. Various cognitive retraining task were developed for healthy normal elderly as well as patients with MCI and dementia, by Kumar et al in 2013. Subsequently, these activities were digitalized and made into an app by Adobe as their probono initiative. It was found to be effective in improving cognitive functions like attention, learning, delayed recall, digit symbol substitution in healthy normal elderly. Specific tasks were designed to load on specific neural network, at increasing levels of difficulty. This is hypothesised to facilitate neural plasticity in the associated neural circuitry that are recruited in mediating these cognitive functions, and improving sub optimal cognitive functions to optimal levels. The app used for the study is designed to improve 8 cognitive domains including attention, working memory, verbal memory, visual memory and response inhibition akin to several internationally used cognitive apps. Each of the exercises were comprised of 3 levels of difficulty (low, medium and high), which selectively enables as the users progressed. To the best of our knowledge, this is the first app based comprehensive cognitive retraining in India. The patient under went app- based cognitive retraining for 30 one hour session spanning over 6weeks. Weekly follow up was done with the patient via whats app video call to improve adherence to training programme.

Design

The study was designed as a single case intervention study with pre and post, assessments. Baseline data and post assessment data after the intervention was collected. Pre post assessment for the patient on neuropsychological tests was compared with the normative data.

Results

Attention and Executive Functions

Table 1 provides the raw scores and the percentile ranks of the patient in neuropsychological assessment for the pre and post neuropsychological assessment on various cognitive functions. For attention it was found that the scores were between the pre (50th percentile) and post assessment for the time taken (15th -20th percentile) for cancellation task was increased, but the errors were reduced (From 10th - 15th percentile, to 95th percentile). On attention for visual modality assessed using corsi block design test forward there was improvement from pre to post assessment (From 5th -10th percentile, to 75th percentile) .On attention for verbal modality her scores remained the same when compared to the previous assessment before intervention (70th percentile).

Functions	Test	Variables	Preassessment	Percentile	Postassesment	Percentile
Attention	Attention Trial	Time taken	155seconds	50th	220	15th -20th
		Errors	4		0	
Verbal working	Digit span test	Forward	6	70th	6	70th
		Backward	4	75th	6	80th -85th
memory						
Visual workingmemory	Corsi block tapping test	Forward	4	5-10th	6	55-75th
		Backward	4	35th	8	>95th
Fluency	Verbal fluency	Fruits	17	95th	15	75th
		Animals	13	40th	22	90th -95th
		Vegetables	11	10th	12	15th -20th
Verbal learning	Word list learning	Total learning	18	10-15th	23	45th -50th
		Delayed recall	3	<5th	6	15th
		Recognition	8	5th -10th	10	95th
	Story memory test	Immediaterecall	4	<5th	9	25th
		Delayed recall	2	<5th	7	5-10th
Visuospatial	Design construction test	Construction	24	95th	24	95th
		Immediate	24	95th	23	15th
		Delayed recall	9	10-15th	10	15-20th

Table 1: Raw scores on neuropsychological assessment pre- post intervention

Fluency was assessed using the category task. The categories fruits, animals and vegetables were used to assess the category fluency. It was found that there was an increase in animals (from 40th to 90th -95th percentile) and vegetables category (10th to 15th -20th percentile), but fruits category was reduced when comparing the pre and post assessment(95th to 75th percentile).Overall there was improvement in fluency, when considering the average score on all the three categories between the pre and post assessment.

Working memory was assessed using digit span backward and corsi block design backward. It was found that both verbal working memory (70th percentile) and visual working memory (35th to >95th percentile) has improved from pre to post assessment.

Memory Abilities

There were significant improvement in verbal learning and memory in terms of total learning (10th -15th to 20th percentile), delayed recall (<5th to 15th percentile) and recognition(5^{th} -10^{th} to 95^{th} percentile),when considering the pre and post assessment for word list task. The patient has significantly improved on immediate recall (<5th to 25th percentile) and delayed recall(<5thto 5th-10thpercentile) of story memory test between pre and post assessment.

For visual memory assessed using visual learning and memory, there was improvement on delayed recall (95^{th} percentile) and decline in immediate recall (95th percentile for pre assessment and 15thpercentile for post assessment).

IQCODE -Informant questionnaire on cognitive decline in elderly and NIMHANS cognitive complaint scale was used to assess the cognitive complaints of the patient. It was found that for both the scales the scores for cognitive complaints were reduced from pre to post assessment after the intervention indicating patient's cognitive functions has improved and corroborating the improvement on neuropsychological tests.

Other Secondary Outcome Measures

Table 2 provides the scores for other measures. On Mild Behavior Impairment checklist (MBI-C), it was found that after the intervention the patient had no difficulties. Similarly, on quality of life Alzheimer's disease (QOL-AD), it was found that quality of life of the patient was improved. On IADL-EDR,- which was used to assess the instrumental activities of daily living of the patient and the patient had no difficulties in activities of daily living.

Table 2: Scores on secondary measures pre-post intervention

IQCODE		NCS		MBI-C		QOL-PA		QOL-FA		IADL-EDR	
PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
3.2	2.84	12	5	2	0	36	38	35	38	0	0

Discussion

This case study explored the effects of mobile based cognitive retraining in Mild Cognitive impairment. Cognitive retraining is known to enhance, brain's ability to reorganize and relearn those functions that were lost with ageing and other disease related degeneration of the brain. Our results support previous studies that show cognitive retraining are helpful in improving memory, attention, visuospatial functions in Mild cognitive impairment [15, 28].

In the present study D-CAP was used to improve multiple domains of cognition including attention, executive function, learning and memory memory. Targeting the compromised cognition, these app based activities enhanced cognitive abilities. Presumably through neural neuroplastic mechanisms which resulted in improvement in the cognitive processes of the patient. Though cognitive retraining tasks for language per se has not been included in the app, an improvement in fluency task was noted after the re-

training. Research suggest that cognitive retraining is the most systematic attempt to obtain transfer of skills (29). Cognitive retraining programme assumes that general cognitive ability can be enhanced by engaging in cognitively demanding exercises. Studies have demonstrated that engaging in cognitive retraining programme improves participants performance on trained as well as other related tasks [30]. These activities are known to improve general cognitive skills in addition to the trained activities. Once these general cognitive skills are improved they possibly boost other capabilities that depend on them, with neural plasticity acting as the mediator [31].This demonstrates near transfer effect for untrained ability of fluency in this study.

On tests of memory, participant showed improvement on both verbal and visual memory after cognitive retraining. This is consistent with the previous studies which suggests cognitive retraining results in improvement in memory [17, 18].The practice on carefully selected tasks focused on specific networks might have facilitated recovery of the disrupted neural circuits along with impaired cognitive processes. These cognitive tasks bring about the neural plasticity, optimized the neural networks and improved the cognitive functions. Studies have shown that in amnestic MCI, a visuospatial speed of processing training resulted in increased resting state functional connectivity in DMN [23]. Van Balkom et al (2020), in a recent review have argued that multi domain cognitive retraining can counteract dysfunctional connectivity patterns in cognitive networks associated with aging and neurodegenertive diseases [20].Studies shows that MCI patients has improved in memory after multi domain training through increasing within-network connectivity in the Default mode network and degree of anti- correlation between networks particular between the FPN and DMN [22, 23]. Above studies demonstrates that cognitive retraining has resulted in improving the functional connectivity among various brain networks . It suggests that cognitive retraining; including app based methods could have potentially resulted in connectivity changes. This might have resulted in improved cognitive functions in the patient.

Behavioral and psychological deficits were ameliorated after cognitive retraining. These results were consistent with previous studies.Cognitive retraining not only improves cognitive functions but also improves the quality of life, activities of daily living and behavioral and psychological symptoms of dementia [32].

Cognitive deficits can result in various behavioral and psychological deficits and this in turn can affect the quality of life of the elderly population. Training multiple domains of cognition results in better generalization to everyday activities as well as possibility of improving associated psychological symptoms, which in turn has improved the quality of life. Cognitive retraining in Mild cognitive impairment could potentially mitigate progression of cognitive deficits and possibly reverse mild cognitive impairment. The current case study is in accordance with others studies demonstrating that improved brain activation may delay the onset of dementia which is a dreadful fear for the elderly, which in turn improves their quality of life and other psychological functions.

Conclusion

As the number of elderly is increasing worldwide, there are serious changes in the economic and social trends in the world, resulting in increased longevity. This is often accompanied with increased vulnerability to various neurodegenerative disorders. Cognitive deficits are known to be the harbinger for behavioral and psychological deficits and in turn can affect the productivity and independent life of the elderly population. Researchers have demonstrated the ability of human brain to change with experiences. Our findings shed light on the usefulness of app based cognitive training for elderly with mild cognitive impairment in India, where there is scarcity of trained professionals who can provide cognitive retraining. Our study demonstrates the potential to use app based cognitive retraining in India to improve cognitive functions, which is both time and cost effective.

Acknowledgments

The study was published in affiliation with the department of Clinical Psychology, NIMHANS, approved by the Ethical Committee of Institute of NIMHANS and Department of Clinical Psychology, funded by the UGC Grant commission.

References

1. E Mariani, R Monastero, P Mecocci (2007) Mild cognitive impairment: A systematic review. J Alzheimer's Di 12: 23–35.

2. Ward A, Arrighi HM, Michels S, Cedarbaum JM (2012) Mild cognitive impairment: Disparity of incidence and prevalence estimates. Alzheimer's Dement 8:14–21.

3. 3.Bruscoli M, Lovestone S(2004). Is MCI really just early dementia? A systematic review of conversion studies. Int Psychogeriatrics. 16:129–40.

4. 4.Ganguli M, Dodge HH, Shen C, DeKosky ST (2004) Mild cognitive impairment, amnestic type: An epidemiologic study. Neurology. 63: 115–21.

5. Manly JJ, Tang MX, Schupf N, Stern Y, Vonsattel JPG, et al. (2008) Frequency and course of mild cognitive impairment in a multiethnic community. Ann Neurol. 63:494–506.

6. Schönknecht P (2011) Neurobiological and psychological aspects of mild cognitive impairment—Bridging the gap. GeroPsych J Gerontopsychology Geriatr Psychiatry. 24: 63–4.

7. Albert MS, DeKosky ST, Dickson D, Dubois B, Feldman HH, et al. (2011) The diagnosis of mild cognitive impairment due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimer's Dement. 7: 270–9.

8. Gold DA (2012). An examination of instrumental activities of daily living assessment in older adults and mild cognitive impairment. J Clin Exp Neuropsychol. 34: 11–34.

9. Teng E, Tassniyom K, Lu P (2012) Reduced Quality of Life Ratings in Mild Cognitive Impairment: Analyses of Subject and Informant Responses.Neurology. Dec; 20: 1016-25.

10. Apostolova LG, Cummings JL (2008) Neuropsychiatric manifestations in mild cognitive impairment: A systematic review of the literature. Dement Geriatr Cogn Disord. 25: 115–26.

11. Bomboi G, Castello L, Cosentino F, Giubilei F, Orzi F, et al. (2010) Alzheimer's disease and endothelial dysfunction. Neurol Sci. 31: 1–8.

12. Ellison JM, Harper DG, Berlow Y, Zeranski L (2008) Beyond the "C" in MCI: Noncognitive symptoms in amnestic and nonamnestic mild cognitive impairment. CNS Spectr. 13: 66–72.

13. Monastero R, Mangialasche F, Camarda C, Ercolani S, Camarda R (2009) A systematic review of neuropsychiatric symptoms in mild cognitive impairment. J Alzheimer's Dis. 18: 11–30.

14. Chandler MJ, Parks AC, Marsiske M, Rotblatt LJ, Smith GE (2016) Everyday Impact of Cognitive Interventions in Mild Cognitive Impairment: a Systematic Review and Meta-Analysis. Neuropsychol Rev. 26: 225-51.

15. Bahar-Fuchs A, Clare L, Woods B (2013) Cognitive training and cognitive rehabilitation for mild to moderate Alzheimer's disease and vascular dementia. Cochrane Database Syst Rev. CD003260.

16. Li H, Li J, Li N, Li B, Wang P, et al (2011) Cognitive intervention for persons with mild cognitive impairment: A meta-analysis. Ageing Res Rev. 10: 285-96.

17. Leung P, Orrell M, Orgeta V (2015) Social support group interventions in people with dementia and mild cognitive impairment: A systematic review of the literature. Int J Geriatr Psychiatry. 30: 1–9.

18. Sitzer DI, Twamley EW, Jeste D V (2006) Cognitive training in Alzheimer's disease: A meta-analysis of the literature. Acta Psychiatr Scand. 114: 75–90.

19. Ballesteros S, Bischof GN, Goh JO PD (2013) Neural correlates of conceptual object priming in young and older adults: An event-related fMRI study. Neurobiol Aging. 34: 1254–64.

20. van Balkom TD, van den Heuvel OA, Berendse HW, van der Werf YD, Vriend C (2020) The Effects of Cognitive Training on Brain Network Activity and Connectivity in Aging and Neurodegenerative Diseases: a Systematic Review. Neuropsychol Rev.30: 267–86.

21. Mahncke HW, Bronstone A, Merzenich MM (2006) Brain plasticity and functional losses in the aged: scientific bases for a novel intervention. Prog Brain Res.157:81–109.

22. Clare Kelly AM, Uddin LQ, Biswal BB, Castellanos FX, Milham MP (2008) Competition between functional brain networks mediates behavioral variability. Neuroimage.39: 527–37.

23. Hampson M, Driesen N, Roth JK, Gore JC, Constable RT (2010) Functional connectivity between task-positive and task-negative brain areas and its relation to working memory performance. Magn Reson Imaging. 28:1051–7.

24. Tripathi R, Kumar JK, Bharath S, Marimuthu P VM (2013) Clinical validity of NIMHANS neuropsychological battery for elderly: A preliminary report. Indian J Psychiatry. 55: 279–82.

25. 25.Jorm AF (2004). The Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE): A review. Int Psychogeriatrics.16: 275–93.

26. Morgan M. Rogers-Carter, Juan A Varela , Katherine B Gribbons, Anne F Pierce1, Morgan T McGoey et al. (2017) HHS Public Access. Physiol Behav. 176: 139–48.

27. Mathuranath PS, George A, Cherian PJ, Mathew R, Sarma PS (2005) Instrumental activities of daily living scale for dementia screening in elderly people. Int Psychogeriatrics. 17: 461–74.

28. Shin M, Lee A, Cho AY, Son M, Kim YH (2020) Effects of process-based cognitive training on memory in the healthy elderly and patients with mild cognitive impairment: A randomized controlled trial. Psychiatry Investig. 17: 751–61.

29. Karbach S, Tilo Strobach JK (2018) Cognitive Training.1st ed., editor. Springer Cham.

30. Simons DJ, Boot WR, Charness N, Gathercole SE, Chabris CF et al (2016) Do "Brain-Training" Programs Work? Psychol Sci Public Interes Suppl. 17: 103–86.

31. Karbach J, Schubert T (2013) Training-induced cognitive and neural plasticity. Front Hum Neurosci 2012–3.

32. Wolinsky FD, Unverzagt FW, Smith DM, Jones R, Wright E, et al (2006) The effects of the ACTIVE cognitive training trial on clinically relevant declines in health-related quality of life. Journals Gerontol - Ser B Psychol Sci Soc Sci. 61: 281–7.