Mobile Tablet Base Therapies for Cognitive Rehabilitation of Stroke Patients

Author

Amna Shad

Regn Number: 00320041

Supervisor

Dr. Asim Waris

SCHOOL OF MECHANICAL & MANUFACTURING ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY

ISLAMABAD

MAY2023

Mobile Tablet base Therapies for Cognitive Rehabilitation of Stroke Patients

Author

Amna Shad

Regn Number

00320041

A thesis submitted in partial fulfillment of the requirements for the degree of

MS Bio-Medical sciences

Thesis Supervisor:

Dr. Asim Waris

Thesis Supervisor's Signature:_____

SCHOOL OF MECHANICAL & MANUFACTURING ENGINEERING

NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY,

ISLAMABAD

MAY 2023

Declaration

I certify that this research work titled "*Mobile tablet-based therapies for cognitive rehabilitation of stroke patients" is* my work. The work has not been presented elsewhere for assessment. The material that has been used from other sources has been properly acknowledged.

Signature of Student

Amna shad

2023-NUST-Ms-Bio-Medical sciences

Plagiarism Certificate (Turnitin Report)

This thesis has been checked for Plagiarism. The Turnitin report endorsed by Supervisor is attached.

Signature of Student

Amna Shad

Registration Number

00320041

Signature of Supervisor

Copyright Statement

- Copyright in the text of this thesis rests with the student author. Copies (by any process) either in full or of extracts, may be made only following instructions given by the author and lodged in the Library of NUST School of Mechanical & Manufacturing Engineering (SMME). Details may be obtained by the Librarian. This page must form part of any such copies made. Further copies (by any process) may not be made without the author's permission (in writing).
- The ownership of any intellectual property rights which may be described in this thesis is vested in the NUST School of Mechanical & Manufacturing Engineering, subject to any prior agreement to the contrary, and may not be made available for use by third parties without the written permission of the SMME, which will prescribe the terms and conditions of any such agreement.
- Further information on the conditions under which disclosures and exploitation may take place is available from the Library of NUST School of Mechanical & Manufacturing Engineering, Islamabad

Acknowledgments

I am thankful to my Creator Allah Subhana-Watala for guiding me throughout this work at every step and for every new thought You set up in my mind to improve it. Indeed, I could have done nothing without Your priceless help and guidance. Whosoever helped me throughout my thesis, whether my parents or any other individual was Your will, so indeed none be worthy of praise but You.

I am profusely thankful to my beloved parents who raised me when I could not walk and continued to support me throughout every department of my life. I would like to express my heartful gratitude to my father for his unwavering love and support throughout my life. His guidance, wisdom, patience, and encouragement have helped shape me into the person I am today. He has been a constant source of strength and inspiration, and I am forever grateful for his presence in my life. I would like to express my deepest gratitude to my mother for her boundless love, prayers, and support throughout my life. Her unwavering dedication, tireless efforts, and endless sacrifices have been the driving force behind my success.

I would also like to express special thanks to my supervisor Dr.AsimWaris for his help throughout my thesis and the courses he taught me. I can safely say that I haven't learned any other engineering subject in such depth as the ones which he has taught. His encouragement, constructive feedback, and mentorship have helped me grow professionally and personally. I am grateful for his patience, kindness, and willingness to help me navigate any challenge. I am truly fortunate to have had the opportunity to work under your supervision.

I am thankful to my all-beloved brothers and sisters for their treasured support and unwavering faith in me. Special thanks to my nephew and niece, whose smiles were enough for me to keep me motivated during all the tough times in the hostel.

I would also like to pay special thanks to my husband Badar Ali for his tremendous support and cooperation. Each time I got stuck in something; he came up with a solution. His love, encouragement, and understanding have been the driving force behind my success. He has always been there for me, offering guidance, motivation, and a listening ear whenever I needed it. His belief in me has helped me overcome my obstacles and challenges along the way.

Finally, very wholeheartedly thank my all friends, and more especially & specifically Zarqa Iqbal and Ujala Gulzaib for being there with me always and feeling like a family during this whole journey. I would like to express my gratitude to all individuals who have rendered valuable assistance to my study.

Dedication

Dedicated to my exceptional Grandfathers Muhammad Hussain Khan (late) and Muhammad Wazir Khan (late)

Abstract

Mobile tablet-based therapies have become an increasingly popular tool for cognitive rehabilitation in stroke patients due to their convenience and accessibility. This research aims to further investigate the potential of Lumosity, a popular mobile tablet-based application, in enhancing cognitive function in stroke patients. To better understand the cognitive difficulties that stroke patients experience, the research also compared cognitive performance between stroke patients and healthy people. To achieve these objectives, three participants were recruited, including one healthy individual and two stroke patients with varying stroke locations and depression statuses. The participants underwent a cognitive assessment before and after a 6-week cognitive training program using Lumosity. The cognitive assessment included speed, memory, attention, and flexibility measures.

The study elaborates that both stroke patients demonstrated significant improvements in cognitive function after the training program, particularly in memory and attention tasks. This research shows that Lumosity could work well for stroke patients who need cognitive rehabilitation. In contrast, healthy participants showed stable performance across all cognitive tasks, indicating that Lumosity may not be as useful for healthy individuals. Furthermore, the study identified differences in cognitive performance among stroke patients, potentially related to differences in stroke location and depression status.

Overall, this study emphasizes the potential of mobile technology in delivering personalized cognitive rehabilitation programs for stroke patients. The usage of mobile apps like Lumosity, which has the ability to be customized to meet the requirements of individual patients, may be a practical and accessible tool to help stroke patients with their cognitive function. These findings suggest that personalized cognitive rehabilitation programs using mobile technology could be an effective and promising approach to help stroke patients regain cognitive function.

On the basis of the psychologist's evaluation, the MMSE scores of all the subjects are within the normal range. The first subjects' memory delay is 3%, speed fluency is 28%, attention is 27% and flexibility is 29%. The second subject's memory delay is 20%, speed fluency is 13%, attention is 10% and flexibility is 1%. The third subject's memory delay is 29%, speed fluency is 12%, attention is 8% and flexibility is <1%

Keywords: Lumosity, stroke, cognitive rehabilitation, mobile technology, cognitive function, cognitive assessment, attention, memory, depression.

Table of Contents

List of Figures

List of Tables

CHAPTER 1
INTRODUCTION

1.1 Background

The international burden of the disease study conducted in 2010 indicates important trends in stroke epidemiology about suffering and surviving from strokes based on different studies. In high-income, middle-income, and low-income nations, death rates appear to have declined between 1990 and 2010, while the proportion of stroke survivors and those who have had their first stroke has increased by 84% and 68%, respectively[1].

A stroke is a disorder when the brain's blood supply is cut off for a variety of causes. Two main conditions are shown in fig 1.1.

i. Blood vessels are blocked, known as ischemic stroke.
ii. Blood vessel burst which bleeds is known as hemorrhage.

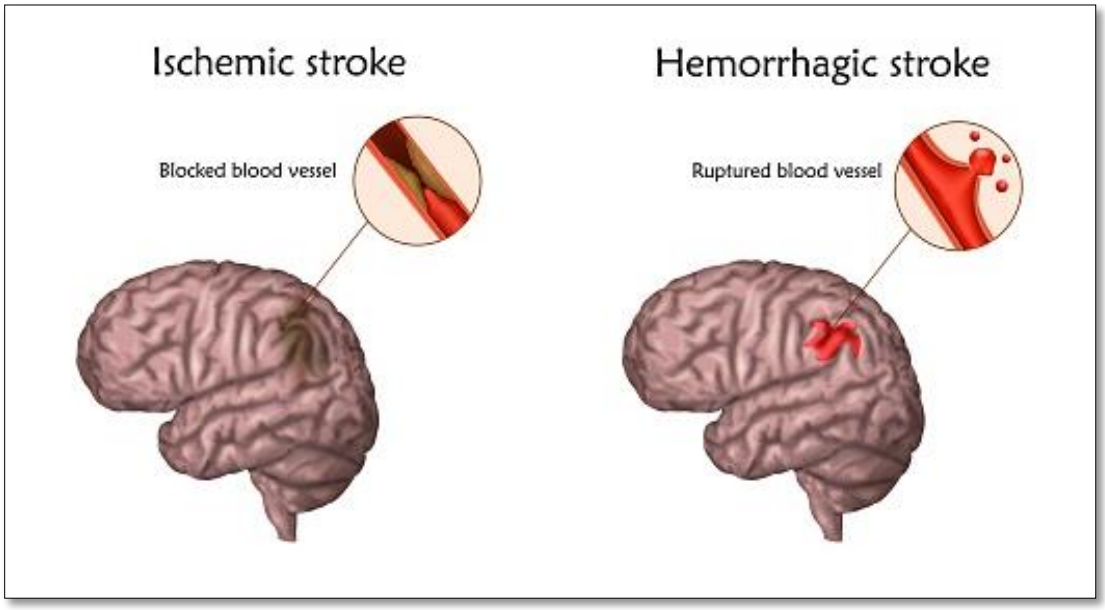


Figure 1.1.: Ischemic stroke and hemorrhagic stroke with blocked and ruptured blood vessels

Because of these two conditions of the brain, cells do not receive proper oxygen and nutrients, so some brain cells are damaged and some die. It can cause impairments in language, cognition motor, and sensory skills. Every stroke is different, it depends upon which part of the brain is being affected and how much damage it is causing. There is another condition of stroke known

as Atherosclerosis in this condition the plaque deposition on the inner lining of the arteries causes the thickening or hardening of the arteries. Every stroke is different, it depends upon which part of the brain is being affected and how much damage it is causing.

1.2 Transient Ischemic Attack (TIA)

It is a warning stroke that there is an increased risk of stroke, and proper medical assistance is required. In this condition, the brain is not getting proper oxygen and blood as shown in fig1.2. Within 24 hours you can recover from this type of stroke.

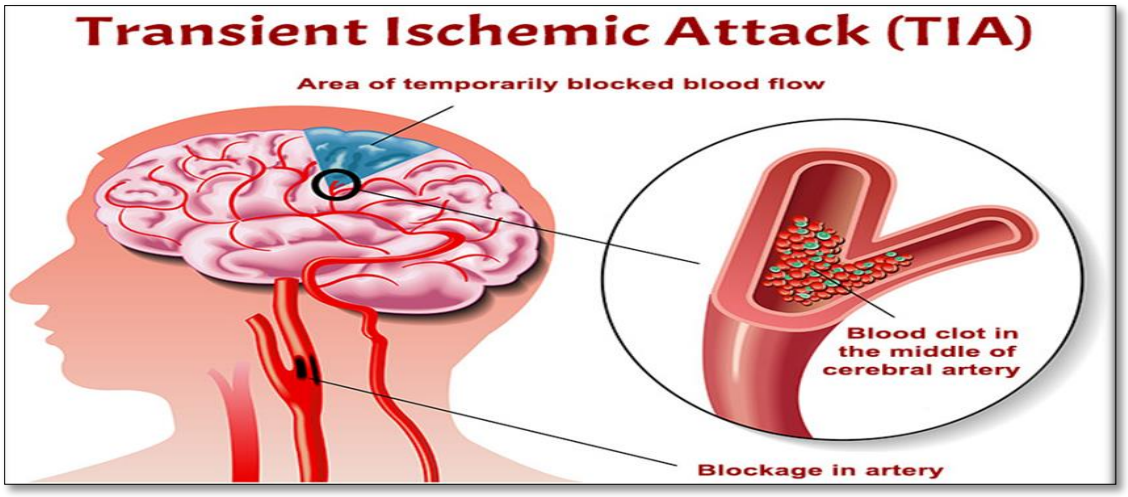


Figure 1.2.: Transient Ischemic attack (TIA)

1.3 Symptoms of Stroke

- Instantaneously feeling weak
- Becoming uncoordinated
- Heaviness of heart
- Reduction in the movement can be on any side of the body in any arm, leg, or face
- Difficulty in walking
- Balance Reduction
- Numbness in any part of the body
- Problem with chewing and swallowing

- Speaking problem. Not finding the right words to say and sometimes it's difficult to understand what other people are saying.

1.3.1 Assessment Scale

Paramedics use an assessment scale that is known as the FAST scale. (Face, Arm, Speech test. Fast acronym for

F (Facial drooping)

A (Arms weakness)

S (Speeches difficulty)

T (Time to call the emergency services)

1.4 Stroke Rehabilitation

Stroke recovery depends upon the time of post-stroke, so it can be divided into three phases as shown in table 1.1.

Table 1.1: Post stroke phases of stroke with duration

Phases	**Duration**
Acute phase	**Less than one month**
Subacute phase	**One to 6 months**
Chronic phase	**More than 6 months**

The Post-stroke condition of the patient is not permanent it can be recovered within the first three months but there are also some cases in which patients do not acquire the original state of pre-stroke and remain with some deficits. The most important body structures that are defective because of the stroke are

- Brain
- Cardiovascular system
- Arms and legs
- Shoulder

The process of stroke rehabilitation is recurrent.

1. Assessment, to identify the problem of the patient and up to which level the damage is caused and what are the necessities of the patient.
2. Goal setting, after knowing the exact situation set the defined goals for improvement.
3. Intervention is the design of a technique for the treatment and improvement of the patient, and this is for the achievement of the goals.
4. Reassessment, checking out what is the progress in the patient's recovery.

Rehabilitation specialists cannot separate cognition from other aspects that are co-related to each other. Those are cognitive, behavioral, social, and emotional functioning and these all are co-related to each other.

1.5 Importance of Post Stroke Rehabilitation

Post stroke rehabilitation is very beneficial if initiated early. The earlier commencement of therapy will have a positive impact on functional ability Ottenbacher and Jannell (1993). Based on several clinical trials, post stroke rehabilitation affects daily activities, particular deficiency and stay in hospital. Furthermore studies suggested that if rehabilitation begun between three to thirty days it will improve functional abilities disused above as compared to the later initiations [2]. The ideal time to start post-stroke therapy has not yet been determined. When the trail of the post stroke rehabilitation (within 24 hrs.) Time is carried out very less required results are obtained as compared to the care after onset. The functional recovery and rehabilitation are also related with dose response as better development being observed at elevated intensity levels[3]. With continuing recuperation, this trend affects a variety of therapies, such as occupational therapy, physical therapy, & language therapy for speech. the observed pattern of the diminishing returns[4].

1.6 Factors affecting stroke Rehabilitation

- Severity and extent of damage to brain
- Age as recovery rate is higher in children and young adults as compared to elders' ones
- Level of vigilance as some strokes reduce ability of person to remain vigilant to follow essential guidelines to participate in rehabilitation activities
- Rehabilitation program intensity
- Coincident medical issues

- Facilities at home such as stair rails and grabbing bars will make them less dependent and safe
- Facilities at workplace, remolding for the betterment and safety so the person get back to work easily
- Supportive family, social networks play an important role in rehabilitation process which usually expands over months
- Initiation of the rehabilitation. Generally, sooner it begins, enhances the chances to recover lost capabilities and functions (NIH Publication No. 20-NS-4846 April 2020)

1.7 Cognitive Rehabilitation

Cognitive rehabilitation is a methodically applicable service based on therapeutic activities to assess and comprehend the deficiencies of the patient's brain[5].The main purpose of cognitive rehabilitation is to gain the brain processes that are important for knowing and understanding. There are two basic kinds of cognitive rehabilitation.

i. Compensatory

ii. Restorative

The patient can regain lost function with the support of reparative therapy, while compensatory therapy helps the patient become more adept at using tools and strategies to get around impairment.

1.7.1 Cognitive Domains

i. There are six basic cognitive domains
ii. Memory and learning
iii. Executive function
iv. Complex attention
v. Movement-related skills
vi. Language
vii. Social cognition

1.7.2 Memory and learning

Learning depends on memory because information and knowledge stored in the brain are associated with memory, which is correlated with the processes of seeking new knowledge. Two types of memory are related to the learning process: recognition and long-term memory.

1.7.3 Executive functions depend on the skills

Executive functions depend on the skills used to control or plan the other cognitive functions.

If there is any disturbance or defect in executive functions, it has the following effects:

- Problems with orders of things
- Difficult to plan and start any task
- Lack of multitasking
- Difficulties in speech fluency
- Struggle in future planning
- Can’t process, store, or restore information properly
- Anger issues
- No interest in humans, animals, and surroundings
- Social behavior is not appropriate
- Can’t learn or get lessons from past mistakes

1.7.4 Complex attention

A person can sustain information for a short duration of time in the mind and use and manipulate it according to the requirement.

1.7.5 Movement-related skills

Cognitive rehabilitation is one of the most common symptoms and problems recorded after a stroke. It is about 70 to 90 percent of the survivors have the problem of cognitive impairment[6].

1.7.6 Language

It is related to the finding and recognition of words and fluency while reading and speaking.

1.7.7 Social cognition

Social cognition is related to the process of cognition for social interaction. And how people store, process, and use information about people during different social situations.

Attention and memory are the most important and common cognitive areas affected by stroke. Some chief functions are also more important, including several cognitive processes like organization, observance, finding solutions, syndicate, and memory regarding work. Cognitive rehabilitation can be defined as using many techniques to improve the cognitive ability of the brain and the quality of life which is not in its original state because of brain injury or stroke[7].

The cognitive rehabilitation technique or any procedure is always for the recovery or any remedy for the cognitive functions: attentiveness, remembrance, understanding, conveying, commencement, self-regulation, and self-control.

Attention, memory, and executive functions are coordinated processes as these are dependent on each other for any proper function or work. Besides theoretical functions, there is also a great convergence of these functions. When an executive function plan or assembles any function, attention and memory are the basic tools that are correlated to it for proper execution.

1.8 Fundamentals of cognitive function assessment

To plan rehabilitation strategy understanding of stroke related neurobehavioral syndromes is very important. All stroke patients should be assessed neuropsychologically. A complete diagnostic procedure comprises of following assessments: subjective complaints, behavioral history, background information, voice and speech evaluation, sensory motor screen, orientation, memory, language, visuoperceptual and visuospatial skills, standard cognitive screen examining attention, praxis, & executive functions. The degree and kind of impairments are determined. The infarct site may help predict region of cognitive impairment. Real-life functioning scenarios should be evaluated as part of a multidimensional evaluation. Instead of focusing on specific deficiencies, the key areas of attention are the individual's communication skills and awareness of his environment [8].

1.9 Cognitive rehabilitation approaches

There are four main approaches used nowadays for the process of cognitive rehabilitation.

I. Cognitive retraining by exercises and drills
II. Models from neuropsychology
III. By the combination of theory and practices of neuropsychology, cognitive and behavioral psychology
IV. By addressing emotional and motivational and also non-cognitive aspects

Two types of therapies are used for cognitive rehabilitation, pharmacological and non. Pharmacological.

Pharmacological rehabilitation is symptomatic treatment, and the diseases are treated with medicines, in non-pharmacological intervention, physical training, and exercises are

considered and used for the process of treatment. The main focus of our study is to bring improvement in stroke patients by making them very less restless and using such techniques that can easily be adapted at home and easily practiced so the chances of betterment will increase.

1.9.1 Mobile Tablet base rehabilitation techniques

In recent years Virtual Reality (VR) has become far more accessible to the public. Reasonably priced HMDs (Head Mounted Displays) offer very high-resolution displays and accurate tracking of the hand-held controllers and headset. This technology is used for rehabilitation of stroke patients that has affected their mental state and mobility. This happens when blood supply has been cut off to part of brain or bleeding in or nearby to brain resulting in damage to brain cells. The result of stroke depends upon which part of the brain is affected. Common presentation comprises of visual impairment, hemiparesis (weakness one entire side of body), inability to write, read and speak, and (PSCI) post-stroke cognitive impairment i.e. lack ability to solve problems, task sequencing and memory loss.

We use the games that are available on mobile phones and can easily practice, we used the Lumosity website and games on that site are available for the improvement of the cognitive functions of people.

Mobile tablet base games for the treatment of cognitive rehabilitation of patients are becoming very popular and these treatments are easy and affordable. However, it is not clear how much is suitable for which type of population, and which time is more suitable and effective for practicing and how it will give better results.

Stroke rehabilitation is continuous, in depth, goal-oriented and time taking process. MTBTs have such potential to full fill these requirements. Game based therapy is more interesting and motivating so the patients choose it by themselves and can easily be trained so the maximum benefits can be obtained. Mobile devices such as smart phones, tablets and laptops can provide personalized and effective communication and home based therapy between patients and trainers[9].

Significant research has been done to leverage technology to conduct rehabilitation at home. Home-based rehabilitation technologies provide flexibility of time and location, and feed backs can also be received remotely. However, use of home based rehabilitation techniques is very complex process and very few systematic requirements are addressed by patients at home to design IT tools for stroke rehabilitation [10].

The patients that are interested in attempting tablet-based stroke rehabilitation are recruited early post stroke. However, tablet-based rehabilitation therapy may be challenging owing to patient system and device associated barriers. These barriers should be minimized to keep patient engaged in tablet based rehabilitation therapy [11].

1.10 Lumosity rehabilitation games

Lumosity brain training experience comprises of games more than 1.5 million people registered around the world. These games focus on novelty, adaptivity, targeting, completeness and engagement. The critical constituents of brain functions are targeted in these games. The Lumosity rehabilitation games are adaptive as challenge is increased with improving performance and back off in case of incorrect response. The Lumosity rehabilitation games act as a gym for the brain focuses on complete training system for brain which include memory, speed of processing, mental flexibility, problem solving and attention.

1.11 Factors to make the Lumosity training effective

The significant factors that make Lumosity training effective are novelty, adaptivity, targeting, completeness and engagement [12]. These factors are discussed in detail below.

1.11.1 Novelty

To exercise the brain effectively it should be challenged with novel tasks. The challenges like crossword puzzles are highly overrated and do not challenge processing system brain in novel ways. To challenge brain system in new ways that are not over learned is important for driving nine nervous system remodeling. Driving nine neurological remodeling is the need to push the brain in novel ways that are not overly taught. The brain develops specialized circuitry to carry out particular activities. The actions that are repeatedly carried out reactivate existing circuits, but actions that have been carried out repeatedly in the past don't. Although the brain may benefit from this stimulation technique in terms of maintaining its activity, no fundamental changes to the brain are made.

1.11.2 Proficiency

Every individual has their specific strengths and weaknesses towards any allocated task. Some tasks are easy for some individuals, and some are near to impossible for other people based on the capabilities of the person. Without discouraging the level of difficulty must be set,

so the maximum benefit of the training can be obtained. And these levels must be different from each other's so when the improvement is shown then change it to the next level. By this way of challenges and the response to every challenge the main components of the central nervous system work, and the responding property of the system is a continuous part of the beneficial learning system. The basic purpose of the cognitive training lies in the methods that how practically and in better way the tasks are adjusted. Every training task is adjusted in such a way that training show its improvement in that specific domain. The revolutionary idea in cognitive training to adjust the level of difficulty in tasks according to the performance of the user is only possible because of computer technology.

1.11.3 Targeting

Productive training sessions must target the specific brain function so that the subject gets the maximum benefits in daily life. Some practices only train the specific function no other cognitive abilities and the activities of daily life. Most effective brain training games not only work on the specific domain of the brain but on other tasks as well, so the person becomes independent in his daily routine tasks.

As not any training task will work on all the cognitive aspects of brain, but carefully designed tasks involve important and basic aspects of the brain function so that easily rehabilitation process is continued.

1.11.4 Completeness

In previous times most brain training programs were developed only for the educational framework, targeting the specific neural function and highly specialized training process which is under the supervision of doctor or researcher is carried out. As the brain is a very complex organ and training in very limited functions is not very beneficial for the results in the real-life dependencies. Like doing chores of daily living, working, going to office, and walking, caring and some basic events of life need the proper functioning of the cognition. If the process of information is not rapid, then the events that are rapidly happening like the any scene in a season will be left than it will not be stored. Same is the process when information is not properly processed so it will not work on the attention of the subject, and it will not be stored in memory. And same in the way when attention is limited so the cognitive ability will also be limited same as the scenes of the season are missing. Finally, if the cognitive system is not working properly and the information not retained for the time being all the scenes must be coherent and so all the

aspects of brain function must work together for better understanding and good possible results.

1.11.5 Engagement

Involvement and the rewards in the games are the basic components for the effectiveness of the game and it encourages the subjects to play. When the brain is in such a state where it is anxious for the reward it is in a better stage of learning. And when the reward is given for the correct response to a given task the mechanism of the brain which processes information works in a more effective way. And the rewards for the right performances tell the brain to do the same actions in that situation again when facing it.

1.12 Aims and Objective

Understanding the viability and obstacles to care for stroke survivors' cognitive rehabilitation using early mobile tablet-based therapies.

- Evaluate the traits of MTBTs interventions that aim to enhance cognition.
- Evaluating efficacy of inpatient & outpatient settings for stroke survivors' mental health at the home.

1.13 Relevance to national need

In a developing country like Pakistan where public health care system is not so established and literacy rate is only 62.1% very few numbers of people is aware about the stroke and its consequences, large number of populations cannot afford the rehabilitation treatment and post stroke services. If the stroke disease keeps on prevailing at a persistent then it will cause disastrous impact on country’s economy. That is why providing an economical, physically comfortable, technologically suitable, self-rehabilitation training concept which is need of the hour.

1.14 Cognitive assessment scales

There are a number of scales for the assessment of cognition MoCA (Montreal Cognitive Assessment), CASP (Cognitive assessment scale for stroke patients) and MMSE (Mini mental status exam).

Montreal cognitive assessment scale is valid for only post stroke cognitive impairments, it is

more sensitive tool but not more accurate and specific than mini mental state examination, MMSE has verified validity.[13]

The Mini mental state examination is a consistent approach to grading and explaining older people's cognitive abilities, and it provides scores which are globally acceptable and relevant to daily life activities. Proper interpretation with the results of Mini mental state examination with the history and the physical condition of the patient it is also helpful in the finding of cognitive disabilities of normal persons, patients of Alzheimer, stroke patients and the patients of depression. It is very useful for knowing about change with the passage of time and what are the effects and results of treatment.[14]

1.14.1 Validity of Mini Mental State Examination

For validity of Mini Mental State Examination in strike patients' study of 116 patients for tested for 6 months (2-8 weeks) after stroke. A neuropsychological test involving five tests evaluating memory, calculation and flexibility was used for validation. Movement, depression, aphasia, and measures of daily routine were evaluated. Uncertainty was in the start, Barthel Indicator, depression scores, level of movement, and most of the neuropsychological tests associated to the MMSE. The study showed 4 independent variables which could predict the MMSE scores. A factor testing showed 3 factors which could explain 53% of the difference. The sensitivity for detecting cognitive disability was 56% and increased to 68% if patients with segregated flexibility was not added. The MMSE had acceptable validity in detecting cognitive dysfunction early post-stroke in this old patient population.[15]

CHAPTER 2

Literature Review

Cognitive rehabilitation plays a crucial role in the recovery process for stroke patients, as it seeks to improve the cognitive functions that a stroke typically affects, including as memory, attention, & capacity for problem-solving [16]. Conventional rehabilitation therapies like in-person therapy sessions can be costly, time-consuming, and logistically demanding for patients. Recently, mobile tablet-based therapies have emerged as promising solutions for cognitive rehabilitation. These therapies utilize tablet computers to provide rehabilitation exercises and activities to patients in the comfort of their own homes. The aim of literature review is to analyze factors that affect the acceptance of mobile tablet-based therapies for the cognitive rehabilitation of stroke patients.

Stroke is a widespread cause of the long-lasting disability, leading to cognitive deficiencies such as memory loss, attention deficits, and difficulties with executive function. Cognitive rehabilitation is a vital aspect of stroke recovery and various therapies and interventions have been devised to enhance cognitive function. Recently, mobile tablet-based therapies have gained popularity as a practical and economical solution for providing cognitive rehabilitation to stroke patients.

As the research on effectiveness of the mobile tablet-based therapies for the cognitive rehabilitation of stroke patients expands, several studies have demonstrated their efficacy. A study conducted by Longley et al. (2022) demonstrated that two noteworthy adverse consequences that individuals often experience after having a stroke include cognitive deficits and poor mental health. For the two distinct factors, treatment advice is not yet provided. Since this, virtual reality is being considered as a potential solution because it can be used in a variety of settings and modes and is thus very adaptable to the specific needs of stroke patients. The purpose of this study was to evaluate the efficacy of virtual reality therapy for stroke survivors at home, in inpatient and outpatient settings to improve their a) cognitive and b) mental health. Additionally, the parallels and differences between the various situations were investigated.

Scopus, Web of Science, and PubMed were the informational resources used for this systematic review of the literature. Virtual reality treatments, records involving stroke patients,

findings involving cognitive and/or mental well-being, and publications made after 2016 were the main inclusion criteria. Quantitative and qualitative data were both assessed.

There were 1824 records found in all, 23 of which were used. A mixed environment was discovered and taken into consideration throughout the evaluation process near the home and inpatient setting. Only a very small percentage of studies used completely immersive virtual reality in every situation. Tablets and computer workstations predominated over the more well-known VR glasses. Games make up the most prevalent intervention modality. The effectiveness of VR varied according to the data, but it was determined to be useful as an additional therapeutic component to conventional therapy[17].

Caughlin et al. (2020) found that mobile tablet-based cognitive rehabilitation was successful in enhancing memory and executive function in stroke patients. The study revealed that patients appreciated the integration of technology in therapy and experienced increased motivation and engagement[18]. Similar findings were reported by Choi et al. (2019), who found that a mobile tablet-based cognitive rehabilitation program was effective in enhancing attention, processing speed, and executive function in stroke patients and was well received by both patients and therapists [19]

Völter et al. (2021) stated that in this research, we compared the outcomes of 19 patients who received computer-based cognitive teletherapy and 20 patients who received conventional in-person speech and language therapy. An outpatient rehabilitation center offered two "real-world" treatment regimens, which were assessed in the analysis. A total of 39 patients were assessed who had moderate to severe closed-head traumatic brain injuries and had endured symptoms for at least a year after their event. Clinical indicators of independence, such as the ability to drive and return to work or school, were examined together with treatment costs overall and per hour. According to the findings of an analysis of covariance that considered time since injury as a covariate, there was no discernible distinction between the groups in regard to driving status, independent living, return to work or school, or total treatment costs. Additionally, computer-based teletherapy memory rehabilitation program produced results that were functionally comparable to those of conventional in-person therapy for speech and language at a cost that was comparable [20].

Pugliese M. R et al. (2018), studied that Stroke patients frequently face functional impairments that require rehabilitation but accessing these therapies can often be challenging.

Mobile tablet-based therapies (MTBTs) may offer a solution by increasing timely access to rehabilitation and reducing resource usage. However, the use of MTBTs for stroke patients, including the delivery methods and patient experiences, is currently unknown. This literature review aims to assess the feasibility of MTBTs after a stroke by summarizing studies in terms of administrative procedures and patient perceptions. The selection criteria for the review included articles that described the outcomes of MTBT interventions with stroke patients. A comprehensive search was conducted using six research databases, grey literature, trial registries, and article references. Information on patient experiences and administration of the interventions was collected and analyzed. Of the 903 articles retrieved, 23 were eligible for inclusion in the review. Most of the studies included chronic stroke patients and were small observational studies. The interventions primarily focused on improving communication, cognition, or fine motor skills and were often delivered through commercially available apps. Tablet-based care was found to be hindered by issues with therapeutic instructions, reliance on fine motor skills, and erratic internet or cellophane connections. Both inpatient and outpatient stroke patients responded favorably to MTBTs, however they would need assistance from therapists or caregivers to get through any obstacles. It is necessary to do more feasibility studies to find administrative tactics that remove barriers and boost patient adherence to treatment plans [21].

On the other hand, not all studies had the same results. Röhner et al. (2021) found that mobile tablet-based therapies were not as effective as conventional rehabilitation techniques for overall cognitive function, leading the authors to call for further research to determine the optimal utilization of mobile tablet-based therapies[22].

According to the author Behle et al. (2020), this study summarizes the numerous cognitive rehabilitation treatments for people with brain injuries that are now offered. While the second method employs ideas from cognitive psychology to diagnose and treat cognitive problems, the first focuses on rehabilitation via drills and exercises. To treat cognitive challenges, the third strategy uses a patient-centered approach that combines learning theory, cognitive psychology, and neuropsychology. The fourth method is holistic and views noncognitive factors such as motivation, emotions, and other noncognitive elements as being entwined with cognitive processes.

The first two strategies, according to the authors of this research, are ineffective in achieving successful clinical recovery. They contend that the most effective strategy for

cognitive rehabilitation would be a combination of the second and third methods, which use a patient-driven and holistic approach[23].

Mace et al. (2017), According to research, the use of passive rehabilitation tools, which automate and provide low-cost therapy by motivating users and delivering feedback, has the potential to be a highly effective stroke rehabilitation technique. While examining the benefits of these tools, the question of whether it is advantageous for a hand-training device to be elastic as opposed to stiff comes up. To address this, a digital handgrip with a novel elastic force and position sensor construction was developed. It encourages autonomous and repeated rehabilitation of grasp function. To assess the effects of flexible vs rigid grip strength control during different visuomotor tracking tasks, usability research involving 66 healthy participants was carried out. According to the findings, beginner users fared much better with the flexible handgrip compared to the stiff version, with an 11% partial fulfillment of the requirement and a mean range of 9–14%. In addition, a threefold rise in the proportion of participants who chose the elastic handgrip over the stiff one was seen. These results indicate that device compliance is a key design factor for the grip training equipment's, particularly for jobs requiring feed forward or feedback controls [24].

More recently, Burns et al. (2021) conducted a study comparing the outcomes of mobile tablet-based therapy to conventional rehabilitation techniques in stroke patients with moderate to severe cognitive impairments. The results showed that mobile tablet-based therapy was more effective in improving attention, memory, and executive function[25].

Maggio et al. (2019), stated that in this study, the utilization of virtual reality (VR) technologies for stroke victims' cognitive rehabilitation is evaluated. For papers that matched the inclusion criteria that had been published between 2010 and 2017, the databases of PubMed, Scopus, Cochrane, and Web of Sciences were searched. The search terms included "VR," "rehabilitation," and "stroke." In multiple cognitive domains (including executive and visual-spatial abilities, along with speaking, attention, & memory capabilities), stroke patients demonstrated noticeably improved after experiencing VR training. By increasing motivation and involvement, rehabilitation using novel VR technologies may improve the cognitive outcomes of stroke patients[26].

The purpose of this study, according to Pugliese M. R. et al. (2019), was to ascertain if stroke patients might enhance their speech and cognitive function by using the tablet-based

rehabilitation therapy platform RecoverNow. A convenience sample of 30 acute stroke patients who were enrolled in the trial utilized RecoverNow for up to three months. The platform's feasibility was determined by five factors: protocol deviations, recruiting rate, adherence rate, retention rate, and the percentage of successful follow-up interventions. This was the main finding of the study.

The results showed that 48 percent of 62 eligible patients were successfully enrolled in the study. Participants only used the RecoverNow tablet for an average of 12 minutes per day, both within and outside of acute care. A large majority of patients (77%) engaged in the follow-up interviews, and 87% of them were successfully completed. The only two significant protocol violations were one enrollment failure and one treatment protocol violation.

However, participants also reported challenges in using the tablet-based treatment, such as difficulties with the complexity of the given programs. The study highlights the challenges in using tablet-based treatment for stroke rehabilitation, especially in maintaining patient engagement. Despite these challenges, the results suggest that tablet-based treatment can be a feasible option for early stroke rehabilitation, as long as the hurdles associated with the patient, device, and system are addressed[27].

Pugliese M. J et al. (2017), stated that Stroke is a growing global health issue that affects millions of people worldwide and restricts their independence. Due to the restricted supply of rehabilitation resources, accessing rehabilitation treatments has grown more difficult as the number of stroke survivors has increased. Traditional rehabilitation techniques can be costly and resource-intensive, even if specialist stroke rehabilitation is necessary for the restoration of functional abilities. By offering services on a platform with minimum resource utilization, mobile tablet-based treatments (MTBTs) provide a novel method for stroke rehabilitation. It is critical to comprehend the viability and difficulties of providing MTBTs to stroke survivors before conducting large-scale clinical trials to evaluate treatment efficacy.

To fully understand the attempted use of MTBTs and the difficulties faced by stroke patients as well as personnel, a complete scoping evaluation will be conducted. The primary focus of the review will be studies of MTBTs given to adult people with stroke for post-stroke health issues or deficiencies. Searching journal indexes, grey literature sources, clinical trial registries, grey literature sources, pertinent organization websites, and relevant articles of eligible studies can help find relevant research. To define MTBTs and comprehend the issues

encountered in context, the research characteristics, care roadblocks, methodological hurdles, patient-reported outcomes, and health findings will be collected. To demonstrate the scope of the subject, the findings will be presented via narrative descriptions, tables, and figures.

By emphasizing prevalent problems and patterns in MTBT feasibility, the review will also highlight important findings and pinpoint areas in need of further study. On how to deal with the difficulties faced by the research team and intervention participants will be advised. This has ramifications for the execution of the randomized clinical trials evaluating the efficacy of MTBT and raises the possibility of a thorough study and meta-analysis of completed studies [28].

Pugliese M. W et al. (2017), described that Mobile health (mHealth) technology provides a solution for increasing access to early stroke rehabilitation for victims. Despite being most effective in the early stages after a stroke, survivors may not have access to adequate resources such as facilities and therapists to start their therapy. An aging population along with improvements in acute therapy have led to an increase in the number of stroke victims and survivors, placing further pressure on the already overstretched rehabilitation resources. To create new and affordable mHealth devices for early rehabilitation in the acute environment, urgent high-quality research is required.

By using mHealth technology, therapists in acute situations may remotely monitor patient development and recommend applications based on common cognitive and physical tests. Based on the input from patients and their progress, they may also alter the recommended therapy. To address the lack of early rehabilitation resources and make use of the potential provided by mHealth technology, the Recover Now platform for stroke rehabilitation in the acute environment was developed. The platform offers apps that simulate speech-language and/or occupational therapy exercises as part of a specially created tablet-based stroke rehabilitation program. More research is still required to establish the viability, acceptability, and effectiveness of the tablet-based stroke rehabilitation, despite the fact that Recover Now demonstrates how mobile technology may be leveraged to address public health challenges. Further investigation and, if necessary, a randomized controlled trial are necessary to determine the effectiveness of early tablet-based stroke therapy [29].

As the research on effectiveness of mobile tablet-based therapies for cognitive rehabilitation of stroke patients expands, several studies have demonstrated their efficacy. A

study conducted by Marin et al. (2022) compared the outcomes of a mobile tablet-based cognitive rehabilitation program with traditional paper-and-pencil exercises. The results showed that the mobile tablet-based program was more successful in enhancing attention, processing speed, executive function, and overall cognitive function compared to the traditional therapy method[30].

Similarly, Sarfo et al. (2018) evaluated the effectiveness of a mobile tablet-based therapy in comparison to conventional rehabilitation techniques for stroke patients with aphasia. The study found that mobile tablet-based therapy was just as effective as traditional techniques in enhancing language and communication abilities [31]

Pugliese et al. (2017), observed that around the world, there is an increasing number of individuals living with post-stroke disabilities due to higher rates of stroke survivorship. Despite the potential benefits of early post-stroke rehabilitation in improving deficits and promoting recovery, many stroke survivors face barriers to accessing these services. Mobile tablet-based stroke rehabilitation may offer a solution for increasing access to treatments for recovery. This thesis offers a review of the literature on early mobile tablet-based therapies (MTBTs) for stroke survivors, including their feasibility and accessibility. The thesis is divided into two primary studies: a cohort study that looks at the viability of using an MTBT to treat post-stroke communicative, cognitive, and fine-motor problems, as well as a scoping review that gives an overview of the research on MTBTs after stroke. There were found to be 23 studies on MTBTs following stroke. The bulk of these therapies targeted communication or fine-motor deficits in chronic patients. Obstacles pertaining to care were listed as difficulties. Treatment started on average four days after the stroke, with a 48% recruitment rate. However, therapy adherence was only moderate because of often encountered treatment hurdles. Tablet technology appeals to stroke victims who want to hasten their recuperation. Early MTBT, however, may be challenging for some survivors because of issues with care. It's essential for patients and therapists to communicate frequently in order to remove these barriers and encourage optimal rehabilitation outcomes [32].

In conclusion, the acceptance and application of mobile tablet-based therapies for cognitive rehabilitation of stroke patients are influenced by a number of factors. These include the perspectives of healthcare providers, patient and caregiver attitudes, economic considerations, and technological advancements. Health providers who are familiar with

technology and recognize the advantages of these therapies, as well as patients and caregivers who have had positive experiences with mobile tablet-based rehabilitation, are more likely to adopt these methods. Conversely, economic barriers, such as the expense of tablet devices and rehabilitation software, as well as technological barriers, such as the lack of reliable internet connectivity or the unavailability of rehabilitation software, may hinder the adoption of these therapies.

Further research is necessary to understand how these factors influence the adoption of mobile tablet-based therapies for stroke patients. This information will aid in identifying areas that need improvement and developing strategies to overcome any hindrances.

Chapter 3

Research Methodology

3.1 Design

The number of participants that are taken is according to the research model. The record of one healthy person and the two persons who were stroke patients and dealing with cognitive issues. Each participant was asked to the:

1) Train on Lumosity basic course (www.lumosity.com) and the main domains of that are Speed, Memory, Attention, and Flexibility for at least 10 sessions.
2) What are the difficulties which are faced during the whole process of training?
3) What are the best parts of the training?

3.2 Participants

Three participants have included in the study one healthy person of 28 years and two stroke patients whose ages ranged from 60 to 75 years old. Subject 1 (S1), Subject 2 (S2) and Subject3 (S3). The criteria for their inclusion was

i. Complete the neuropsychological assessment prior to training
ii. Be able to access a computer & the internet
iii. Can use mobile or tablet and have a clear vision
iv. Willing to answer the semi-structured interview questions during the whole session of training
v. Have not such motor disability so can properly hold the tab or mobile for a time to play games.

Table 3.1: Characteristics of participants

Participants	Sex	Age	Qualification	Handed	Stroke month/year	Depressed GDS	Stroke location
S1	Female	28	18	Right	NO	No	Nil
S2	Female	67	12	Right	07/2019	No	L-Hemorrhagic
S3	Male	59	14	Right	10/2021	Mild	R-Hemorrhagic

3.3 Neuropsychological Measures

It is a field that includes neurology, psychology, and psychiatry. It tells about how well the brain is working when its function is disrupted by any injury or disorder. As globally the level of cognition is measured by a Mini Mental Status Exam (MMSE), we also used this scale to know about the level of cognition of patients and healthy persons before and after the training sessions. So that the difference between playing games and the purpose of the study becomes clear.

The maximum score for MMSE is 30 but a score of more than 25 is considered the normal limit of cognition. Areas that are under consideration are Speed, Memory, Attention, and Flexibility, so the tests regarding these areas which are the main domains are performed. Like speed tests are performed on how many words can be formed by the alphabet that is given within the time limit of one minute like no word will be repeated and any meaningful word can be generated. For memory and attention, different items and things are kept on the table in front of the person in a specific sequence and asked the person sees the things and tells the names after that let him busy for a random talk after two or three minutes ask the name and sequence of the objects that are kept in front of the person and according to the answer rate the marks. For flexibility draw specific geometrical diagrams with specific conditions and ask the person to draw them again by giving the conditions and rating their performance accordingly.

Table 3.2: Pre-training Neuropsychological testing score

Participants	**MMSE (cognition)**	**Memory (Delayed)**	**Speed (word fluency)**	**Attention (complex figure copy)**	**Flexibility (trail making)**
S1	WNL	4%	26	23	26
S2	WNL	25%	08	07	<1
S3	WNL	30%	12	04	<0.1

3.4 Lumosity Games

Lumos Labs (www.lumosity.com) developed several games for the cognitive rehabilitation of people whether they are suffering from some mental illness or due to age factor and can be other reasons. Participants are allocated their specific name and log-in id to start the game. Their caregivers are also completely trained to give them proper training and visual guidance related to the whole process of training and playing games. game. Many games are present for the process of brain training and improvement of cognitive functions.

But our main focus is on memory, speed, attention, and flexibility. Games related to these fields are played and the data and results are compiled for a total of 04 days. The sessions can be more than twice per day. The Lumosity performance index (LPI) is a standardized measure for the improvement of cognitive functions. And also, the stats and daily results are available, and we can compare daily progress with these daily base results. While playing daily games that daily which ability is getting stronger the daily ranking is also available in parisons between the worldwide players of your age group and also the number of players that are using this technique specifically in your area.

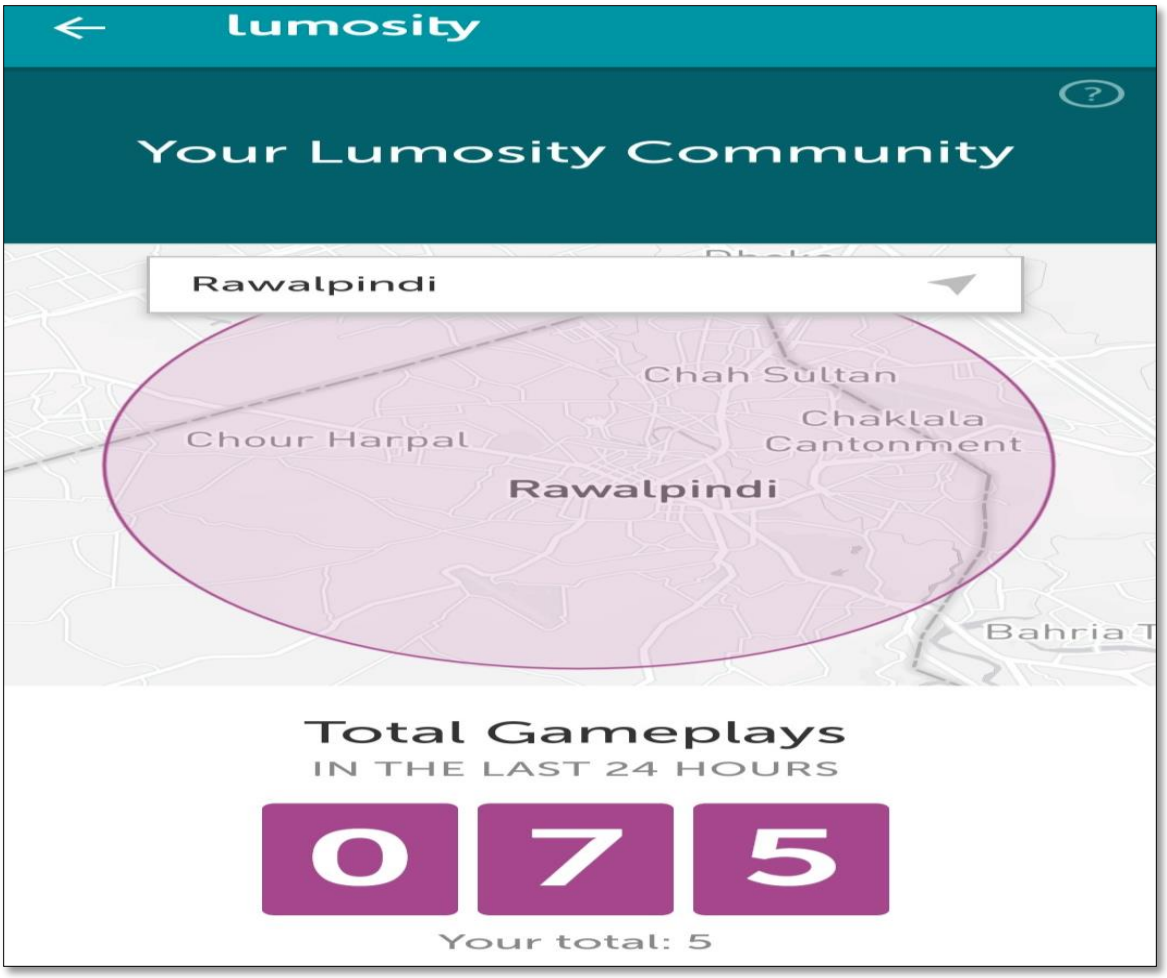


Figure 3.1: Screenshot of Lumosity community in Rawalpindi

The interfaces of the games used for the whole training process are shown with the help of the figures.

3.4.1 Speed

To increase the speed like in deciding or thinking process to talk about something or the problematic issues that can't respond within a short and easy time.

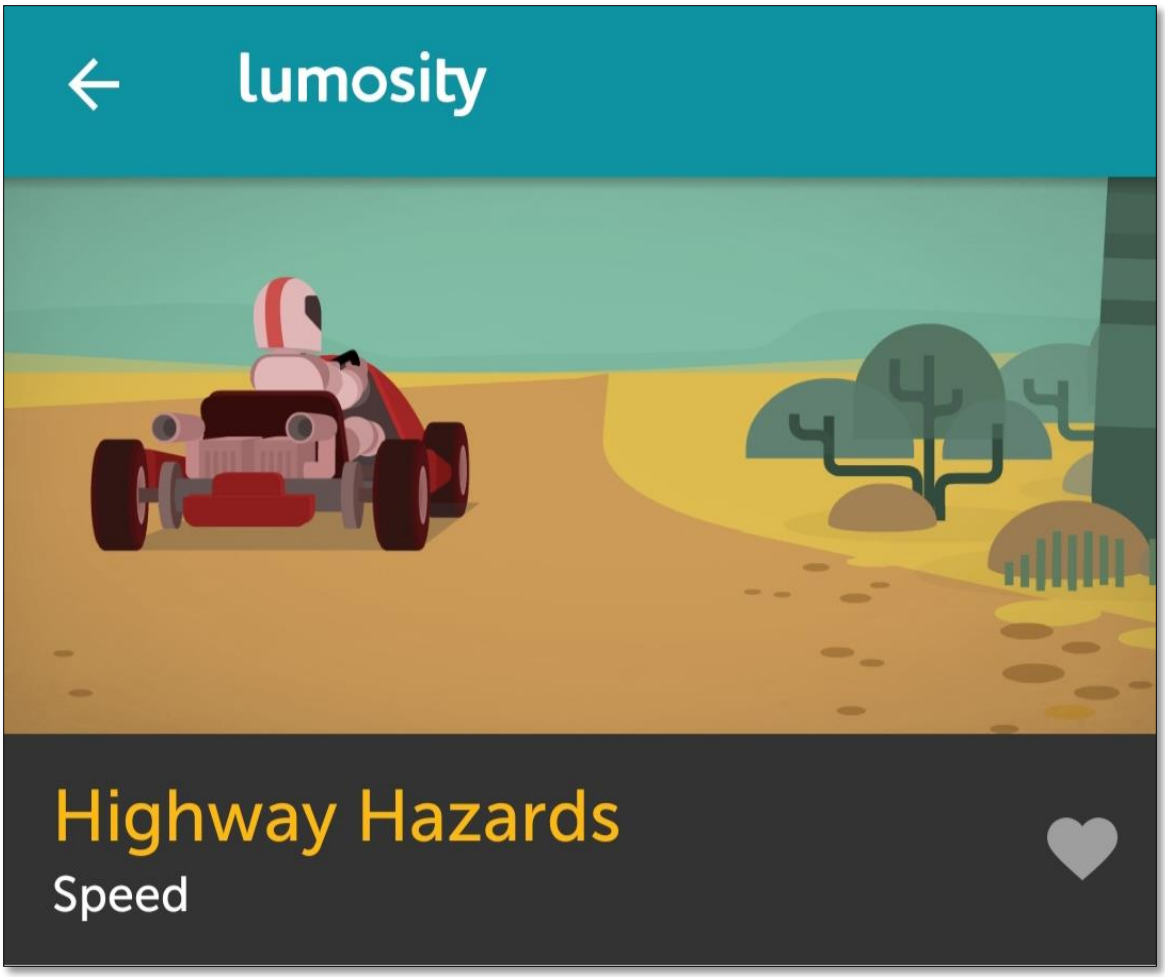


Figure 3.2: Screenshot of Lumosity game highway hazards for speed of thinking process

In this game have to control the car while there will be different hurdles during the drive rough roads or any rolling ball to stop the car and to reduce it while seeing it from distance have to change the side and continue to move.

3.4.2 Memory

This game is specifically working on remembering things and making the memory of a person better in a way that their daily routine tasks can be performed by themselves. The interface of this game is shown in the figure below.

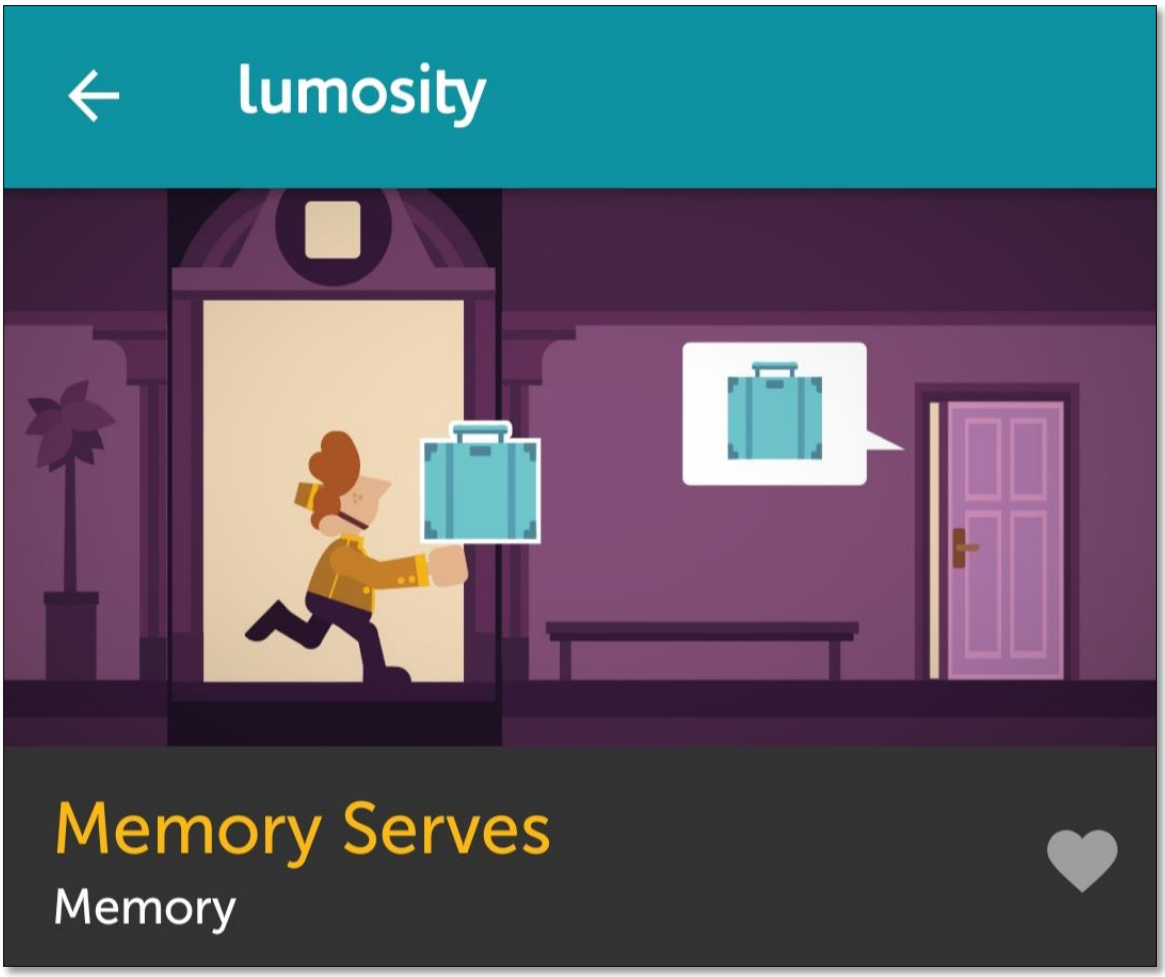


Figure 3.3: Screenshot of Lumosity game memory serves for memory improvement

In this game, you have to collect luggage of different types and drop it on the specific doors, but you have to remember which type of luggage you have collected without seeing that you have to drop whether you have collected that one or not.

3.4.3 Attention

For the improvement in attention that how much you are attentive to what is going around you and how you will deal with any unsuitable situation. The preface of the game is given below.

Figure 3.4: Screenshot of Lumosity game assist ants for attention improvement

In this game, ants are collecting their food we have to notice that no two ants collide with each other so their pile will feel like there will be no ants so have to give proper attention to every single one so that their pile does not fall otherwise no points will be gain.

3.4.4 Flexibility

For flexibility, the game color match is used to play. In this game the color and names are mentioned, a person has to match the color of the word which is written and what is the color of the word.

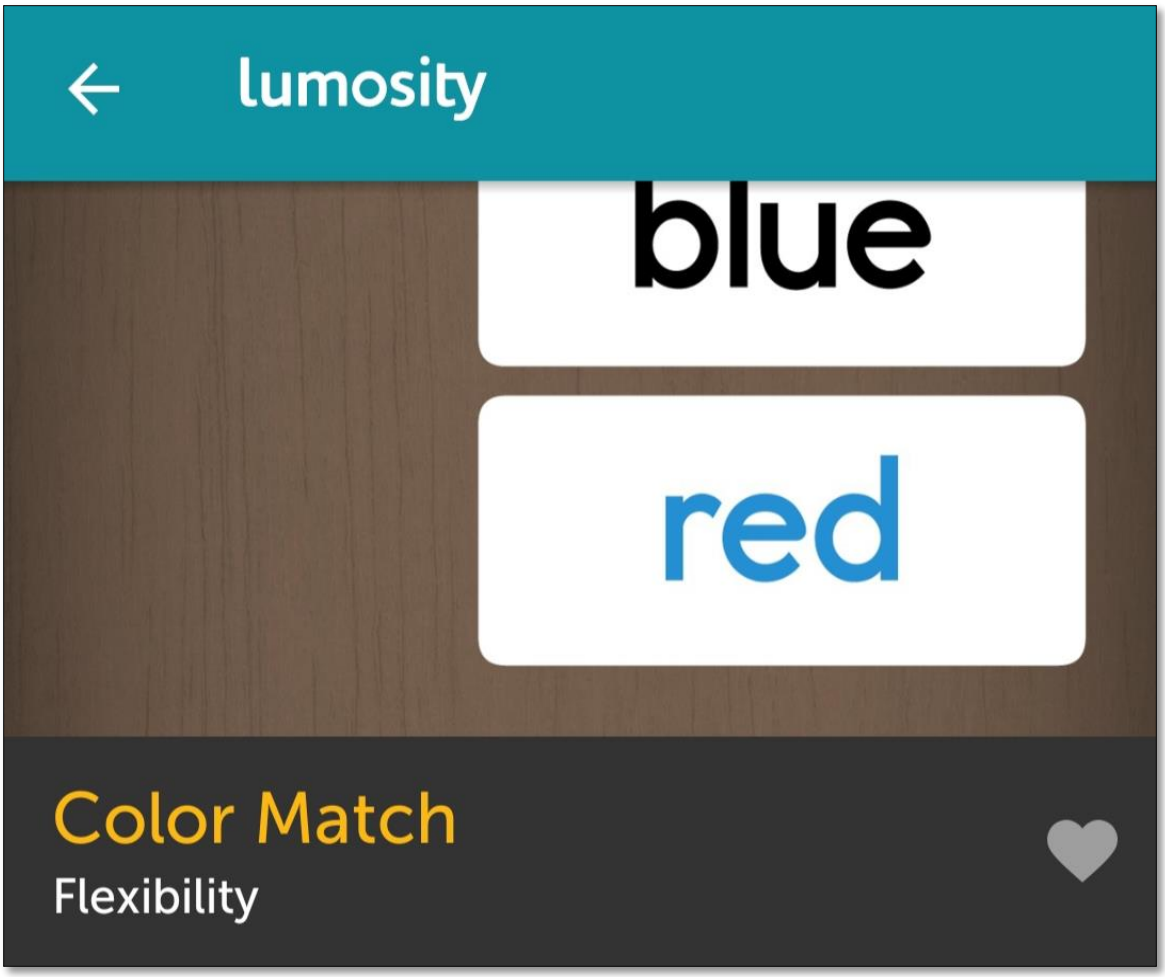


Figure 3.5: Screenshot of Lumosity game color match for flexibility improvement

3.5 Scales for the Cognitive assessment

There are a number of scales for the cognitive assessment of stroke patients. We studied three scales and chose the one on the basis of validity and reliability of the scales.

3.5.1 Cognitive assessment scale for stroke patients (CASP)

The Cognitive Assessment scale for Stroke Patients (CASP) is a prompt test for testing for post-stroke cognitive impair persons. It can be executed at any place by a non-professional assessor. A CASP score of less 35 by 36 should alert to the likely existence of cognitive deficiency. The score can help foresee a intermediate-term cognitive prediction.[33]

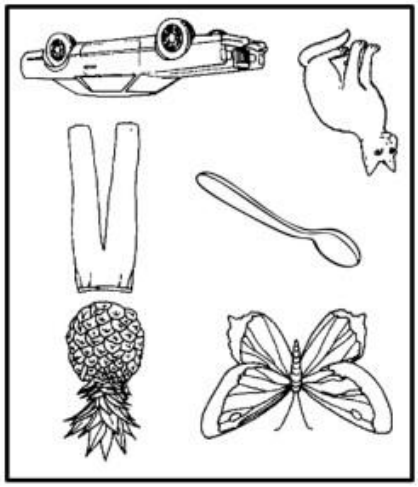
Cognitive Assessment for Stroke Patients (CASP)

Last name :

First name :

Date :

1) NAMING---------- / 3



"I will show you images. You must name what you see". Show the image *"what is it?"* Add *"you must remember what you see".*

Note the answers:

Score: ½ point by correct answer

2) COMPREHENSION---------- / 3

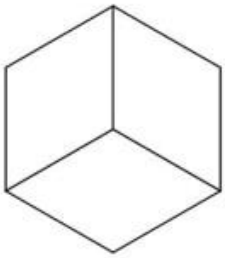
Place a pen, phone and sheet of paper in front of the patient on a table and arranged them in a vertical column. Ask the patient:

a. *Touch the pen*
b. *Show me your nose*
c. *Place the pen next to the phone*
d. *Show me your knees*
e. *Put the phone on the sheet of paper, don't touch the pen*
f. *Show me your stomach*

Score: ½ point for each correctly performed task

OK

3) REPRODUCING A COPY OF A CUBE---------- / 4



"Here is a drawing" (show the cube). *"You must draw an identical cube next to it"*

Score: 4 points if the three sides are reproduced and the angles are kept. 1 point only per reproduced side if the angles are not respected. 0 points if not.

4) GRAPHIC SERIES---------- / 2

∇ X ∇ X ∇ X

O X O X O X

"Here is the beginning of a suite". Show the suites. *"You must continue this suite until the end of the page".*

Score 1 point per correctly executed suite (10 correct alternations), if not score 0.

1

5) INHIBITION / FLEXIBILITY---------- / 4

"When I pound once on the table with my fist, you answer by pounding twice. When I pound twice, you pound once". Ensure that the patient has understood by giving him/her an example of each condition. Then complete the series: 1-1-2-1-2-2-1-1-1-2. **Take out 1 point per mistake, on the basis of 2 points**

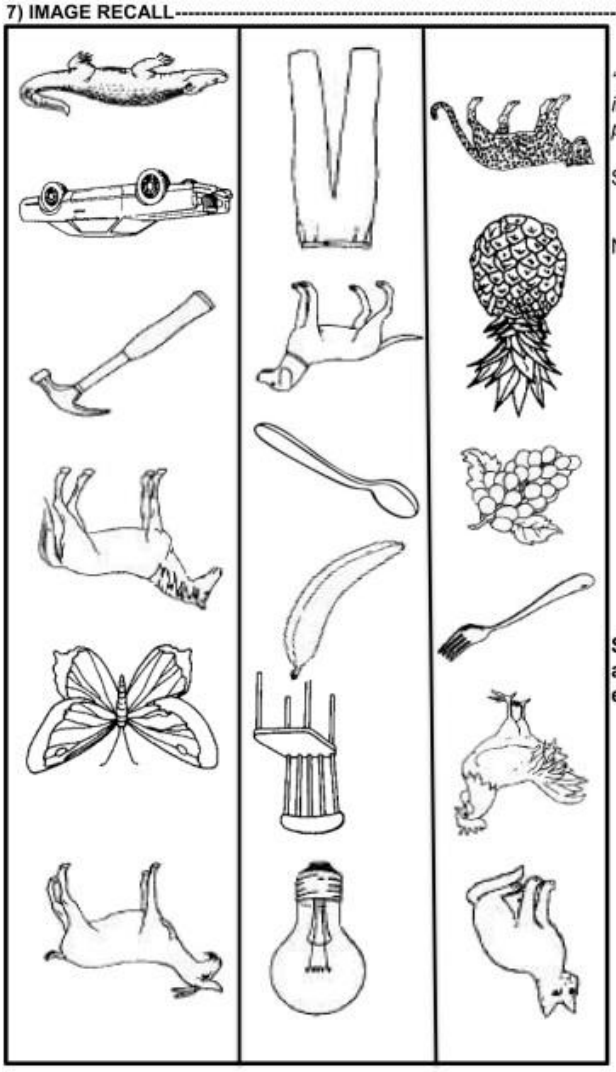
"Now when I pound once, you will answer by pounding once as well. When I pound twice, you will not do anything". Again, make sure the patient has understood by making an example. Then complete the series: 1-1-2-1-2-2-1-1-1-2. **Take out 1 point per mistake, on the basis of 2 points**

6) BISSECTION OF A HORIZONTAL LINE---------- / 2

The line on the right side of this page: we hide the rest of the page with a white sheet *"Please indicate by a mark the middle of the line"*.
Le center of the line and the deviation by ±6.5mm are indicated on the right side of page 1

Score: 2 points if the task is completed (norms on page 1)

7) IMAGE RECALL---------- / 6



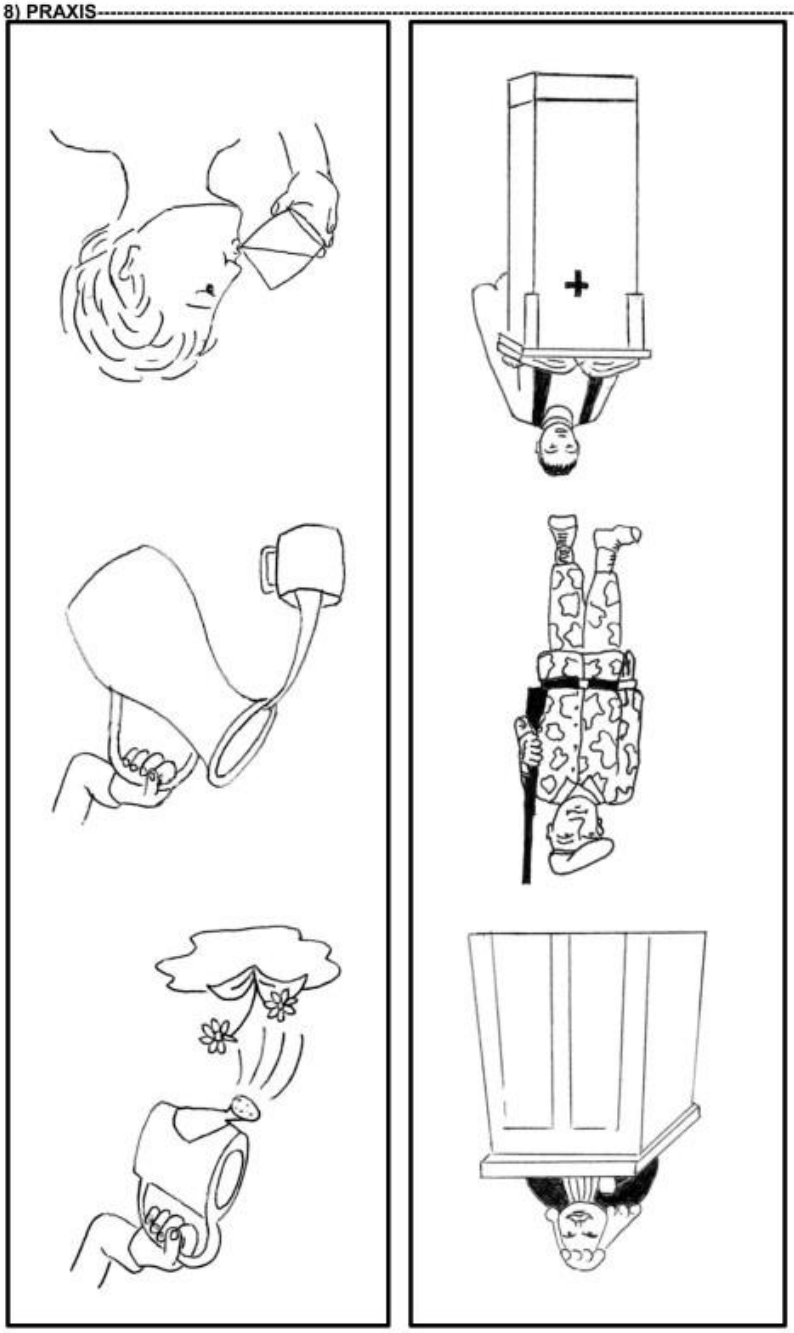
"Earlier on, I showed you 6 images, can you find them and point them to me?"

Show the 3 columns of 6 images.

Note down the answers:

Score 1 point for each good answer. Take out 1 point for each false recall recognition.

8) PRAXIS ---------- / 6



a. *"Do like me".* Hand on the table, make a horn with the 2nd (index) and 5th (little) fingers extended, the others flex.
b. *"Do like me".* Make a pinch with the thumb and middle finger.
c. *"Make the gesture of blowing a kiss".*
d. *"Make the gesture to say "shhh"".*
e. The examiner makes a military salute and asks the patient to associate this gesture to one of the three drawings (1st column).
f. The examiner makes the gesture of drinking a glass of water (without a glass) and asks the patient to associate this gesture to one of the three drawings on the 2nd column.

Score: 1 point for each successfully completed test

9) CALENDRIER-- / 6

SUNDAY	31		2017
	30		2016
SATURDAY	29		2015
	28		2014
FRIDAY	27		2013
	26		2012
THURSDAY	25		2011
	24	DECEMBER	2010
WEDNESDAY	23		2009
	22	NOVEMBER	2008
TUESDAY	21		2007
	20	OCTOBER	2006
MONDAY	19		2005
	18	SEPTEMBER	2004
	17		2003
"Can you tell me what day it is today, complete with month and year? You can use this calendar."	16	AUGUST	2002
	15		2001
	14	JULY	2000
	13		1999
	12	JUNE	1998
	11		1997
	10	MAY	1996
Score 1 point for the day of the week (e.g. Wednesday), 1 point for today's date (the 9th), 2 points for the month, 2 points for the year.	9		1995
	8	APRIL	1994
	7		1993
	6	MARCH	1992
	5		1990
	4	FEBRUARY	1917
	3		1916
	2	JANUARY	1915
	1		1914

[34]

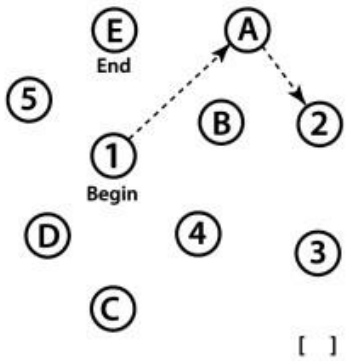
3.5.2 Montreal cognitive Assessment scale (MoCA)

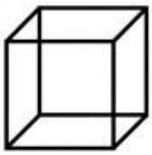
The Montreal cognitive assessment scale is a very shot tool for screening of the cognitive impairment of the patients. This test is used only to know whether cognitive impairment is present or not. Total score on MoCA is 30 and 26 out of 26 considered as a mild cognitive impairment.[35]

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education : Date of birth :
Sex : DATE :

VISUOSPATIAL / EXECUTIVE — POINTS





Copy cube

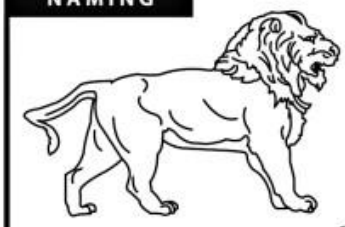
[ ] [ ]

Draw CLOCK (Ten past eleven) (3 points)

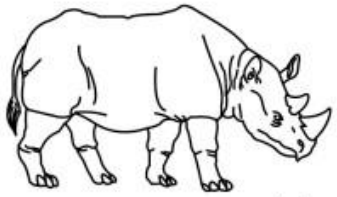
[ ] Contour [ ] Numbers [ ] Hands

__/5

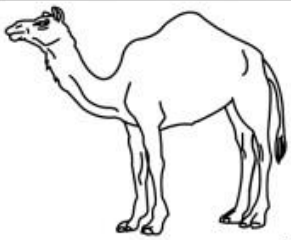
NAMING



[ ]



[ ]



[ ]

__/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).

Subject has to repeat them in the forward order [ ] 2 1 8 5 4

Subject has to repeat them in the backward order [ ] 7 4 2

__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65

4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**

__/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]

The cat always hid under the couch when dogs were in the room. [ ]

__/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words)

__/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler

__/2

DELAYED RECALL

	FACE	VELVET	CHURCH	DAISY	RED	Points for UNCUED recall only
Has to recall words **WITH NO CUE**	[ ]	[ ]	[ ]	[ ]	[ ]	
Optional Category cue						
Optional Multiple choice cue						

__/5

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City

__/6

© Z.Nasreddine MD www.mocatest.org Normal ≥ 26 / 30

TOTAL __/30

Add 1 point if ≤ 12 yr edu

Administered by: _____

[36]

3.5.3 Mini mental state examination (MMSE)

This scale was developed in 1975 for the quantitative assessment of the cognitive impairment in adults at that time.[37]

We used the MMSE for our research process. It is a set of eleven questions which are asked by the health care professionals to know about the cognitive impairment of the persons and the difficulty with the process of thinking, memory and understanding.

The maximum score for the MMSE score is 30. Score 25/30 or higher than 25 are considered as the normal cognitive ability. And scores less than 24 are considered to be abnormal and the person is considered cognitive impaired.

Most recent cut of recommendations are 27 and above it no cognitive impairment, 21 to 26 mild cognitive impairment, 11 to 20 moderate and 10 and less than 10 are considered to be severe cognitive impaired. [38]

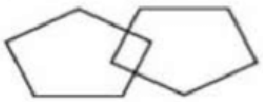
The MMSE is a direct measure to professional. Patient attributes such as age and level of education affect scores. It is observed by direct observation and is therefore not appropriate for delegate use.

Questions that are mostly asked in this scale and these can be performed in any language according to the patient's requirement.

Mini-Mental State Examination (MMSE)

Patient's Name: _____ Date: _____

Instructions: Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, ...) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL

(https://medworksmedia.com/product/mini-mental-state-examination-mmse/)

CHAPTER 4
RESULTS AND DISCUSSION

4.1. Results

The results that are obtained from games for all three people are below.

Table 4.1: Data record of a healthy person (S1)

Cognitive Domains	Day 1	Day 2	Day 3	Day 4
Speed	**401**	**478**	**511**	**525**
Memory	**495**	**503**	**521**	**542**
Attention	**342**	**346**	**346**	**335**
Flexibility	**554**	**543**	**532**	**572**

This table shows the results of cognitive assessments conducted on a healthy person named as S1 across four main cognitive domains: speed, memory, attention, and flexibility. S1 appears to perform relatively well on all four measures. Specifically, S1's speed scores show a gradual increase across the four assessments, suggesting that they may be improving in this domain. Memory scores also show a general trend of improvement, with scores increasing from the first to the fourth assessment. Attention scores appear to fluctuate somewhat, without a clear trend. Finally, flexibility scores show some variability across the four assessments, with scores ranging from 532 to 572, suggesting some degree of variability in performance in this domain. Overall, these results suggest that S1 has good cognitive functioning across multiple domains, with some potential for improvement in speed and memory. The overall performance of all four traits is shown below with the help of Graphs.

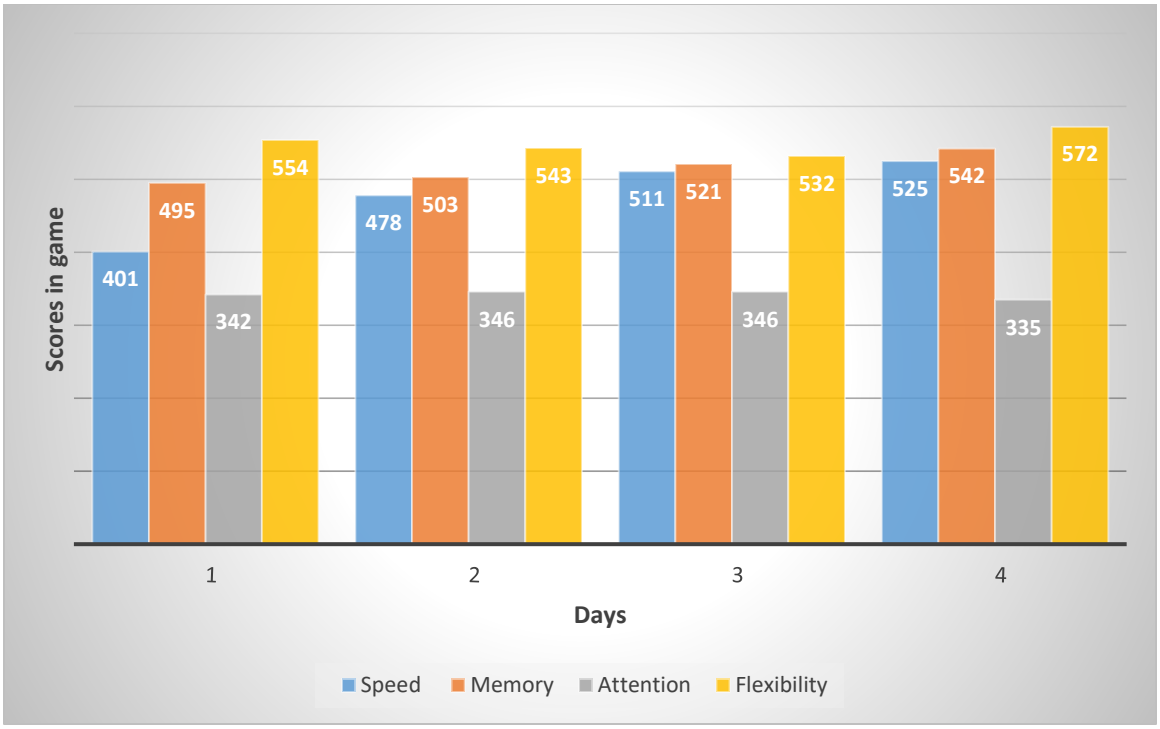


Figure 4.1: Combine graph of all four cognitive domains of (S1)

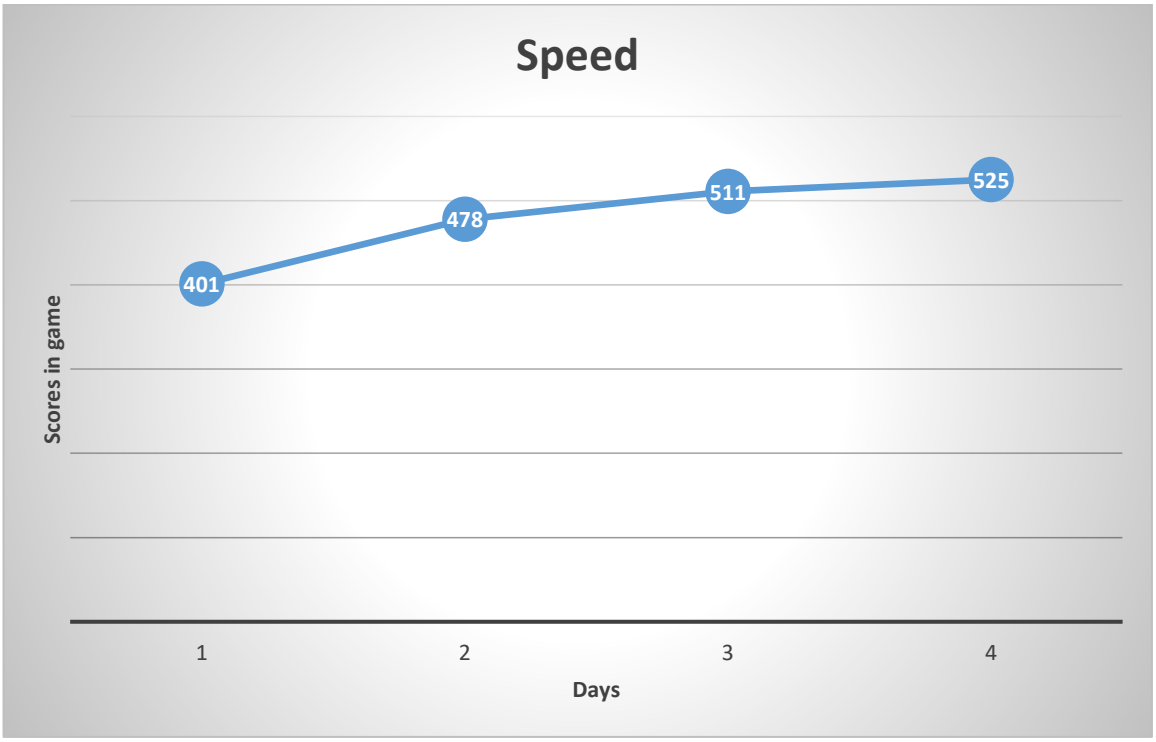


Figure 4.2: Graph representing speed of (S1)

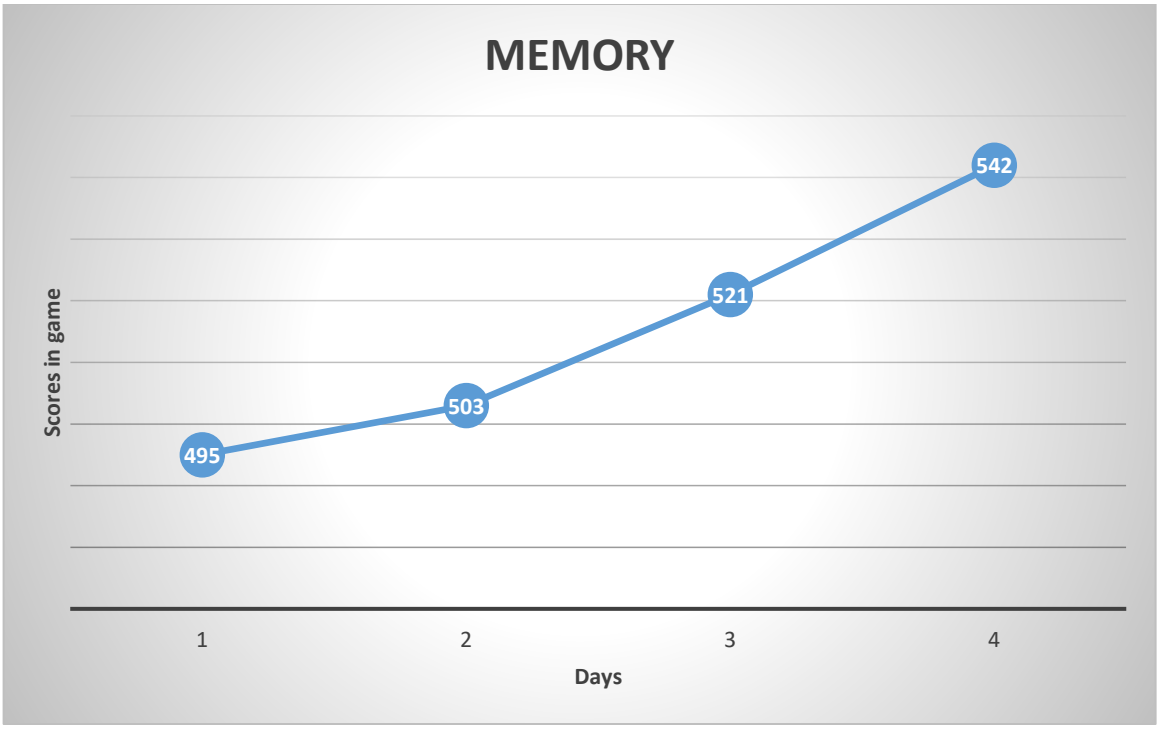


Figure 4.3:Graph representing memory of (S1)

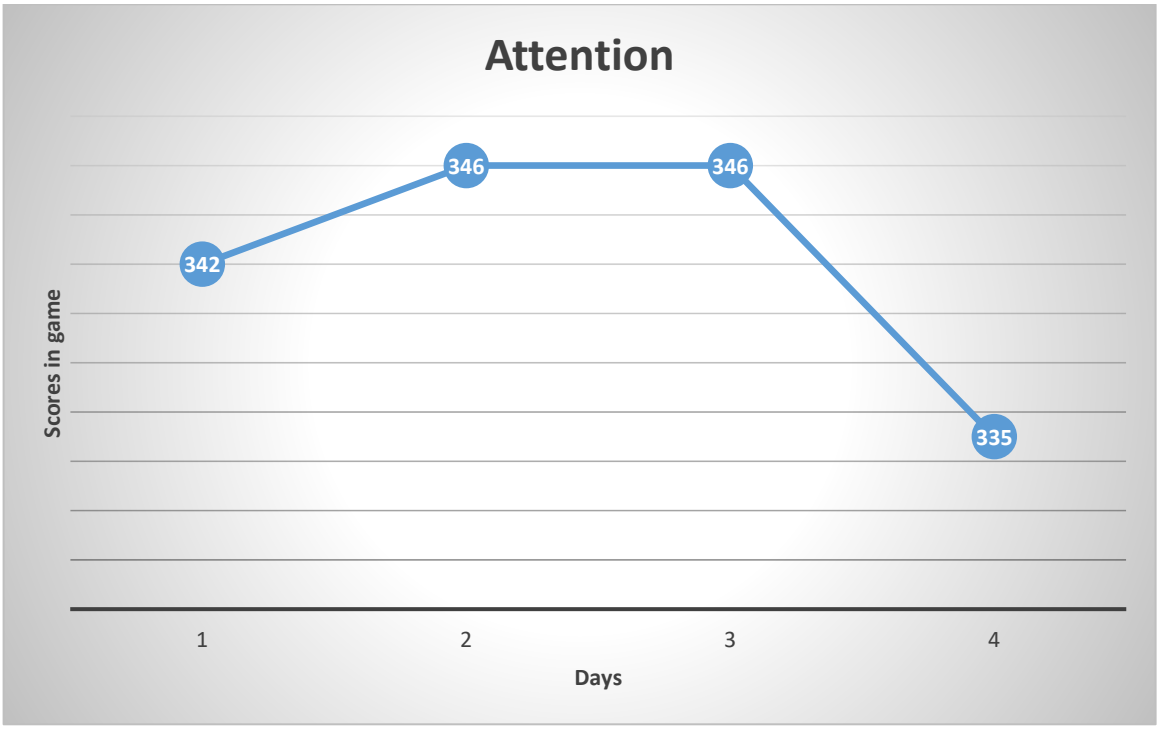


Figure 4.4: Graph representing attention of (S1)

There is a drastic drop in the attention factor because for certain reasons the person was not willing for the session that day, was busy with other activities, and wasn't giving proper attention to the game.

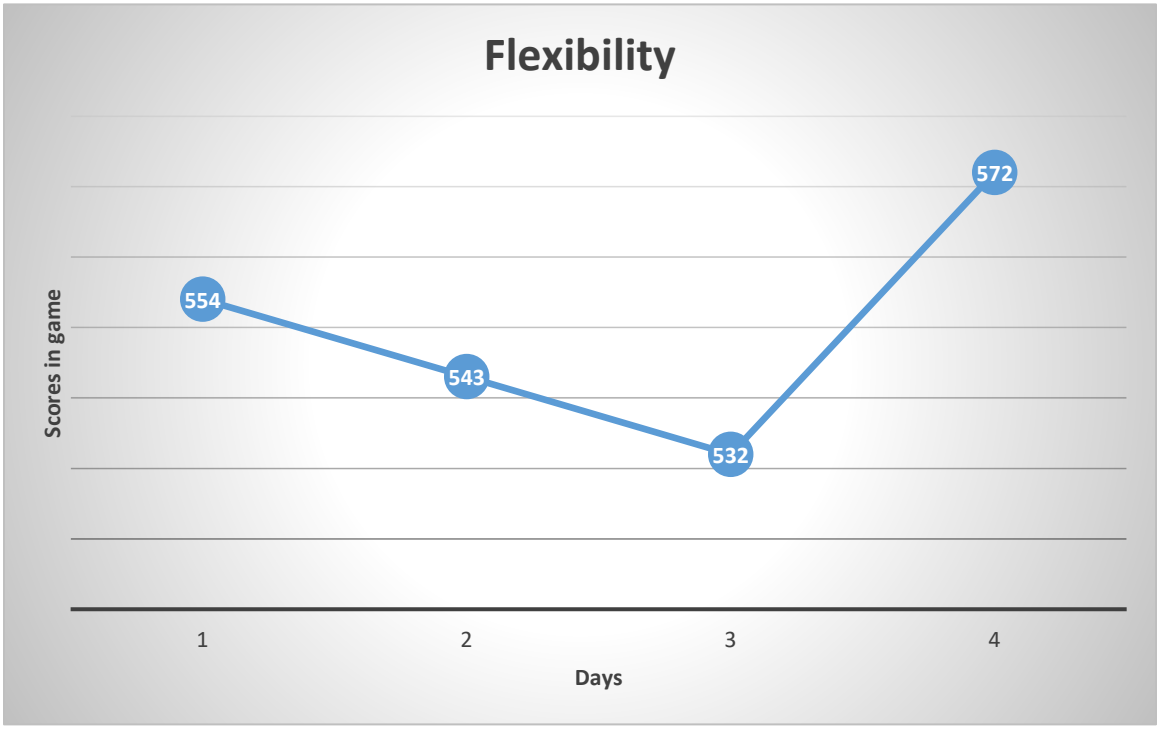


Figure 4.5: Graph representing flexibility of (S1)

Because of the understanding level during the starting session the person was not ready to do the sessions properly but there is drastic improvement can be seen at the end of the session.

Table 4.2: Data record of female patient S2

Cognitive Domains	Day 1	Day 2	Day 3	Day 4
Speed	**418**	**419**	**427**	**427**
Memory	**448**	**503**	**530**	**526**
Attention	**363**	**363**	**363**	**335**
Flexibility	**424**	**411**	**411**	**478**

Regarding memory, subject two (S2) showed scores of 448, 503, 530, and 526. The scores are generally lower than those of the healthy person (S1), except for the second measurement. For attention, the S2 showed scores of 363, 363, 363, and 335, which are lower than those of the healthy person S1. The scores were relatively consistent across all four measurements.

In terms of flexibility, Subject 2 showed scores of 424, 411, 411, and 478. The scores are generally lower than those of the healthy subject (S1), except for the last measurement. Overall, the data suggest that the patient (S1) is experiencing cognitive impairment, especially in memory and attention, compared to a healthy person.

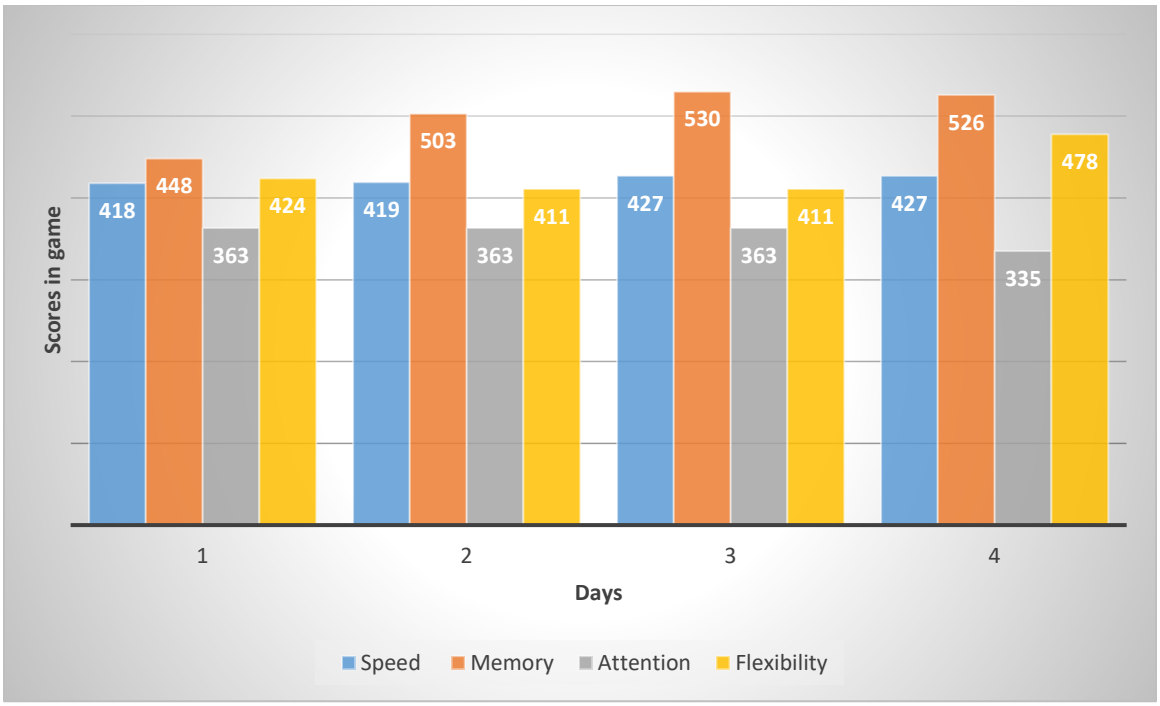


Figure 4.6: Combine graph of all four cognitive domains of (S2)

As speed and memory are improving to some extent. The separate graphs of every trait will show the clear differences.

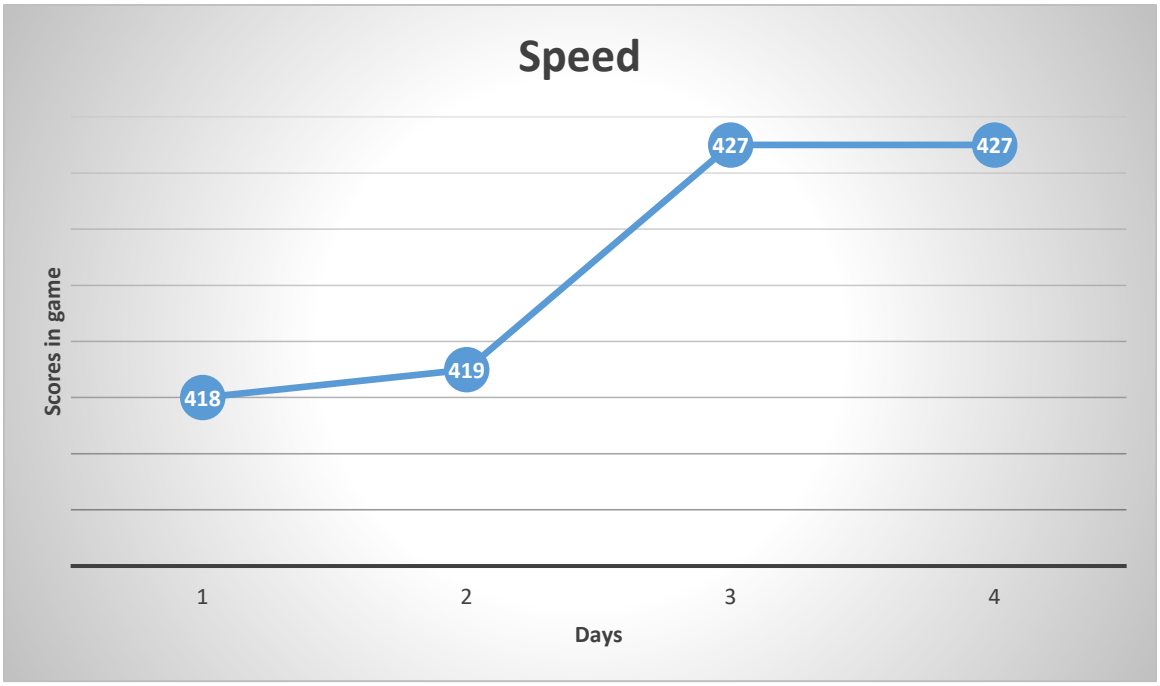


Figure 4.7: Graph representing speed of (S2)

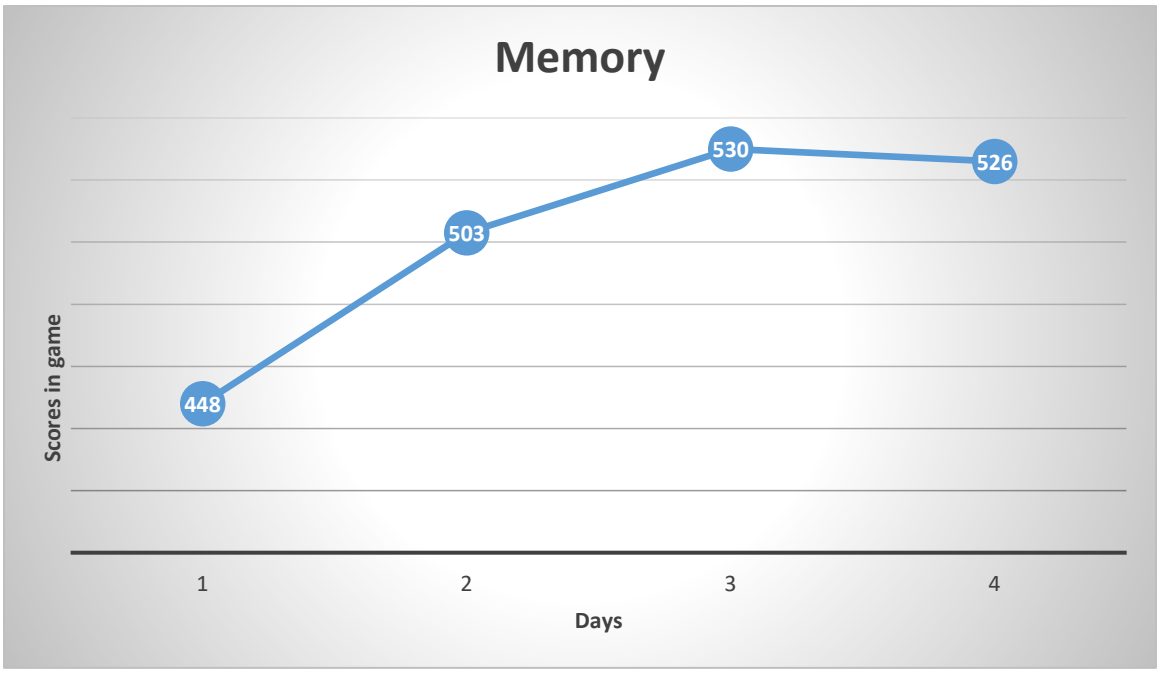


Figure 4.8: Graph representing memory of (S2)

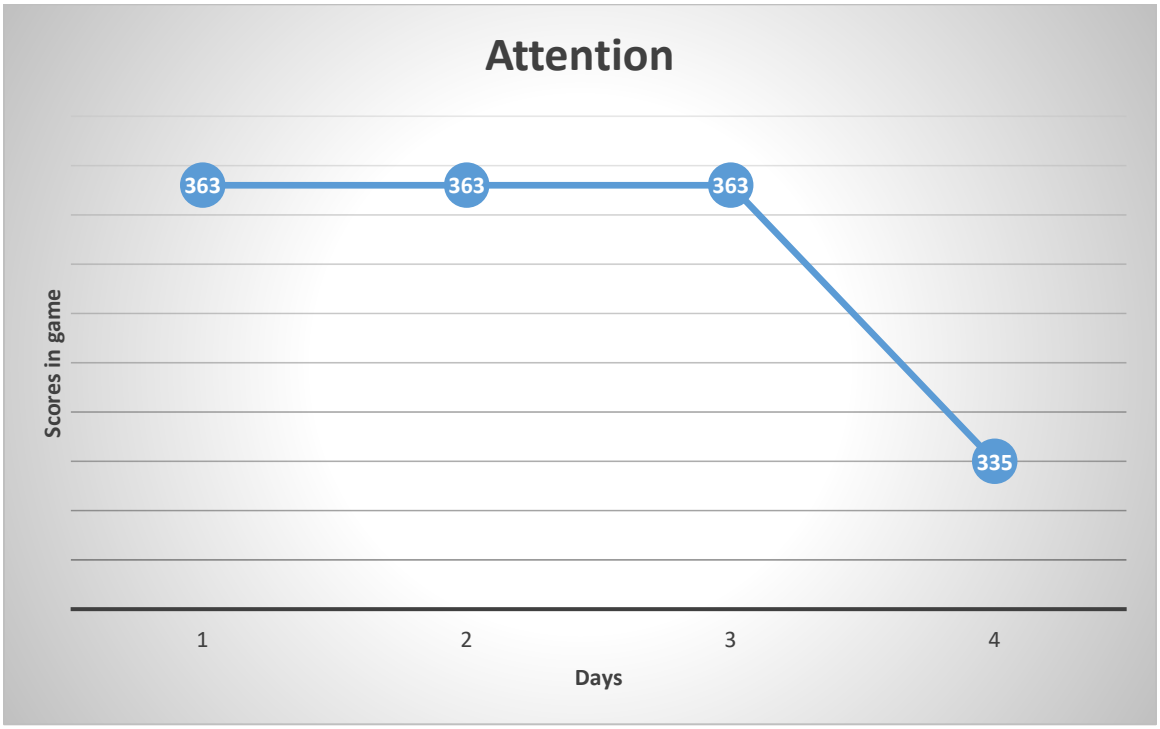


Figure 4.9: Graph representing attention of (S2)

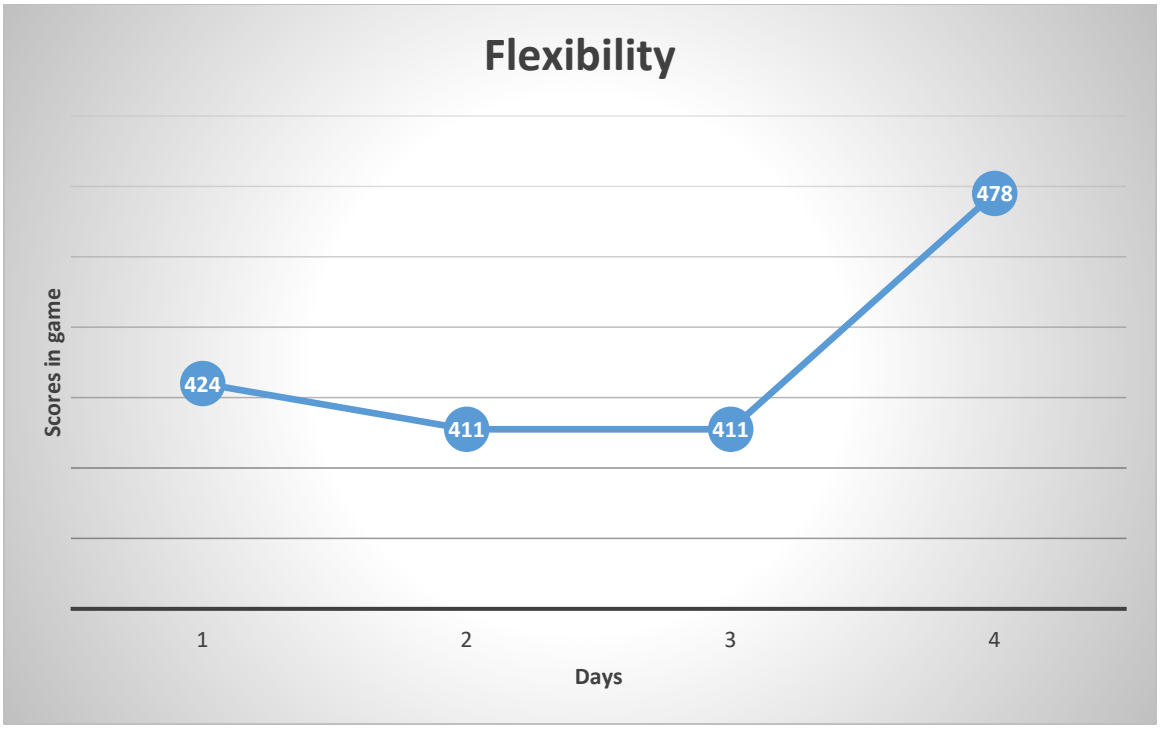


Figure 4.10: Graph representing flexibility of (S2)

Based on the given data records, we can see that there are differences in the performance of the healthy person (S1), the female patient (S2), and the male patient (S3) across the four cognitive domains: speed, memory, attention, and flexibility.

Table 4.3: Data record of male patient (S3)

Cognitive Domains	Day 1	Day 2	Day 3	Day 3
Speed	**406**	**433**	**411**	**398**
Memory	**489**	**510**	**481**	**513**
Attention	**342**	**335**	**342**	**342**
Flexibility	**520**	**486**	**544**	**536**

Looking at the speed domain, we can see that the healthy person S1 has the highest performance, with scores ranging from 401 to 525, followed by the male patient S2 with scores ranging from 398 to 433, and then the female patient S3 with scores ranging from 418 to 427.

In terms of memory, we can see that the healthy person S1 has the highest performance, with scores ranging from 495 to 542, followed by the male patient S2 with scores ranging from 481 to 513, and then the female patient S3 with scores ranging from 448 to 530. Looking at the attention domain, we can see that the healthy person S1 and the male patient S2 have similar performance, with scores ranging from 335 to 346, while the female patient S3 has slightly lower performance, with scores ranging from 335 to 363.

In terms of flexibility, we can see that the healthy person S1 has the highest performance, with scores ranging from 532 to 572, followed by the male patient S2 with scores ranging from 486 to 544, and then the female patient S3 with scores ranging from 411 to 478. It is also worth noting that the male patient S2 seems to have more variability in his performance across the different domains, with some scores being higher and some scores being lower compared to the other two individuals. Overall, these data records suggest that there are differences in cognitive performance across different individuals and that cognitive assessment can be used to identify areas of strength and weakness in different cognitive domains.

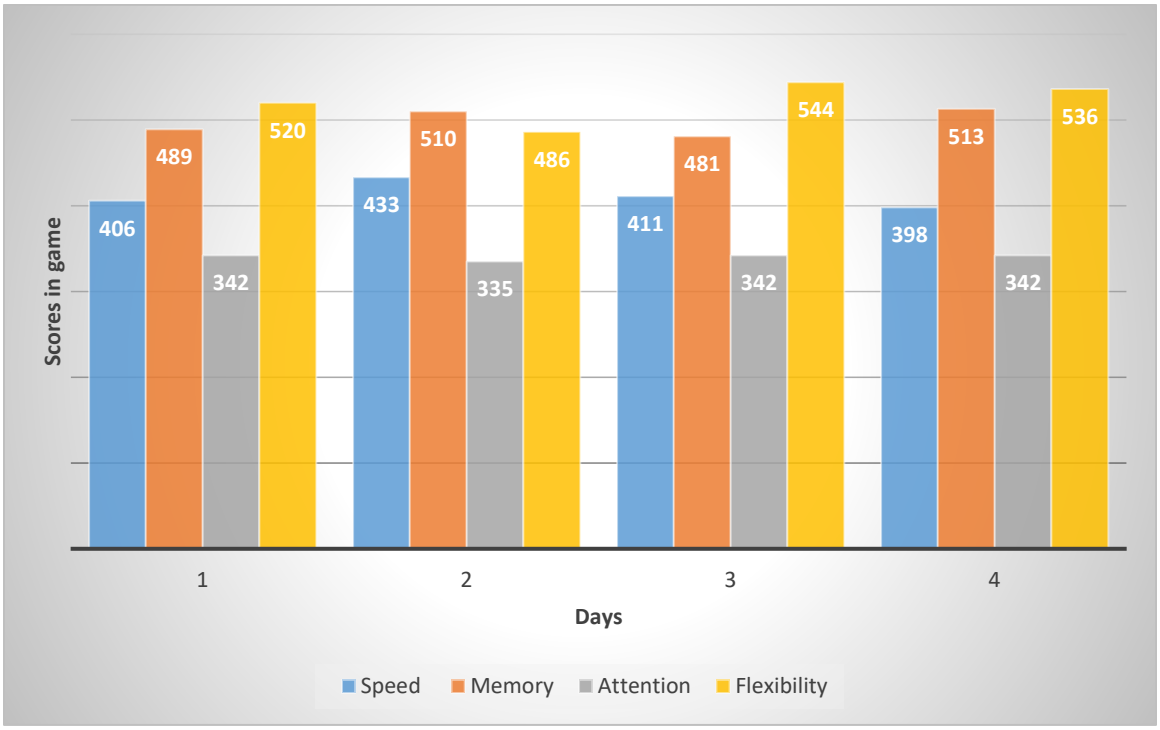


Figure 4.11: Combine graph of all four cognitive domains of (S3)

The memory and flexibility of this patient are getting better. Attention and speed factor remain the same almost there are no visible improvements shown in these traits.

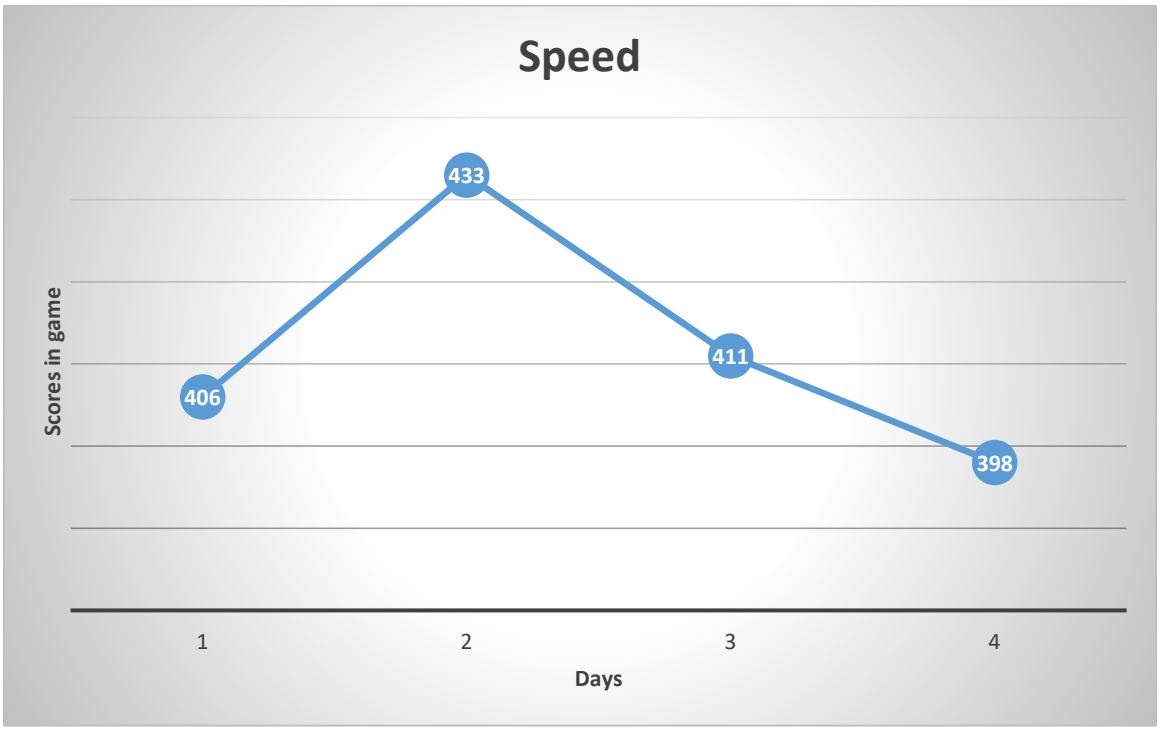


Figure 4.12: Graph representing speed of (S3)

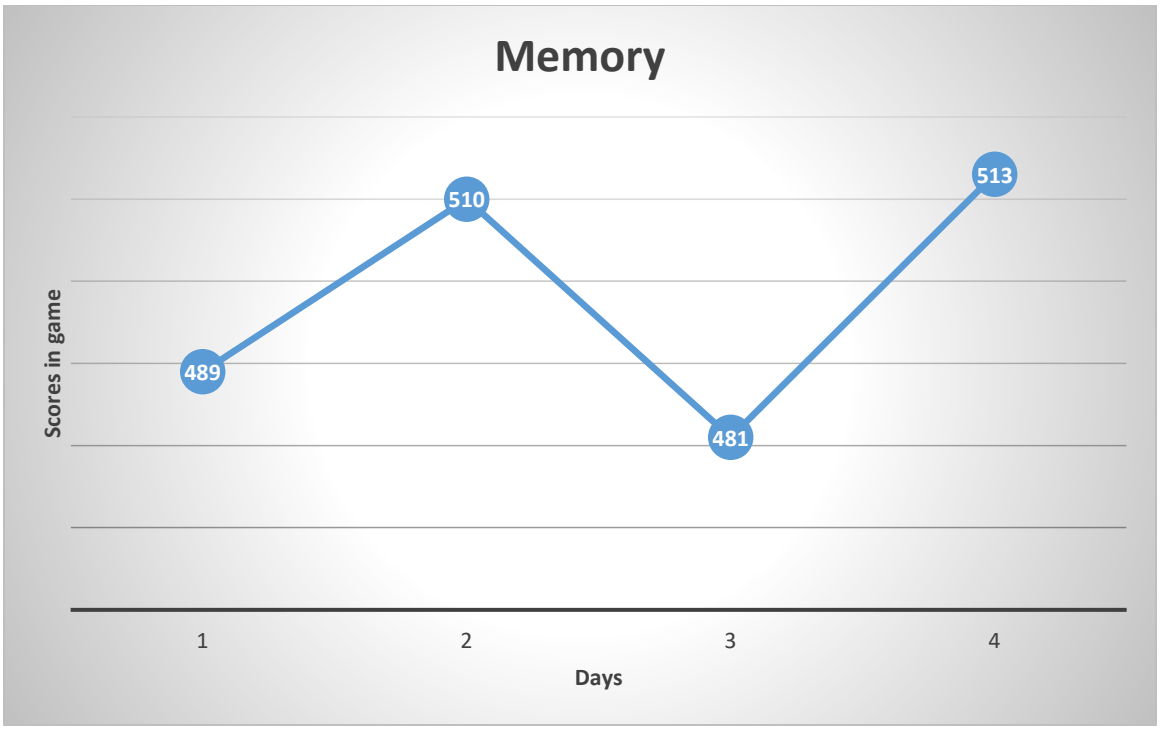


Figure 4.13: Graph representing memory of (S3)

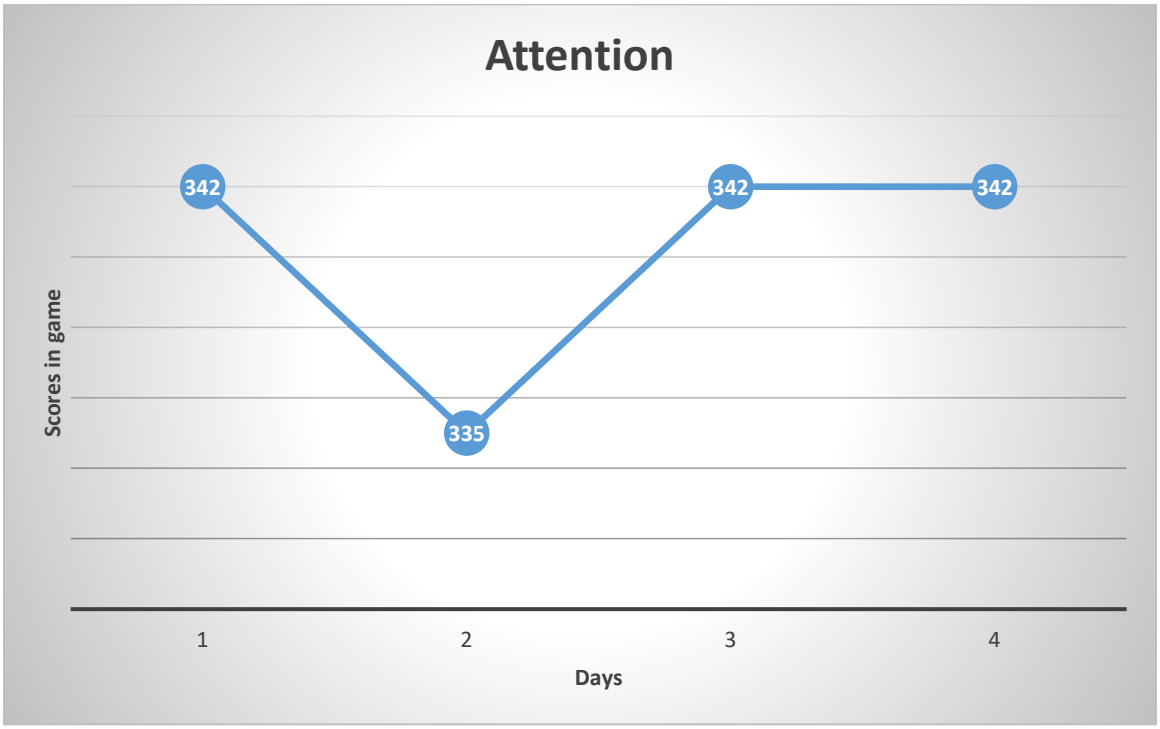


Figure 4.14: Graph representing attention of (S3)

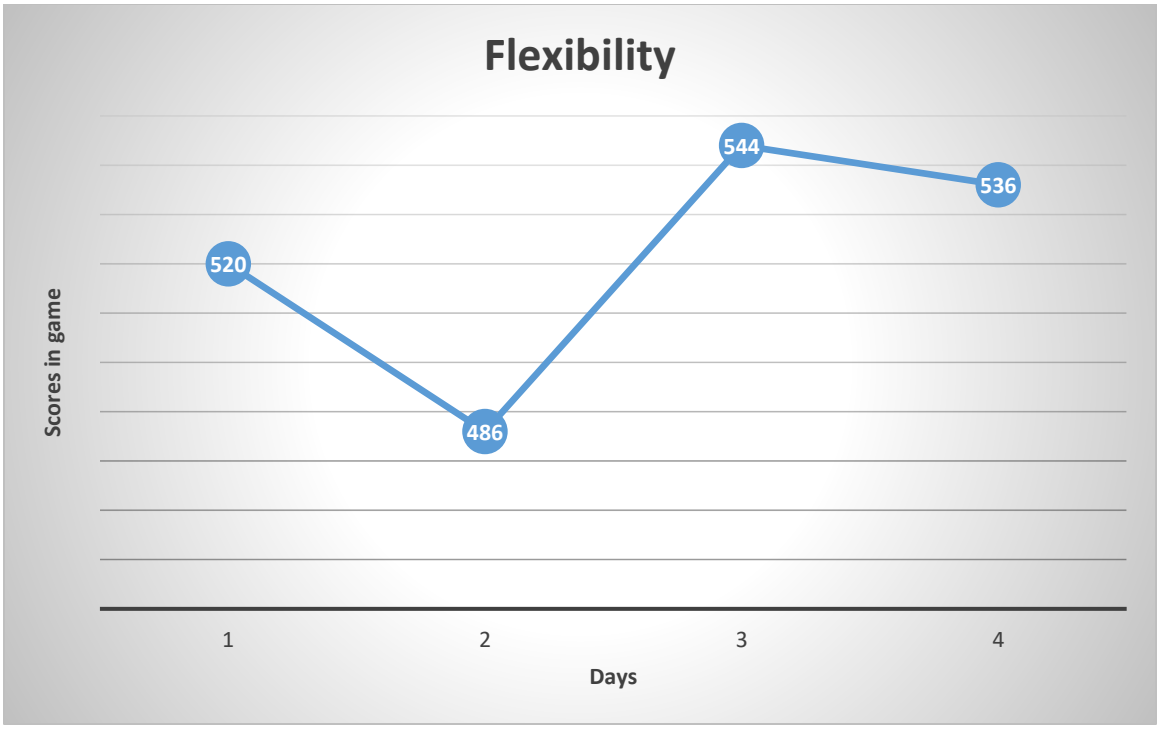


Figure 4.15: Graph representing flexibility of (S3)

Based on the psychologist's evaluation, the results of the training for the three individuals can be summarized as follows:

Table 4.4: Results of the phycologist after the training

NAMES	MMSE	MEMORY DELAYED %	SPEED FLUENCY%	ATTENTION (COMPLETE FIGURE) %	FLEXIBILITY (TRAIL MAKING %
S1	WNL	3	28	27	29
S2	WNL	20	13	10	1
S3	WNL	29	12	8	<1

S1: The individual's MMSE score is within the normal range, which suggests no cognitive impairment. The individual's performance in delayed memory recall is slightly below average (3%), and there is a minor decline in speed fluency (28%) and attention (27%). However, their flexibility in task switching remains relatively intact (29%).

S2: The individual's MMSE score is also within the normal range. However, there is a notable decline in their performance in delayed memory recall (20%). Additionally, there is a decrease in speed fluency (13%) and attention (10%), but flexibility in task switching seems to be relatively well-preserved (1%).

S3: The individual's MMSE score is within the normal range. However, there is a significant decline in performance in delayed memory recall (29%). There is also a decline in speed fluency (12%) and attention (8%), but their flexibility in task switching remains relatively intact (<1%).

Overall, it appears that the training has had some positive effects on the cognitive function of the individuals. However, there are still some areas of concern, such as declines in memory recall, speed fluency, and attention, which may require further intervention or monitoring.

4.2. Discussion

A promising strategy that has attracted attention recently is the use of mobile tablet-based therapies of cognitive rehabilitation of stroke patients. In our study, three stroke patients were examined for how well this therapy improved their cognitive function S1, S2, and S3. The results showed varying degrees of improvement in different cognitive domains.

S1, who was a healthy person, showed consistent and high performance across all cognitive domains before and after the training. This suggests that mobile tablet-based therapies may be useful not only for stroke patients but also for healthy individuals to maintain and enhance their cognitive function.

S2, a female stroke patient, showed significant improvement in memory-delayed recall and flexibility after the training. However, her speed and attention did not show significant improvement. These results suggest that mobile tablet-based therapies may be particularly effective in improving memory and cognitive flexibility in stroke patients but may have limited impact on other cognitive domains.

S3, a male stroke patient, showed significant improvement in attention and flexibility after the training, but no significant improvement in memory and speed. These results suggest that mobile tablet-based therapies may be particularly effective in improving attention and

cognitive flexibility in stroke patients but may not have a significant impact on memory and processing speed.

Overall, our study suggests that mobile tablet-based therapies can be a useful tool for cognitive rehabilitation of stroke patients, particularly in improving memory, attention, and flexibility. However, the degree of improvement may vary depending on the individual's cognitive strengths and weaknesses. Therefore, a personalized approach to therapy may be necessary to achieve optimal results.

4.2.1 Limitation

As mobile tablet -based therapies have the potential to be a valuable tool for cognitive rehabilitation of stroke patients , there are several limitations that must be considered and addressed in order to optimize their effectiveness.

1. **Limited access to technology**: Some stroke patients may not have access to mobile tablets or may have limited experiences using technology, which can make it challenging for them to engage in therapy.
2. **Lack of customization**: Mobile tablet-based therapies are often designed to be generic which means that may not be tailored to meet the specific needs and abilities of individual stroke patients.
3. **Limited human interaction**: Mobile tablet base therapies may lack human interaction and support the traditional therapies, which is more challenging and stay motivated and engaged.
4. **Lack of transferability to real world setting**: The skills and abilities that stroke patients gain through mobile tablet-based therapies may not necessarily transfer to real world setting, which can limit the overall effectiveness of these therapies.
5. **Education:** It is important to consider the perspectives and experiences of all individuals, including those who may be uneducated or have limited education, when discussing the limitations of mobile tablet base therapies for cognitive rehabilitation of stroke patients. While these individuals may not have specialized knowledge or training in the field of heath care or rehabilitation, they may have unique insights and observations that can inform the discussions. For example, uneducated individuals may have limited access to

technology or may not be familiar with how to use mobile tablets, which can make it difficult for them to engage in these therapies.

6. **Upper limb impairments:** Stroke patients frequently experience upper limb limitations, which can greatly limit their ability to participate in rehabilitation activities like mobile tablet-based therapies. Specifically, upper limb impairments can limit a patient's ability to manipulate and interact with mobile tablets, which can make it more difficult for them to engage in therapy activities that require fine motor control or the use of both hands. This can lead to frustration, reduced engagement, and a decreased likelihood of completing therapy sessions. While mobile tablet-based therapies can be adopted to accommodate upper limb impairments, such as through as through the use of adoptive equipment or modified therapy activities, these adaptations may not be accessible or effective for all patients, therefore upper limb impairment can be considered a limitation of mobile tablet-based therapies for cognitive rehabilitation of stroke patents.

4.2.3. Future Directions

1. There is a lot of potential for developing new and effective mobile tablet base therapies for cognitive rehabilitation of stroke patients. Researchers and developers could explore different types of interventions such as personalized cognitive training, virtual reality, music therapy.
2. Mobile- based therapies could be integrated with other emerging technologies such as wearables or brain computer interfaces to enhance effectiveness and efficiency.
3. Currently there is limited data on the long-term effects of mobile based therapies for cognitive rehabilitation of stroke patients. Future research could focus on following patients for longer period of time to determine whether the benefits of these interventions are sustained over time.
4. Finally, one of the key challenges facing the adoption of mobile base therapies in clinical practice is the lack of integration into standard care pathways. Future research could focus on developing guidelines and protocols for integrating these interventions into routine care of stroke patients.

Chapter 5
Conclusion

In conclusion, in this study, we looked at how well mobile tablet-based therapy helped stroke patients' cognitive performance. The results showed that such therapies can be particularly effective in improving memory, attention, and flexibility, but may have limited impact on other cognitive domains such as processing speed. However, the degree of improvement may vary depending on the individual's cognitive strengths and weaknesses.

According to our research, mobile tablet-based therapies can be a helpful tool for stroke patients' cognitive rehabilitation, however for best outcomes, a tailored treatment plan would be required. Further research is needed to explore the long-term effects of such therapies and to compare their effectiveness with other forms of cognitive rehabilitation. Based on the graphs showing improvements in memory for stroke patients who underwent mobile tablet-based therapies, it can be concluded that these therapies have the potential to be an effective tool for cognitive rehabilitation. While the improvements in memory observed in the graphs are promising, it is important to note that they may not be sustained over time or generalize to real world settings, Additionally the short duration of sessions may not be sufficient to fully address the cognitive impairments that stroke patients may experience. Therefore, while the graphs showing the improvements in memory provide some evidence to support the use of mobile tablet bases therapies, further research is needed to determine the long-term effectiveness of these therapies and how they can be optimized to address the specific needs and abilities of individual patients. Additionally, it may be beneficial to explore the use of mobile tablet-based therapies in conjunction with other forms of rehabilitations, such as traditional therapy sessions, to maximize the potential benefits for stroke patients. Overall, while mobile tablet-based therapies for cognitive rehabilitation of stroke patients have their limitations, they also have the potential to be a valuable tool for improving patients' outcomes and quality of life. By continuing to explore and optimize these therapies, we can work to develop more effective and accessible rehabilitation options for stroke patients and other individuals with cognitive impairments.

References

1. Pugliese, M., *Mobile Tablet-Based Stroke Rehabilitation in the Acute Care Setting*. 2017, Université d'Ottawa/University of Ottawa.
2. Cifu, D.X., D.G.J.A.o.p.m. Stewart, and rehabilitation, *Factors affecting functional outcome after stroke: a critical review of rehabilitation interventions.* 1999. **80**(5): p. S35-S39.
3. Teasell, R., N.J.E.-b.r.o.s.r.H. Hussein, and S.F.C.P.f.S. Recovery, *Background concepts in stroke rehabilitation.* 2016.
4. Wang, H., et al., *Time to inpatient rehabilitation hospital admission and functional outcomes of stroke patients.* 2011. **3**(4): p. 296-304.
5. Rabinowitz, A.R., Juengst, S. B., & Bergquist, T. F, *Mobile Technology for Cognitive Rehabilitation. In Neurorehabilitation Technology*. 2022, Cham: Springer International Publishing. p. 549-561.
6. Evans, R.A., McAuley, H., Harrison, E. M., Shikotra, A., Singapuri, A., Sereno, M., ... & Cairns, P, *Physical, cognitive, and mental health impacts of COVID-19 after hospitalisation (PHOSP-COVID): a UK multicentre, prospective cohort study.* The Lancet Respiratory Medicine, 2021: p. 9(11), 1275-1287.
7. Reilly, K.T., Holé, J., Nash, S., Pugniet, V., Servajean, V., Varsovie, D., & Jacquin-Courtois, S, *Description of an interdisciplinary, holistic cognitive rehabilitation program for adults with mild to moderate cognitive impairment after acquired.* Disability and Rehabilitation, 2023: p. 1-10.
8. Alladi, S., A. Meena, and S.J.N.I. Kaul, *Cognitive rehabilitation in stroke: therapy and techniques.* 2002. **50**(suppl): p. S102-S108.
9. Choi, Y.-H. and N.-J.J.J. Paik, *Mobile game-based virtual reality program for upper extremity stroke rehabilitation.* 2018(133): p. e56241.
10. Chen, Y., et al., *Home-based technologies for stroke rehabilitation: A systematic review.* 2019. **123**: p. 11-22.
11. Pugliese, M., et al., *Mobile tablet-based therapies following stroke: A systematic scoping review of administrative methods and patient experiences.* 2018. **13**(1): p. e0191566.
12. Hardy, J. and M.J.S.F. Scanlon, CA: Lumos Labs, *The science behind lumosity.* 2009.
13. Gierus, J., et al., *The Montreal Cognitive Assessment as a preliminary assessment tool in general psychiatry: validity of MoCA in psychiatric patients.* 2015. **37**(5): p. 476-480.
14. Vertesi, A., et al., *Standardized Mini-Mental State Examination. Use and interpretation.* 2001. **47**(10): p. 2018-2023.
15. Agrell, B., O.J.A.C. Dehlin, and E. Research, *Mini mental state examination in geriatric stroke patients. Validity, differences between subgroups of patients, and relationships to somatic and mental variables.* 2000. **12**: p. 439-444.
16. De Luca, R., Russo, M., Naro, A., Tomasello, P., Leonardi, S., Santamaria, F., ... & Calabrò, R. S, *Effects of virtual reality-based training with BTs-Nirvana on functional recovery in stroke patients: preliminary considerations.* International Journal of Neuroscience,, 2018: p. 128(9), 791-796.
17. Longley, W.A., *Cognitive rehabilitation in multiple sclerosis.* Australian Journal of General Practice, 2022: p. 51(4), 233-237.
18. Caughlin, S., Mehta, S., Corriveau, H., Eng, J. J., Eskes, G., Kairy, D., ... & Teasell, R, *Implementing telerehabilitation after stroke: lessons learned from Canadian trials.* Telemedicine and e-Health, 2020: p. 26(6), 710-719.
19. Choi, M.J., Kim, H., Nah, H. W., & Kang, D. W, *Digital therapeutics: emerging new therapy for neurologic deficits after stroke.* Journal of stroke, 2019: p. 21(3), 242.
20. Völter, C., Stöckmann, C., Schirmer, C., & Dazert, S, *Tablet-based telerehabilitation versus conventional face-to-face rehabilitation after cochlear implantation: prospective intervention pilot study.* JMIR Rehabilitation and Assistive Technologies, 2021: p. 8(1), e20405.
21. Pugliese, M., Ramsay, T., Johnson, D., & Dowlatshahi, D, *Mobile tablet-based therapies following stroke: A systematic scoping review of administrative methods and patient experiences.* PloS one, 2018: p. 13(1), e0191566.

22. Röhner, E., Mayfarth, A., Sternitzke, C., Layher, F., Scheidig, A., Groß, H. M., ... & Sander, K, *Mobile robot-based gait training after Total Hip Arthroplasty (THA) improves walking in biomechanical gait analysis.* Journal of Clinical Medicine, 2021: p. 10(11), 2416.
23. Behle, C.R., *Interventions for cognitive impairments and mental health by the means of virtual reality among stroke survivors*. 2020: (Master's thesis, University of Twente).
24. Mace, M., Rinne, P., Liardon, J. L., Uhomoibhi, C., Bentley, P., & Burdet, E, *Elasticity improves handgrip performance and user experience during visuomotor control.* Royal Society open science, 2017: p. 4(2), 160961.
25. Burns, S.P., Terblanche, M., Perea, J., Lillard, H., DeLaPena, C., Grinage, N., ... & Cox, E. E, *mHealth intervention applications for adults living with the effects of stroke: a scoping review.* Archives of Rehabilitation Research and Clinical Translation, 2021: p. 3(1), 100095.
26. Maggio, M.G., Latella, D., Maresca, G., Sciarrone, F., Manuli, A., Naro, A., ... & Calabrò, R. S, *Virtual reality and cognitive rehabilitation in people with stroke: an overview.* Journal of Neuroscience Nursing, 2019: p. 51(2), 101-105.
27. Pugliese, M., Ramsay, T., Shamloul, R., Mallet, K., Zakutney, L., Corbett, D., ... & Dowlatshahi, D, *RecoverNow: A mobile tablet-based therapy platform for early stroke rehabilitation.* PloS one, 2019: p. 14(1), e0210725.
28. Pugliese, M., Johnson, D., Dowlatshahi, D., & Ramsay, T, *Mobile tablet-based therapies following stroke: a systematic scoping review protocol of attempted interventions and the challenges encountered.* Systematic Reviews, 2017: p. 6, 1-7.
29. Pugliese, M.W., Wilson, K., Guerinet, J., Atkinson, K. M., Mallet, K. H., Shamloul, R., ... & Dowlatshahi, D, *Mobile Tablet-based Stroke Rehabilitation: Using mHealth Technology to Improve Access to Early Stroke Rehabilitation.* International Journal of Interactive Mobile Technologies, 2017: p. 11(1).
30. Marin, A., DeCaro, R., Schiloski, K., Elshaar, A. A., Dwyer, B., Vives-Rodriguez, A., ... & Budson, A, *Home-Based Electronic Cognitive Therapy in Patients With Alzheimer Disease: Feasibility Randomized Controlled Trial.* JMIR Formative Research, 2022: p. 6(9), e34450.
31. Sarfo, F.S., Ulasavets, U., Opare-Sem, O. K., & Ovbiagele, B, *Tele-rehabilitation after stroke: an updated systematic review of the literature.* Journal of stroke and cerebrovascular diseases, 2018: p. 27(9), 2306-2318.
32. Pugliese, M., *Mobile Tablet-Based Stroke Rehabilitation in the Acute Care Setting*. 2017, University of Ottawa: (Doctoral dissertation, Université d'Ottawa).
33. Benaim, C., et al., *Cognitive assessment scale for stroke patients (CASP): A multicentric validation study.* 2022. **65**(3): p. 101594.
34. Mahendran, R., et al., *The mini-mental state examination and other neuropsychological assessment tools for detecting cognitive decline*, in *Diet and Nutrition in Dementia and Cognitive Decline*. 2015, Elsevier. p. 1159-1174.
35. Julayanont, P. and Z.S.J.C.s.i.A.p.a. Nasreddine, *Montreal Cognitive Assessment (MoCA): concept and clinical review.* 2017: p. 139-195.
36. Benaim, C., et al., *The Cognitive Assessment scale for Stroke Patients (CASP) vs. MMSE and MoCA in non-aphasic hemispheric stroke patients.* 2015. **58**(2): p. 78-85.
37. Lancu, I. and A.J.H. Olmer, *The minimental state examination--an up-to-date review.* 2006. **145**(9): p. 687-90, 701.
38. Zeltzer, L.J.S.E., *Mini-Mental State Examination (MMSE).* 2020.