



Braincog-An Innovative Design for Cognitive Assessment in Cancer Survivors

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Received date: 07 July, 2022, Manuscript No. BMA-22-60284;

Editor assigned date: 11 July, 2022, PreQC No. BMA-22-60284 (PQ);

Reviewed date: 18 July, 2022, QC No. BMA-22-60284;

Revised date: 26 July, 2022, Manuscript No. BMA-22-60284 (R);

Published date: 04 August, 2022, DOI: 10.4172/Bma.1000510

Abstract

Cancer survivors encounter late or suppressed side effects due to cancer or cancer related treatment when they are diagnosed with primitive stage of disease. These consequences or complications worsen finitude of life, and alter morbidity and mortality rates. General, late and suppressed side effects in different cancer types (breast, colorectal, head and neck, lung and prostate cancer) due to different cancer treatments which include fatigue, bone loss, musculoskeletal pain, lymph edema, bowel dysfunction, cognitive dysfunction, dysphasia/GERD, neuropathy, cardiovascular disease, pulmonary dysfunction, endocrine disturbance (infertility, metabolic syndrome, vasomotor symptoms), dermatitis, mental health issues (anxiety, depression, body image concerns), oral health issues, sexual dysfunction, sleep apnea and urinary dysfunction.

Keywords: Cardiovascular disease, Cognitive dysfunction, Oral health issues

Introduction

Cancer survivors encounter late or suppressed side effects due to cancer or cancer related treatment when they are diagnosed with primitive stage of disease. These consequences or complications worsen finitude of life, and alter morbidity and mortality rates. General, late and suppressed side effects in different cancer types (breast, colorectal, head and neck, lung and prostate cancer) due to different cancer treatments which include fatigue, bone loss, musculoskeletal pain, lymph edema, bowel dysfunction, cognitive dysfunction, dysphasia/GERD, neuropathy, cardiovascular disease, pulmonary dysfunction, endocrine disturbance (infertility, metabolic syndrome, vasomotor symptoms), dermatitis, mental health issues (anxiety, depression, body image concerns), oral health issues, sexual dysfunction, sleep apnea and urinary dysfunction [1].

The impact of cancer treatments in various cancers including central nervous system cancers and other cancers lead to cognitive defects which is one of the major problem in cancer survivors. “Chemo fog” occurs due to chemo toxic effect of drugs and

modifiable trials been conducted for assessment of cognitive decline in cancer. It is found that cognitive decline may be due to diverse factors including genetic, psychological and physiological, socio-demographic factors and lifestyle. Conventional neuropsychological measures locate impairment and site of lesion in patients suffering from traumatic brain injury, conditions with moderate to severe neurological dysfunctions. Traditional objective measures seem to be doubtful in ruling out subtle positive changes. Hence, generating a purpose to develop technology based cognitive assessment in cancer survivors.

Traditional methods of cognitive rehabilitation have focused on specific physical training and compensatory techniques for cognitive deficits in cancer survivors to deal with cancer. Formerly, computer based or technology based cognitive rehabilitation that focused which has caused more impact and positive reinforcement on processing speed and memory [2].

With technology reaching its pinnacle, smart phones are used by majority of population. Hence there is a need to develop a more accurate, objective and easier way of assessing cognitive function in cancer survivors.

The present study took up the task of designing cognition assessment software in a game form for android mobile phones only. The novelty of this conception is this is the first time that an android application in the game form has been designed that would assess the cognitive levels in cancer survivors. The design conceived would be doctoring friendly, patient friendly, cost effective, would save time and assist to perform repeated assessments in normal individuals and cancer survivors. This application is a single game android application to assess different cognitive functions in cancer survivors.

Materials and Methods

Materials

This section describes the hardware, software and sample used to conduct this experiment.

Hardware

In this design, an android application will be developed using agile model which will update the errors after feedback from the user feedback will be taken. Graphics will be used to develop images and animation videos will be used for 3-D effects. Agile model includes registration, preparation of games followed by data analysis and results.

Software

In the android application, coding is converted into python language. The programme will run and final application will be made. The application designed will be suitable for android mobiles and to make it user-friendly, all the data related to each patient will be stored on Google cloud.

Methods

The application will be tested and validity and reliability of the application will be calculated post development on 84 normal

individuals of age group 35-45 years. Sample size was calculated using $n=2(Z+Z)^2 \cdot 2d^2$. After successful validation of the application, it will be used to assess cognitive impairment in cancer survivors.

Experimental Apparatus Design

Identification of modules: The first step for developing application is identification of different modules to be included in the android gaming application. These modules were identified by considering the authenticated users of the android gaming application.

The modules are as follows: Admin module has access of doctor users and number of patients. Doctor's module has access to view and update data of patients. User's module has access only to game (patients).

Application features

It aims to assess various cognitive functions of brain. Functions included in this game are executive/working memory, attention/concentration, verbal memory, visual memory, processing speed, reaction time, critical thinking, emotions, motor speed and fine motor control, reaction time analysis, episodic memory, remote memory, visual spatial ability & color recognition all of which are related to cognitive functions.

Results provide detailed knowledge about each function and will generate score. Analysis of game to make connections to users (subjects) mental strengths, weaknesses and cognitive patterns. It can be used in any condition which demonstrates cognitive impairment (Example: Degenerative conditions or in cases of head injury) [3].

Design of the application

All the instructions including audio clips, paragraphs, other hints and clues, basic guidelines, question and answer session will be provide multiple languages that can be opted before starting the game.

Description of the design of android application in detail

User is locked in a room and needs a password to unlock to start playing the game.

Concepts covered: Executive/working memory, attention/concentration, verbal memory, processing speed.

Description: Mission begins here as user is locked in a room and needs to unlock himself using the hint provided in the audio clip

Controlled Oral Word Association Test (COWAT): From audio clip provided as the hint to unlock from the room user have to keep note of certain words and related numbers. To identify the category of words (e.g., helpline number, hospital/ambulance number, pin code number, code to unlock, etc. where number will be limited to 6 digits).

One back test: Tries to put the code in implementation to unlock oneself from the room (Multiple attempts will reduce the score and give more accuracy).

For attention/concentration: To hear the audio clip, the pattern or password will be required to unlock the room.

For verbal memory, the audio will consist of different alphabets, words, symbols and numbers. Hence one will have to remember the appropriate password and details to proceed further.

Prior to the commencement

Prior to the commencement of the mission the participant has to memorize the instructions to continue with the game.

Concepts covered: Attention/concentration, verbal memory, visual memory, processing speed.

Description: Attention and concentration-A map of entire journey will be provided to the user to understand the path leading to his home.

Verbal memory: The instructions will be provided regarding the journey and obstacles user would face throughout the mission. Hence, user needs to understand and learn the instructions required. User has to memorize the instructions within certain time for calculation of processing speed.

Further challenges

The user passes through a jungle where tools will be provided for further challenges, one will have to select the tools and use appropriately.

Concepts covered: Visual memory, processing speed, reaction time.

Description: Visual memory the total number of tools will be 12 and user can choose any 6 of them information of tools will be coded into a puzzle with certain symbol identical to the tools so if puzzle is not solved then by looking and identifying the symbol, user can choose the tool. User can use maximum number of tools [4] in the post-forest challenge and user has to use remaining 2 tools in the further challenges. Hence, before user crosses the river 2 tools will be locked and after user crosses the jungle 2 tools will be unlocked
Critical

Thinking to choose/pick the tool: As mentioned above, user can choose any 6 tools from 12 tools. The result will be generated on decision making skills and how well those tools are used. Processing speed: Symbols need to be identified to select tools (i.e., symbol digit coding test)

Note: For higher accuracy, While passing through the jungle the tools information will be provide that alternate sides (i.e., left or right) after knowing the situation of what has to be done, the user can go back and choose 6 tools among the 12 tools in order to complete the journey. While performing the task, tool information will be provided on alternate sides of the screen, and while returning, the tool will be displayed on the opposite direction of what user visualized, here critical thinking/concentration/attention will be tested.

Decision making user

The user has to face animal and then cross the bridge either by road or water (Choose one option).

Concepts covered: Critical thinking test, reaction time, motor speed

Description: Critical thinking test-User has multiple ways to cross the post jungle challenge which will be a forest animal before crossing the bridge. The score will be allotted on how user faces the challenge.

Decision making user will have to choose the best path from two available paths i.e. by water or by land to cross the bridge or river to proceed. Motor speed and fine motor control a time limit will be set to

a specific seconds for the bridge to blast so that user will have to move fast and take decisions quickly.

Reaction time and fine motor control analysis (tap and response): The speed of the user to react to the surroundings; to solve the problems.

User notices a person

The user notices a person is being attacked by two criminals. A telephone booth is available to call for help. The user either chooses not to save victim and ignore the sight and runs away or help victim by calling for help. The criminals start attacking the user when they notice him calling ambulance & police for help to save the victim.

Concepts covered: Alertness, emotions (social devotion/helping nature), attention/concentration, decision making skills, visual spatial ability and color recognition, verbal memory, executive/working memory.

Description: Alertness and emotions (social devotion / helping nature) test it depends on the user if he/she opt to save the victim or ignore the crime scene. Here, the decision-making skills and the reaction time will be tested.

Concentration: Since multiple options are available, user needs to make quick decisions which are difficult as the criminal’s attention is shifted towards the user.

Decision making skills: User can either ignore the crime scene or help the victim by opting for emergency or ambulance help and the user also attempts to fight against criminals for self - defense.

Verbal memory and executive memory will be required to recall the audio clip information and call ambulance or emergency on telephone booth. For Visual memory & reaction time analysis to perform self-defense a gun will be provided at crime scene (dropped down on the road).

Visual spatial ability and color recognition: The background color and main prop color will be different. Example: The road color may be light grey and telephone booth, victim and the tools available will be in red color.

Reaction time of the user will be assessed by the speed of the criminals with which they will move towards user and the speed of the user during self defense will be traced. The distance and the time required for the criminal to reach the user will be calculated in kilometers. The user has to visually track the gun; pick it up and shoot the criminal in order to perform self defense before they attempt robbery and in sometime police approaches at the crime scene.

The user has to face criminals and perform self defense (Option to choose)

Concepts Covered: Reaction time analysis, motor speed.

Description: Reaction time analysis / motor speed will be tested while performing self defense. Here the ability of user to perform self defense will be assessed.

Critical thinking/motor speed: Pick up the gun for self defense or use the tool which was previously chosen (2 tools that are now unlocked and ready to use after crossing the jungle).

The user continues journey to his home

The user has to reach the location from where he/she had begun the journey

Concepts covered: Remote memory.

Description: Remote memory to recall map/location of home and complete the journey.

The user has to answer the questions which will be asked by the police about the whole journey

Concepts covered: Episodic memory, remote memory.

Description: Episodic memory the user has to recall the entire journey and answer the questions asked by the police (here the number of correct responses will be recorded; 3 attempts will be given to the user).

Remote memory: The user has to recall the journey.

PAL (Paired Association Learning) the response pattern will be compared and tracked down. The pattern and number of wrong attempts will alter the results.

Note- If first answer is correct to increase the level of complexity and accuracy the next question will be more difficult and complicated as compared to the previous one, and if first answer is wrong next question will have less complexity and the user will get three attempts for the same (Figure 1).

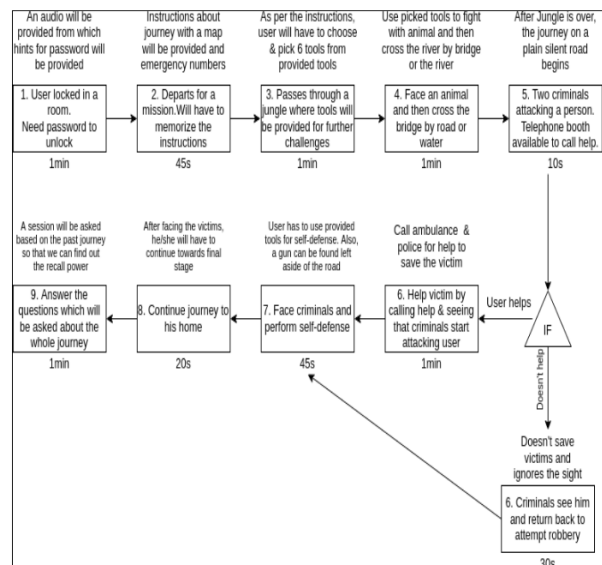


Figure 1: Design layout of the innovative android application for cognitive impairment.

Statistical Analysis

Descriptive statistics will be used to describe the study population at the baseline. The baseline data of the assessment tool will be calculated. The validity and reliability of the application will be tested using Cronbach’s alpha test. Further, cognitive impairments in homogenous cancer survivors will be assessed using the application.

Discussion

Cognition is the method used by the central nervous system to process information. It is the process of knowing and understanding through thought and senses which includes awareness, reasoning, judgment, intuition, memory and executive function. [5]

Chemotherapy induced cognitive impairment, also known as chemo brain or chemo fog is leading cause of cognitive function in cancer survivors. It is one among the common side effects due to chemotherapeutic agents like 5-fluorouracil, carmustine, cisplatin and cytarabine which is usually administered to treat various solid tumors mainly breast, lung, prostate and ovarian cancers. This cognitive side effect adversely affects quality of life. Chemotherapeutic drugs administered penetrate blood brain barrier can cause direct neurotoxic damage to central nervous system and lead to cognitive impairment due to injury to microglia, oligo dendrocytes, neural axons and subsequent demyelination, alterations in water content and neurotransmitter levels [6].

Study conducted by Collie, Darby and Maruffin 2001 examined the use of conventional neuropsychological and computerized cognitive testing for assessment of sports related cognitive deficits in sports settings. The conventional neuropsychological tests are designed for detection of gross cognitive impairments in a single assessment and not for identification of mild cognitive deficits on repeated assessment. A number of computerized cognitive tests and test batteries have been developed over past two decades. These tests offer major scientific and practical advantages over conventional tests.

Athanasios Papatthasiou and colleagues explored efficacy of central nervous system vital signs to detect cognitive dysfunction of multiple sclerosis which is a recently developed computerized cognitive screening battery which also has a Greek version. Brief core assessment of central nervous system vital signs contains 7 neuropsychological tests: Verbal and visual memory, finger tapping, symbol/digit coding, stroop word color association test, shifting attention and continuous performance test. Final results are automatically computed, expressing patient's performance on specific domains such as composite memory, processing speed, psychomotor speed, executive function, reaction time, complex attention and cognitive flexibility. [7,8]

The present study aims to develop an android gaming application which is user friendly and handy for physiotherapists and other medical professionals to assess cognitive function in normal individuals and cancer patients. The game designed has unique content and is created on basis of innovations of the author and the technical support from the team.

Using this android gaming application, mild cognitive impairments of following cognitive functions will be assessed: Executive/working memory, attention/concentration, verbal memory, visual memory, processing speed, reaction time, critical thinking, emotions, motor speed and fine motor control, reaction time analysis, episodic memory, remote memory, emotions, paired associated learning, visual spatial ability and color recognition.

This application will allow quick and repeated assessment of cognitive impairment. It will be an objective measure which will record minor or minimal cognitive deficits in cancer by playing a single game and will be cost effective. The instructions for the users will be available in multiple languages.

To access the android gaming application, the user (doctor) has to register and submit their and the hospital details. The application will strictly be used by trained professionals only and not the subjects. It will not have access to share the application directly without registration. The application designed will be available for free on the Google play store and consists of one single game.

The final results of the game assessment will be automatically computed and the results will be generated in portable document file format. The results displayed will include personal details of the subject, chief complaint, history of their presenting illness, any co morbidities and chemotherapeutic history. The results will be displayed in numerical value and in form of pie diagrams or graph as well. The reports of the subject's cognitive assessment will be stored in cloud storage and can be accessed only by the referred physician or physiotherapist. The admin of the application will have access only to the number of doctor users and patients and not the personal details of the individual.

The development of the designed gaming application is under process and once developed initially it will be tested on normal individuals; its validity and reliability will be calculated and the average of the normal values automated will be standardized for the particular age group. This application will be not exhaustive and will require 8-10 minutes for assessment of cognitive deficits in cancer survivors. The android gaming application is user friendly (for both doctors and subjects) [9].

Conclusion

Design of an innovative android gaming application for assessment of cognitive impairment in cancer patients. It is a multi-language android gaming application which will be objective measure to assess cognitive decline in cancer survivors. It consists of a single game to assess different cognitive functions and will assist to measure minor cognitive deficits and perform repeated detailed assessments in short duration of time. The android game developed is user friendly and cost effective. The development of the android application is under process and the implementation of the same on patients is awaited for final development.

The main strength of the study is that the application can be used in android mobile, it gives instructions in different languages, easily accessible anywhere by health professionals; can be used even in hospitalized patients; is user-friendly (both doctor and patient) and cost-effective. The limitation of this application is that it cannot be used in 1-phone Operating System (iOS).

Acknowledgement

We would like to express gratitude to Miss. Priyanka Khant (B Tech) and Team, Rajaram Bapu Institute of Technology, Islampur, Maharashtra, India for their technical intellectual suggestions for designing the android gaming application for cancer patients.

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