Assistive Technology for Neurological Disorders

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Abstract: The neurological disorders contribute to the world's largest cause of death or disability. This paper attempts to review various assistive technologies (AT) for the treatment of neurological disorders. These ATs tend to reduce the burden of the therapists and caretakers. They play a major role in boosting the self-confidence and help patients in achieving autonomy and independence.

Keywords: Assistive Technology, rehabilitation, AAC, Aphasia, Dementia.

1. Introduction

According to an estimation by WHO in 2006, neurological disorders (epilepsy, Alzheimer's disease and other dementias, Parkinson's disease, multiple sclerosis, migraine, stroke, etc.) account for 6.3% of the global DALYs (years of healthy life lost due to death or disability). The burden of neurological disorders has increased by 7.4 percent from 1990 to 2015 globally. These disorders caused 250.7 million DALYs in 2015. The total contribution of neuropsychiatric disorders by India is approximately 11.6% of the global burden of disease as stated by WHO (2008). World Alzheimer Report 2015[1] shows that 46.8 million people worldwide are living with dementia in 2015 and the number is expected to double every 20 years.

According to Monica DiLuca and Jes Olesen [6], the yearly cost of the treatment of 179 million people suffering from these disorders in Europe is about 800 billion euros as estimated in 2010. In 2010, the yearly household cost of caring for a person with dementia in India ranges between INR 45,600 to INR 2, 02,450 in urban areas and INR 20,300 to INR 66,025 in rural areas, the total expenditure of the country being 23,330 crores [20]. Owing to demographic changes and lesser mortality rate, the long-term burden of these disorders is likely to increase in future. These costs not only refer to "direct costs" but also acknowledge the "indirect costs" of these diseases. The direct costs include the cost of medication and treatment and the indirect costs pertain to the loss at work place like low incomes due to reduced efficiency which all attribute their cause to impairment due to these disorders [25]. The burden of these heavy expenditures poses a formidable socio-economic challenge for the healthcare sector. To overcome these challenges, there is a dire need for technological innovations and low-cost assistive interventions. The purpose of this paper is to review different assistive technologies used for the various kinds of neurological disorders.

2. Neurological Disorders

Some major neurological disorders are as follows:

a. **Aphasia**: It is a language impairment that might affect one or more aspects of communication. The patient suffering from aphasia might have a halting speech, difficulty in retrieving words and understanding speech or might find it hard to repeat words and phrases. Aphasia can be of many types based on the nature of impairment.

[1]https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf

Global aphasia is the most severe form of aphasia whose symptoms are limited understanding of spoken language and the most of the words spoken by the patient are not recognisable. Broca's aphasia (non-fluent) is characterised by halting and clumsy speech that takes a lot of effort. Also, the patient is not well versed in writing skills. In Wernicke's aphasia (fluent), the patient is unable to grasp the meaning of the spoken words but somehow manages to put together words and phrases that might seem irrelevant at the point. Anomic aphasia can be applied to patients who find it hard to retrieve words. Primary progressive aphasia (PPA) involves degradation of language skills over time. It is caused by neurodegenerative diseases like Alzheimer's disease or frontotemporal dementia.

b. **Dementia**: It is a syndrome that involves loss of memory and a decline in mental performance (reasoning ability, judgement, conceptual and language disorders). It can result from stroke, mental trauma or other injuries to the brain. The most common types of dementia are Alzheimer's disease (AD) (60-80%), vascular dementia (10% of cases), dementia with Lewy bodies (DLB), mixed dementia, Parkinson's disease, frontotemporal dementia (FTD), etc.

c. **Stroke**: It is the second largest cause of deaths in the world. It occurs due to interruption in the blood supply to the brain (ischemic stroke) or due to spilling of blood into the surrounding brain cells when a blood vessel bursts in the brain (haemorrhagic stroke).

d. **Multiple sclerosis**: It is a disorder in which the brain and/or spinal cord can be affected. Fatigue, bladder and bowel dysfunction, depression, weakness, pain, impairments of vision and balance as well as other limitations in dexterity and mobility. The patient tested positive for MS tends to suffer from frequent exertion and other communication related problems. The patients of MS have been observed to show reduced enthusiasm and participation in various disciplines of life like self-care, leisure and building and maintaining relationships. The statistics reveal that 70-80% of the patients suffer from unemployment five years after diagnosis.

2.1. What are Assistive Technologies?

A formal definition of assistive technology (AT) which is commonly used comes from the United States Legislation, The Assistive Technology Act of 1998, as amended (2004). The US legislation defines AT as:

"Any item, piece of equipment or product system whether acquired commercially off the shelf, modified, or customized that is used to increase, maintain or improve functional capabilities of individuals with disabilities."

ATs focussing on cognitive disorders can be divided into two types: ATs for cognition (ATC) and for augmentative and alternative communication (AAC).

2.2. ATs for Cognition (ATC)

ATC interventions aim at improving a set of functional activities which require cognitive skills like complex attention, executive reasoning, prospective memory or self-monitoring. These interventions can be extremely simple as an alarm that acts as a reminder for people to take care of their medication schedules and doctor's appointments or as complex as a PDA (Personal Digital Assistant) that helps facilitate organisational ability like Opportunity Knocks (PDA based navigation device).

They can help people with a variety of disabilities, including traumatic brain injuries, dementia, learning disabilities, aphasia or other neurological disorders. Examples of ATC are prospective memory aids (PMAs) and retrospective memory aids (RMAs). PMAs are context-aware aids that make use of artificial intelligence to determine if a particular guidance is necessary or not at the moment, thus help to remember future intentions (making and keeping appointments) in case the patient fails to do so. Some examples of PMAs are Memory glasses, MemoClip, etc. Memory Glasses help in reminding the patient in a timely manner of a situation that needs his attention but in a context-aware manner. Context-awareness is provided using computer-perception techniques that involve capturing visual images. It is highly accurate and also adaptable towards user's preferences. RMAs are devices that help the patient to retrieve episodic memory (the collection of past experiences that occurred at a particular time and place). An example of RMA is Microsoft's SenseCam, a device designed to capture photographs passively without the wearer's knowledge. The collected information when reviewed by the patient would help him to recollect past events that might have been forgotten.

Monitoring and managing health for patients with morbid cognitive disabilities is a tough task. These interventions help in early detection of disorders (preventative approach). Use of these interventions were found to reduce the formal care by an average of 50% fewer hospital visits, 11% less emergency room use and three fewer days of bed-care.

2.3. Alternative and Augmentative Communication (AAC)

As stated by ISAAC,

"AAC is a set of tools and strategies that an individual use to solve everyday communication challenges."

AAC interventions tend to enhance or augment an individual's capabilities. These devices enable the patients to verbally communicate their needs. AAC includes Speech Generating Devices (SGD), software programs and communication apps for efficient production of speech. SGDs consist of devices that provide an individual with speech impairment the ability to meet his functional speaking needs.

Design aspects of AACs need to consider clutter-free displays, multi-modality information (e.g., graphics, video, and audio), least number and complexity of decision making points, sequential information and reduced dependence on memory. The cognitive weight of the system should be reduced by designing an extremely simple, image based graphical interface. The icons and buttons on the screen should be large enough and highly contrasted for easy comprehension and there should be minimum eye candy for least distraction. The navigation should not be complex or highly hierarchical.

Factors to consider when exploring AAC:

- Selection of the right equipment: A SLP should be consulted while selecting the equipment for the impairment.
- Consideration of cost: The various costs taken into consideration are the maintenance, repair and replacement costs of AAC devices.
- Training and Support: Product training and technical support for the AAC device should be available.
- Requirements and specific needs of the patient.
- Portability, accessibility and durability of the device

3. Review of various Assistive Technologies:

Ruth B. Fink et al (2005) developed MossTalk Words (MTW), a computer assisted treatment that helps in word-retrieval and phonological difficulties faced by patients of aphasia. This software is multi-modular (Core Vocabulary, Multiple Choice Matching and Cued Naming modules), customisable as per user needs and contains an extensive vocabulary. Effectiveness of hierarchical cueing was investigated under the complete and partial supervision of the clinician for 6 chronic patients who were prompted to say the word using atmost 6 cues in a hierarchy. The results showed that clinicians preferred MTW for 79% of the patients. Two of the three patients made serious improvements from the naming exercises. The verb retrieval exercises showed significant progress on untrained words. (Trained: 35%-80%; untrained: 27%-60%). Some advantages of MossTalk include high user satisfaction, cost effectiveness, minimal clinician guidance, etc. Limitations observed were the less number and type of exercises available, extra aid required for software and hardware at home, high cost of early support and maintenance of computers. Also for the older generation, the computers still depict an unfamiliar and uncomfortable space. The future directions involve finding out the optimal extent of clinician supervision required for the best treatment.

Anna Kotteritzsh et al (2015) studied the Information and Communication Technologies (ICT) like Teleconsultations (Videoconferencing systems for therapeutic sessions), Teletherapy (Web based applications that don't require clinician supervision) and Teleassessment (collection and transmission of progress of patients) and their role in aphasia therapy. The paper was focussed on devising therapies from other disciplines of life to be corroborated in the treatment of the neurological disorders. Benefits of this technology are resolution of mobility issues and help generate timely reports that reflect the current state of the patient. Also these are equally effective as face-to-face therapy and help in building a better cognitive understanding. The technology improves the overall word output of the patient. It also enhances social interaction among older adults. Some demerits of this technology are extra burden on therapists and security issues pertaining to the sending of records to a remote location. Moreover, the data is not analysed digitally. In future, NFC (near field communication) tags and gesture-based systems could be used to train the patients. Sensors and tracking devices could also be incorporated as a trigger for the caregiver. Gamification is yet another feature that could improvise these softwares. To make the process of making and updating patient profiles totally automatic, user-modelling and ubiquitous computing are some of the available approaches that could be utilised. The ICTs must be accessible, useful and usable.

Paula Messamer et al (2016) designed an app BangaSpeak for aphasic clients and SLP. The approach of claims analysis has been used for procuring the needs of the user. An assumption about what could be kept in the design of the app that might be useful is called a claim. 90 claims (assumptions) were collected through patients, interview of SLPs, product

reviews for aphasia apps, ASHA website etc. on the basis of which the app was designed. BangaSpeak consists of a speech recognition feature and has therapy tasks like dialogue practice, personal narratives, oral reading of words and phrases, etc. The salient features are gamification (score, timing, feedback and rewards), simple interface, phonological, semantic and orthographic information of images and its ability to work in edit mode (for SLP) and presentation mode (for patient). Advantages of the app are hierarchical arrangement of cues, availability of hints in different modalities, encourages independence of the patient to work on exercises all by himself, gives greater emphasis on phrases used more often in day to day life, the content of exercises pre-selected by the patient and their answers already feeded into the system which results in increased interaction between the patient and his SLP. Due to this, the patient feels more interested in using the app on a regular basis. BangaSpeak helps in sentence production. Disadvantages are the presence of just a single hint button which is pre-selected by the clinician. It is yet not evidence-based and there is no concept of virtual therapist to model responses. As there is an absence of Virtual therapist, the patient can't imitate the facial model when the text is read aloud. The emphasis of the study is more on the process of claims approach rather than devising variety of exercises for the patient.

Ruth B. Fink et al (2008) talk about the intervention SentenceShaper (SSR). It is a computer program that allows the user to record spoken fragments that the intervention assembles accordingly and minimises the memory requirement for real-time speech. The narratives used in this study were obtained from Bartlett et al. 5 patients of chronic aphasia were asked to create functional narratives for 2 situations under 3 conditions: unaided (U), with SentenceShaper (SSR), Post-U (unaided after using SSR). The two ANELT situations were "The Lost Glove" and "The Broken Glove" situation. In totality 30 samples were obtained. The main parts of the SSR are an on/off button; when the user presses the off button, the recorded audio forms a shape in the work space that can further be dragged and placed to make a meaningful sentence. The unwanted shapes can be thrown into a trash hole and there is a provision for side buttons that play the pre-recorded pronouns, nouns, etc. SSR is evaluated using Correct Information Unit (CIU) count that pertains to the number of words that are accurate and relevant to the content of the picture/topic in each of the conditions. Scoring is done by segregating the narrative to obtain the number of CIU and Non-CIU counts. It was observed that all the participants had higher percent CIU in The SSR condition. In 4 out of 5 participants, the progress was more than 20% in the case of SSR. The study validates the effectiveness of SentenceShaper. The main reasons of its effectiveness lie in its inbuilt extensive support for words and also the absence of any kind of pressure of the clock ticking over the head which results in a rich content that makes much more sense.

Christine Estes et al (2011) investigate the functional and linguistic effects of Dragon NaturallySpeaking, a Voice Recognition Software (VRS) for written communication. It is a continuous dictation program intended for the patients of chronic aphasia. A patient can dictate upto 160 words per minute. The software is trained in a manner that it understands and picks up the pattern of the patient's voice and as the user uses the software regularly, the written content improves gradually. The study is based on the experiments conducted on a 65 year old woman with conduction aphasia. Initially to obtain the current status of the patient, she was subjected to two tests BDAE and BNT. Results of the tests revealed that her oral language skills were better than her written skills; hence she was the appropriate choice for VRS. She was then tested for elementary knowledge of the computer skills. After getting a satisfactory result, she was trained with Dragon NaturallySpeaking for 10 hour long sessions. The overall structure of the tests was based on A-B-A-C design (A: baseline testing, B: initial treatment, A: reassessment, C: Transfer) to determine if the participant could generate email using VRS and communicate via the internet. The results showed independence of participants in the use of program, increased accuracy of dictation from 42% to 98%, increase in the detection and correction of errors from 65% to 100%. The performance using the software was far better than the written description. The study showed that with persistent use of the VRS, it could fill the void of writing ability to generate functional content. It might give benefits to the patient until long after the period of treatment is over depending upon the frequency and its habitual use. The demerits are the absence of ample evidence to show the relevance of VRS in the natural environment. The lack of enthusiasm in introducing a new software can be an impediment to its success.

Marjorie Nicholas et al (2011) explore C-Speak Aphasia (CSA), a computer program that is picture-based for patients with non-fluent aphasia. Using this program, the patients create messages by learning to select icons. The messages are spoken aloud by the speech synthesizer. Also, there are provisions for assistance with conversing on the phone, writing, etc. In the study, 5 tasks were given to patients to be done under 2 conditions: using CSA ("on-computer") and not using CSA ("off-computer"). The tasks required the patient to learn the production of statements, the art of communicating over the phone and via email using CSA. A treatment period was of 6 months at the rate of 2-hour long sessions. The results showed that 4 participants showed greater improvements in "on-computer" condition than their "off-computer" conditions. 2 participants showed moderate improvement while 4 participants showed minimal or no improvement. The participants with the same baseline profiles (auditory comprehension, semantic knowledge and non-verbal executive functioning) didn't respond positively to the treatment. Thus, it was concluded that non-verbal executive functioning has greater importance than language skills. The aspect that needs to be explored in future is the understanding of past, present and future events so that they could be depicted through icons or pictures.

Jaime B. Lee et al (2008) describe AphasiaScripts software, a computerized therapy program that makes use of an animated agent (virtual therapist) to practice personalized conversational scripts. The software is based on the notion that repeated practice over a definite script leads to mapping of stimuli which could make the responses almost automatic given the environment.is similar in nature. Merits of the software consist of provision for pause time between sentences and the total time allocation between utterances to be adjusted according to the user. Other merits are that the player has control over his own sessions, they can plan and track their practice with a visual timer, the interface is simple, increased patient-clinician interaction for script development, the length and content of script are decided as per the relevance and need of the patient and is drafted by the clinician. The clinician takes into consideration the word type and grammatical complexity along with selection of vocabulary. The study highlights and elevates the role of the clinician. Automatization of script is provided by the software itself, thus saving the time and labour of the therapist. Also there is a drastic improvement in confidence and social interaction on the part of the patient. The demerit is that the script writing is a tedious task for the clinician and even during self-practice by the patients, the involvement of clinician is needed to a large extent.

Csaba Daniel et al (2009) explore an innovative therapy program, Virtual ELA (Everyday Life Activities) - House for the rehabilitation of patients of cognitive neuropsychological disorders. The virtual world is based on computer simulation that imitates real scenarios of everyday life and users

interact via avatars. There are three types of exercises: Discovery (aim: learning vocabulary), Structured Discovery (aim: production of response) and Memory (aim: Retention of memory) tasks. The program is currently available in German and English languages. The future direction aims for introducing customisability to user needs that entails developing a program that caters specifically to the cognitive needs of the patient and also extending Virtual Environment over the internet with addition of more exercise types. Another prospective field could be the possibility of entering the VE with the therapist and other fellow patients interacting with each other at the same time.

Alberto Abada et al (2012) describe a web-based platform VITHEA (Virtual Therapist for Aphasia treatment) that helps the patients in recalling details of a picture or photo. It makes use of the ASR (Automatic Speech Recognition) technology with the help of a virtual animated character. The corpus on which the study has been conducted is a series of nomination tests of various native speakers of Portugal called the Aphasia Portuguese Speech (APS). The corpus is bifurcated into APS-I and APS-II consisting of 1004 and 850 as total extracted speech segments of 8 patients of aphasia each in smaller and larger rooms respectively. The WNS (Word Naming Score: ratio of correct word detections to the total number of words) using VITHEA is calculated and compared with manual WNS to measure its efficacy. VITHEA has been found equally effective as its manual counterpart. The advantages of the system are its simple and accessible interface and longer hours of intense, repeated and inexpensive therapy due to computer delivery of simulation. It provides a way to track the progress of the patients. Future possibilities indicate the exploration of supervised and unsupervised dimensions of the module. It would also extend its adaptability for other types of speech disorders.

W. Mieke E.Van De Sandt-Koenderman et al (2006) investigate the efficiency of TouchSpeak (TS), a computerized communication aid that implements a scenario-oriented approach. It requires the user to build his vocabulary with personally relevant items (photographs, words, sentences, etc.) These items pointed by buttons are clicked and the hierarchical system generates a message which is spoken out by the computer or displayed on the screen. The study was conducted in two phases taking into consideration 34 patients of aphasia. Out of these, 94 % (32) patients could successfully complete phase I which was training patients to improve their ability to navigate. Phase II which focussed on building one's personal vocabulary and its usage was completed by 26 patients (76%) successfully. 17 patients finally decided to use TS after completion of phase II and only 12 patients could be interviewed for 3 years follow-up. 2 of them were still using TS. The use of TS highly benefits the stroke patients with severe aphasia. One of the major advantages of TS is that it boosts the self-esteem of the patient as he feels in-charge of building his own hierarchical vocabulary by interacting with his caregiver who plays a significant role in the process. It plays an important role in day to day life and is general in nature related to everyday communication. The disadvantage could be the regular need to update the system according to the changing needs of the patient. Also the study had no control group (who were deprived of TS training) against which the results could be compared and better deductions could be made.

Lefkos B. Aftonomos et al (1997) introduce Lingraphica System (LG), software that has many icons each of which represents an item of the linguistic category (nouns, verbs, adjectives, prepositions, etc.). It assesses whether a patient is able to resume his therapy after a break. A total of 23 patients were treated at 2 sites (VMCA and centre site). 3 patients who had been taking the treatment long enough were treated at VMCA site and the other 20 at centre site. The therapy constituted of using the LG system. At the VMCA site, the first two patients received one hour of individualised therapy and another one hour together with each other. The third patient at that site was subjected to one hour of individualised therapy with the clinician. After 40 hours of therapy it was found that there was a significant improvement by patients at both sites. The condition which provided maximum benefit was that of the patient working on the system under supervision in the clinic also using it beyond the walls of the clinic in between sessions and in their leisure time. It has the collection of therapeutic resources in various modalities. The LG system is quite generic for all types of patients of aphasia and is flexible, interactive and highly motivational therapy.

Kimberly Tee et al (2005) describe VERA (Visually Enhanced Recipe Application), an application that makes use of the residual ability of the aphasia patient and helps him to cook step-by-step by providing visual representation of objects. It also displays audio and text for the ease of the user. The demerits of the application were the dissatisfactory audio quality and the tablet on which the application was run was pen-based and not touch-based. The patient was unaware about his performance. The merit was that a possible learning effect was seen. Further expectations involve the development of a compiler that could convert the textual recipe into visual instructions.

Suzanne Doesborgh et al (2010) investigate the effect of Multicue, a computer program that encourages the user to discover the right kind of cue for him independently by trying and testing it repeatedly. Not being a fixed approach, it has effects on untrained words as well. For the experiment, the patients were categorised into experimental (9) and control groups (10). The experimental group was specifically required to use only Multicue for 10-11 hours of treatment that stretched over a period of two months whereas no treatment was allowed for the control group. There was a provision of four types of cues like cues for word meaning, etc. Multicue provides therapy in the form of pictures shown to the patients and they were asked to use cues that were activated one by one with each passing session and during the last session, all the types of cues were at the disposal of the patient. In this manner, they would be able to identify the type of cue with which they are comfortable and find most helpful. The merits associated with Multicue are that it encourages the patient to use therapy even under partial supervision. It restores the long lost self-esteem of the patient. Also it relieves the patient of any kind of pressure to complete the therapy in a given time. The disadvantage of such a program is that it may prove way too complex with people having poor cognitive skills. In addition to that, it shows no improvement on the speech of the patient. The future studies need to confirm if further intensive treatments using Multicue could lead to better results.

Zelai S´aenz de Urturi Breton et al (2012) provide detailed description of KiMentia, a tool that helps improve the cognitive impairments and physical movements (using Microsoft's Kinect sensor) at the same time for the patients of dementia. The tasks are arranged in the form of images on the screen. The user selects the correct response by moving his hand over the image. The hand movement is captured and detected by Kinect and the response and other details get passed on to the database that is further used to determine the progress of the patient. The tool was tested by a panel of 5 field experts who were asked a set of questions each and they were required to answer them on a scale of 5 points ranging between extreme disagreement (0) to total agreement (5). The result was found to be positive as inferred from the opinion of the experts. The therapy also focuses on user motivation by indulging him in physical exercises. The pros of KiMentia are the flexibility in its usage as the camera can be adjusted to suit patient's convenience. The patient is free of remembering the position and working of the buttons on the remote as a controller is

being used. The use of cables has been eliminated too. This tool can be extended for other types of disorders in future.

Samuel Benveniste et al (2010) elaborate on the design and details of MINWii, a video game that has therapeutic and renarcissization effects (Music Therapy) on the patients of Alzheimer and Dementia. Renarcissization is the process of reviving the lost self-confidence of the demented patients. Wiimote can be used with MINWii to play or make changes to the stored songs for the older generation. The therapy consisted of patients gathering in a room once a week in a group of 3 or 4 and using Wiimote to play the songs of their choice. They were helped by the staff members when they faced any problem. It reduces the burden and guilt of the caregivers for not giving ample time towards the care of the patients. It is cost-effective and has a simple, graphical interface. It doesn't judge the patient (scores, etc.) in any manner and doesn't compel the user to make decisions (uses Wiimote on which all the buttons do exactly the same task). It is highly flexible in its level of difficulty and hence is suitable for a variety of audience besides the patients of dementia. It can be comfortably used by anyone even if the person has no previous experience related to music.

Azrulhizam Shapi'I et al (2014) propose Rehabilitation Gaming System (RGS), a framework which could be used to design rehabilitation for patients suffering from TBI (Traumatic Brain Injury) and stroke in a gaming format. It is made up of four basic components: condition (refers to assessing the needs of the user), process, activity and outcome. The merits are that it is web-based, cost-effective, feasible, textless and highly unsupervised. It motivates the patient through its personalised gaming experience.

K Sureshkumar et al (2015) describe Care for Stroke, a web-based intervention for stroke patients to be used on smartphones. Data was gathered to know the expectations of people from a rehabilitation intervention through structured surveys, interviews and expert guidance. The data was further incorporated to design the intervention that consists of five sections involving videos related to stroke information, home based exercises, functional skills training, activities of daily living and assistive devices. It is portable, accessible, cost-efficient and keeps a check on the patient's progress. Most of the content of the intervention is preferably of the audio or visual form and was developed keeping in mind the needs of the stroke patients, their caregivers and also the suggestions of the experts.

Debbie Rand et al (2015) explore the effectiveness of Rehab-let, a protocol used for personalised training that utilizes iPad gaming applications that aids upper-arm and finger movements for treatment of impaired dexterity after stroke. It presents a comparison between conventional therapy GRASP (Graded Repetitive Arm Supplementary Program) and therapy through these apps. Training with Rehab-let is time and cost efficient, it offers a wide variety of apps to choose from, possible to measure the progress quantifiably and they are less boring and much more motivating. It encourages the patient to take responsibility for his improvement, thus giving a boost to their self-confidence.

Kurt L. Johnson et al (2009) studies the effectiveness and prevalence of cognitive aids and strategies adopted by the patients of multiple sclerosis. It also examines the needs of the patients for AT that are not yet fulfilled by the existing ATs. A study was conducted on 1063 patients of MS in Washington State. The participants were asked to fill a survey which had a variety of questions on a number of topics like demographics, psychosocial, functional or disease specific characteristics. A version of EDSS was used to measure the extent of mobility of the patient. An instrument that made use of graphic images with related text was used to assess the subtype of MS. MS was categorised into relapsing remitting, primary progressive, progressive relapsing and secondary progressive. To measure the extent and prevalence of ATs, the authors prepared a questionnaire consisting of 11 questions which had to be answered in terms of usage of ATs, ranging from "never" to "always". To measure the total fatigue, Modified Impact Fatigue Scale was used which has 21 items and a 5-point Likert scale ranging from 0(never) to 4(always). A shorter version of the CES-D (Centre for Epidemiologic Studies Depression Scale) was used to test depression. The intensity of pain was tested by asking the patients to indicate it on a scale of 0 to 10 for the last week. The data collected from the surveys was analysed using regression modelling to identify the factors that play a significant role in the prevalence of ATs. The multivariate model was built on the factors mentioned above like demographic, psychosocial, etc. The results reflect that memory strategies was used by the maximum number of participants (70.2%), followed by walking aids (50.7%) and electronic memory aids (41.6%). The significant ATs are Mobility aids (37%), home modifications (38%) and bathroom aids (37%). The ATs with less percentage of respondents were vehicle aids, cooking aids, communication and computer access aids. Despite the remarkable and descriptive results of the study, it had mainly two limitations. The sample was exclusively from a specific geographical domain and may represent biasness. Also the rate of response was extremely low which indicates the inaccuracy of these estimates.

Eric Dishman et al (2007) reviews the latest research works and their challenges. ETAC (Everyday Technologies for Alzheimer's Care) was established with the objective of investigating the potential of ICTs for the diagnosis of disease, tracking their progression, its treatment and lessening the burden of the caregiver. The current domain of disease diagnosis is limited to the two dimensional pen and paper test. The demerit of such tests is the difficulty to interpret the findings and also its inability to clearly demarcate the various types of aphasia. For this, researchers are exploring VR (Virtual Technology) to measure the ability to process and interpret visual information about where objects are in space (visuospatial). This technology is more confirmatory and less troublesome. Vandenberg shape comparison test is one of the two classic paradigms in which the images of objects are rotated mentally in 3D, manipulated physically and the comparison is made to match a standard shape. Another test which is more common is Morris water maza that uses shutter glasses for alternate and rapid occlusion of eyes and also VR machines. In the field of music technologies, Hyperscore is a computer application that has proved to be of immense help to patients of AD in composing their own music and refining their motor skills to interact with the application. For tracking the progression of the disease and spot any anomalous pattern in the behaviour of the patient that might indicate dementia, monitoring systems like wireless audiovisual networks and pocket personal computer (PocketBuddy) are used. These technologies are available within a range of varying intrusiveness to choose from. Some capture all the information while others only record the information for which the data has been entered. Some of the advantages beside personal welfare are the uninterrupted monitoring of the patient to give reminders to take prescribed pills in a timely manner, gathering evidences that show signs of dementia. The overall safety is ensured by these. The disadvantages are poor mapping (difficulty in getting the precise location of the participant), false alarms due to interference by wireless devices and the large amount of data that needs to be reviewed manually. MEG/EEG based systems are used to measure activity of the brain to help tailor cognitive training.

Donna Jo Blake et al (2002) presented a detailed description of assistive technologies for the people suffering from multiple sclerosis. In addition to that, other specific areas that were reviewed in this study are- the opportunities of funding for these ATs, limitations of activities and impairments that the patients of MS experience and determining different

low-tech and high-tech technologies that could be used by the patients. Extensive literature survey has been done to gather facts and figures. The effectiveness and impact of different ATs along with health dimensions were discussed based on the WHO common 'health language'. Impairments consisting of primarily loss of vision, hearing loss, vertigo and dizziness etc. were considered as a result of brain and spinal cord involvement. Emphasis was also laid over the quality of life for persons with multiple sclerosis and how the usage of several assistive technologies could lead to improvement of patient's health as well as restoring the personal, environmental and social factors of their life. Highlights of the study were the need to add "service" component to the standard definition of assistive technology to ensure that the performance of AT would be measured once it has been recommended. The surveys studied in this paper didn't provide sufficient information related to the cost benefit analysis of AT, measuring the outcomes along with adequate assessment procedures. Availability of the devices had been taken into account and various strategies to make the daily life activities of the patients easier were discussed. Factors such as limited marketing, lack of information about the products that could be used and preferences of people were primarily determined as reasons because of which many available ATs were overlooked. The best device to be used by the patients was described as one with which the patients were comfortable and which could adjust itself according to their disabilities. The diverse ways to obtain funding for ATs was also considered an important factor and methods have been suggested for that.

4. Future Work

According to 2001 census, only 12.8% people of India have listed English as their first language. Currently there is an absence of any kind of computer-based assistive technology for the neurological patients who have Hindi or any other regional languages as their first language. As a result, most of them are deprived of an essential tool which could help them in the early diagnosis of the disease, tracking its progression or providing multi-modal interactive therapies for self-practice and evaluation beyond the clinic. They are devoid of these inexpensive and effective technologies that could be even used without the direct supervision of the therapist at all times. The literature survey shows evidences of interventions that have successfully helped the patients to recover with its use even after the traditional methods of therapy were completed. The future work demands the development of such technologies in the form of web applications, Android or iOS apps whose interface is totally in Hindi or regional languages. The multimedia content should be maximised so that the patients could easily grasp information and show significant signs of recovery. The authors will be focussing on the development of such technologies in any one of the popular regional languages in the future.

5. Conclusion

These disorders degrade the life of the patient to a large extent and are responsible for their dependency and incapacity. Also, they impose a substantial burden on their caretakers. Thus, the assistive technologies play a central role to obviate the need for institutional care in the long run and have the potential to bring a drastic improvement in the quality of life of the patient. They not only make the patient independent to a certain extent but also restore his dignity and self-confidence that generally take a back seat after the onset of the disease. They are integral to achieve an adequate frequency of the training required in the treatment of these disorders.

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