Technology for Post-Stroke Cognitive Rehabilitation

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***Abstract*—Stroke is a major cause of disability worldwide. Cognitive rehabilitation is a must for many stroke survivors. Due to the specificity of the cognitive impairment, in terms of affected cognitive area and quantification of the specific deficit, the rehabilitation intervention has to be individually tailored in content and quantity, and it must be adapted to the functional and energetical restant of the patient, for each session. The intervention can be a no-tech, low-tech, medium-tech or high-tech one. The clinician psychologist must choose and adapt the appropriate technology to be used for each patient, depending on the cognitive impairment (in terms of cognition area and severity), as well as on one's personality and motivation, general attitude towards technology, expectations for one's future functioning and quality of life.**

***Index Terms*—cognitive rehabilitation, rehabilitation technology**

I. Introduction

Stroke, otherwise known as cerebral vascular accident (CVA), is a severe cause of disability. Stroke effects upon human body functionality (stroke impairing both peripheral and central nervous system activity, including superior cerebral functions) include numbness, weakness – lack of muscle force and control, often on one side, loss of balance, loss of movement coordination, confusion, memory problems, decreased mental ability, vision problems, slurred speech, distractibility, impaired judgment, dizziness and severe headache. The effects range from very mild to extremely severe. This will depend on the severity and the location of the stroke.

While cognitive decline may continue post stroke, approximately 16-20% of patients with cognitive impairment improve. Most improvements occur in the first 3 months but recovery may continue for at least the first year post stroke. Clumming *et al*. notes that "at one year post stroke, a majority of patients still had attention deficits, while deficits in language and memory were more likely to have resolved" [1].

Cognitive rehabilitation. Cognitive rehabilitation offers retraining in the ability to think, use judgment and make decisions. The focus is on correcting deficits in memory, concentration and attention, perception, learning, planning, sequencing and judgment. The goals of cognitive rehabilitation are to enhance the person's capacity to process and interpret information and to improve the person's ability to function in all aspects of family and community life. In order to do that we may use all kind of techniques, from low tech, using pencil-paper notes or recorded notes and so on, until high tech, like computer assisted training for cognition or global positioning systems or even, applying adapted software programs.

Professional literature indicates that, in some cases, non-pharmacological techniques of cognitive stimulation, such as: standard therapies (behavioral therapy, orientation in reality, validation therapy and reminiscence therapy) and/or alternative therapies (art therapy, melotherapy, occupational therapy, complementary therapies, aromatherapy and multisensory stimulation) may determine an improvement of symptoms just as efficient as pharmacological intervention. Thus, it is

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widely recognized these should be used, in best practice, as first line approach [2].

These therapeutic techniques, encompassing a wide range of enjoyable activities, stimulate attention and concentration, thinking and memory.

Technology must accommodate a certain methodology. The therapist must prepare the physical environment, in order to create the appropriate atmosphere and to bring into the attention of the subject the appropriate triggers. The subjects must feel comfortable, safe and must enjoy the staying. The cognitive rehabilitation intervention is an active and dynamic approach. The subject is active participant in the therapeutical process, and the process itself keeps changing, to adapt the content and the approach method to the cognitive and emotional status of the subject, in real time. Interventions for cognitive rehabilitation are broadly classified as:

1. direct remediation/cognitive skill training
2. compensatory strategy.

These techniques aim to reinforce, strengthen or re-establish previously learned patterns or behavior; or, to establish new patterns of cognitive activity trough internal/external compensatory cognitive mechanism for impaired neurological system and also to enable persons to adapt to their cognitive disability.

As it is seen in Fig. 1, a certain method requires certain technology. One specific domain of post stroke cognitive rehabilitation is represented by the increasingly used reminiscence therapy.

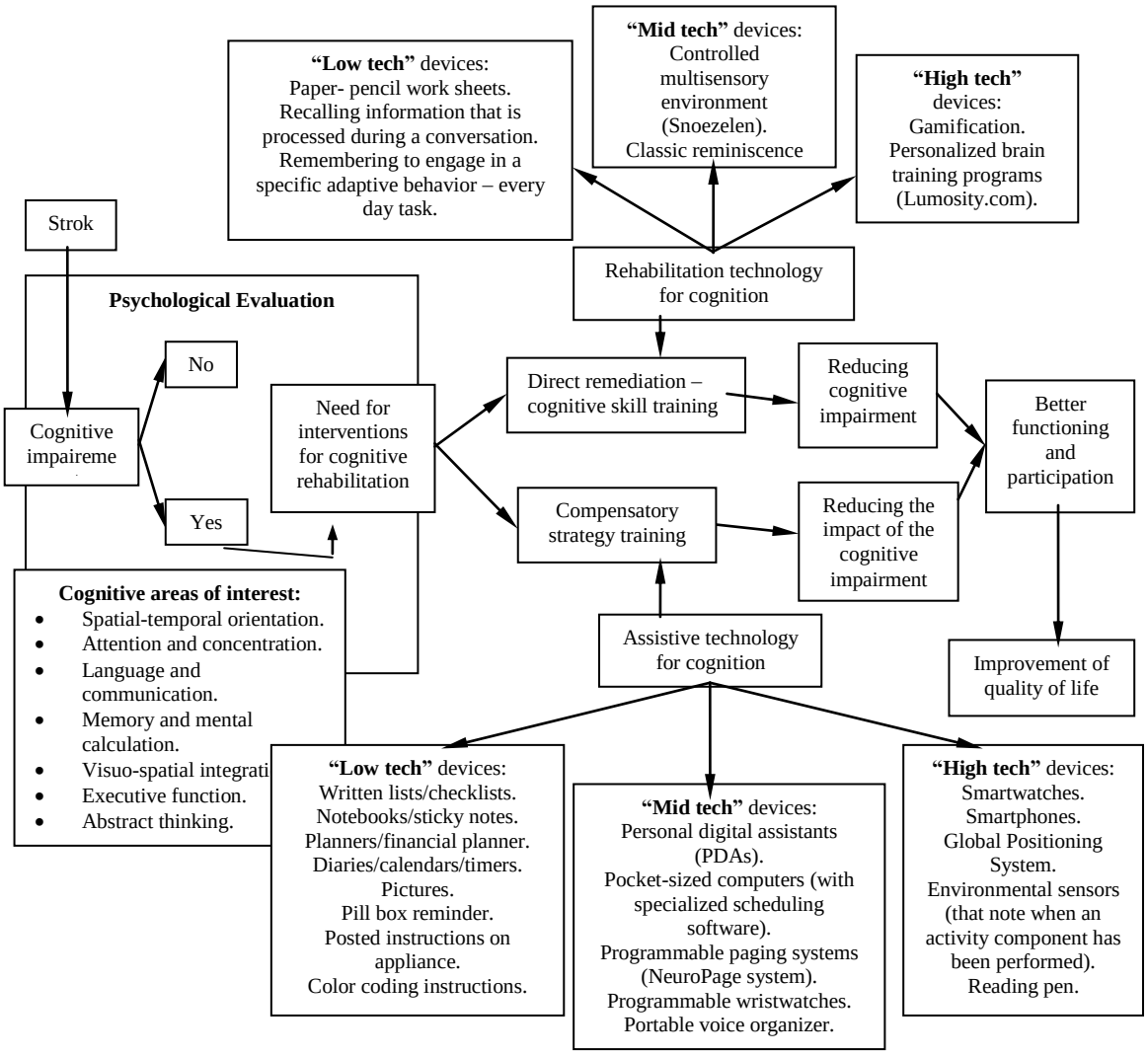

Fig. 1. Rationale for choosing the appropriate technology for cognitive assistance and rehabilitation for stroke patients.

Reminiscence Therapy is a Rehabilitation Medicine approach, not an assistive technique or a simple leisure activity, and for sure, it must not be confused with "living in the past".

Technology used in reminiscence therapy should involve the triggers and the technology needed to collect and organize them, the techniques to approach the triggers, the techniques and technology used to approach and direct the subject in the process of reminiscence and the techniques to evaluate the results of the RT session and of the RT programme.

In order to have a good therapy rehabilitation plan we should be able to answer at the following questions:

What to use? This aspect refers to the triggers, their degree of complexity, organizing and storing them.

How to use? This aspect refers to the procedure we need to perform in order to administer the trigger to the subject, in order to reach the purpose of the therapeutical approach, in terms of cost efficiency.

Depending on the nature of the trigger, we can **classify the triggers** in the following categories:

- Triggers addressing the sensory memory:
  - Addressing sight: from a natural and/or anthropic scenery to recorded images and movies of objects, people and places important for one's personal and contextual history.
  - Addressing hearing: words, laughs, other sounds, music, on specific rhythms, adapted to the person.
  - Addressing smell and taste: perfumes, flavors, food, beverages with specific connection to one's history.
  - Addressing touching: different objects and materials with specific connection to one's history.
- Triggers addressing ability memory and active performance:
  - Words, specific material used in making conversation, giving advices, personal log.
  - Music for dancing.
  - Playing reminiscence theater plays.
  - Performing professional activities, hobby crafts.

A multisensory trigger approach proves beneficial [3]. Technologies that support reminiscence tend to focus on helping people manipulate and capture information. The value of photos as tools for reminiscing has led to a number of software systems [4], [5] or special devices [6].

Some technology addresses specifically the communication between the subject and his beloved ones (HomeTouch, at: http://www.myhometouch.com), or provides memory triggers to the subject (as ‚Pensieve" soft, et: http://pensieve.cornellhci.org/), while other address the need to rapidly store and access the triggers ("Historical Scrapbook" at: http://www.alzproducts.co.uk/1910s-1920s-1930s-1950s-1960s-1970s-scrapbook-robert-opie.html), others aims to improve emotional and physical wellbeing altogether (old dance music records), while others promote memory training and learning, as well as improving the speed of reaction and the connection with the present (brain games, theater play roles, active involvement of the person with MCD and ED in present day life by soliciting help in house activities, craft activities and advices from someones own lifelong experience) [7].

It has been noticed that reminiscence serves a number of positive functions throughout a person's life, including maintaining relationships, working through current situatons [8], [9] and accepting the past [5].

Therapeutical purposes of RT can be: reducing social isolation and improving social participation, offering an enjoyable, stimulating activity, promoting intergenerational communication, strengthening the family bonds, promoting self esteem. RT outcomes include: mood improvement, cognition improvement (focused attention, memory), behavior improvement for the subject, increase in the quality of life for the informal caregiver (the family) and more cost efficiency for the formal caregivers [10]. In terms of usability: the users enjoy using high tech devices, those make them feel empowered, the systems improve participation and engagement. Personalized items are especially appreciated.

Cognitive skill training – Cognitive Enhancement Therapy (CET) is a perform-based, comprehensive, developmental approach to the rehabilitation of social, cognitive and neuro-cognitive deficits. Participants work at recovery through structured group and computer exercises.

There are 3 basic components in CET: computer exercises to enhance cognitive skills, a psycho-educational group where interactive work is done through lectures, homework and group exercises and 1-on-1 coaching. This understanding facilitates a personal process of adjusting to disability and to help participants eventually become more socialized into meaningful adult roles that they identify as goals in their recovery plan [11].

Compensatory strategies may have restorative effects at certain times. Some cognitive rehabilitation programs rely on a single strategy (computer-assisted cognitive training), while others use an integrated or interdisciplinary approach [12].

The psycho-educational interventions on the specific individual and on his family, together with the supportive therapy or other therapeutic procedures deemed to be necessary for each case make up the type of multimodal therapy with a multidisciplinary approach [13].

The therapeutic team includes: the medical rehabilitation physician, the physical therapist, the aphasiologist/speech pathologist, the clinician psychologist, the occupational therapist, the physiotherapist, the prosthesis therapist, the neurophysiologist, the recreational therapist, the vocational consultant, the biologist, the architect, the medical assistant, the stretcher bearer, the auxiliary personnel.

There are different healthcare professionals involved in cognitive rehabilitation after stroke. Cognitive rehabilitation may be performed by an occupational therapist, physical therapist, speech/language pathologist, or a physician.

II. Objective of the Study

The aim of the study is to assess the practical value of two different approaches of cognitive rehabilitation for stroke patients: the individually tailored intervention versus a general protocol for cognitive optimization. Hereby the investigators present estimative results of the individually tailored approach.

III. Experimental Design

Two hundred patients undergoing stroke rehabilitation programs have been enrolled in the study, in the last two years. The inclusion criteria were: subacute or chronic stroke, mild to moderate cognitive impairment, mild to

moderate expressive aphasia, no receptive aphasia, maintained learning ability.

Following the initial psychological evaluation, the clinician psychologist decided the appropriate technology for assistance and cognitive training, considering the area of deficit, the patient's own resources, as well as the specific conditions offered by the rehabilitation environment. (Fig. 1)

The intervention program consisted of 10 sessions, 1 session per day, of personalized training with paper-pencil worksheets (Syllable Clock, anagrams, integrams, digit span series) and brain training games (Lumosity personalized training program, computerized attention games, brain optimization computer application). The cognitive status of the patients was assessed through a neuropsychological standardized evaluation at T0 (before the first session) and at T1 (after the tenth session). The outcome measures are:

a. the scores of the psychological evaluation: Mini Mental State Evaluation Score, Wechsler Memory Scale Score, Clock Drawing Test Score, Yerkes Cubes Score.

b. the progress of the time spent by the subject for solving different cognitive tasks: Yerkes Cubes Time, brain training specific programs and applications. Number Search Game and Brain Optimizer daily training program – application developed by Studio39 (developers.studio39@gmail.com) has been used for these approach [14].

IV. Estimative Results

Personalized cognitive stimulation therapy proved to be very efficient for training cognitive abilities; one of the outcome measures was the improvement of the ability to perform a specific task, involving a specific cognitive domain – the domain which was subjected to the cognitive training.

Increased work performance and decreased time required for solving the assigned work tasks were observed. Halving of working times of attention and concentration short and simple computer games has been observed for most of the subjects. The statistical analyze will be performed by applying specific non-parametric tests.

V. Discussion

Rehabilitation technology refers to the systematic application of technologies, engineering methodologies and scientific principles to meet the needs of and to address the barriers confronted by individuals with disabilities, in order to enhance the rehabilitation and to provide an optimal degree of independent living. The term refers to rehabilitation engineering, assistive technology devices and assistive technology services.

A large body of literature supports the efficacy and effectiveness of external aids for improving independence and life participation for people with cognitive impairments. External aids have been called "cognitive orthoses", "cognitive prosthetics", "assistive technology" (Cole, 1999) [15] and more recently assistive technology for cognition (ATC al. 2004) [16].

The assistive technology literature describes a wide variety of aids, ranging from *low tech* tools designed *for single task guidance* to *highly technical* devices that *compensate for cognitive impairments* across environments and task domains [17]. The primary clinical goal of these interventions is to improve performance of functional activities that are critical components of independent community life, that contribute substantially to quality of life or that significantly reduce the caregiver burden.

Compensatory devices are used both to improve particular cognitive functions and to compensate for specific deficits [18]-[20].

Joode's conclusion, after reviewing twenty-eight papers presenting 25 studies concerning the efficacy and usability of assistive technology for patients with cognitive deficits, was that the efficacy of assistive technology in general is not yet sufficiently studied in randomized controlled trials, although promising results have been reported [21]. Furthermore, several survey studies established that both potential users and clinicians have optimistic expectations about the usability of assistive technology, but the compensative approach must be completed by the restorative one. The assistive technology empowers the individual in his attempt to regain cognitive functionality improving the results of the restorative approach.

In the area of applied clinical psychology delimitations between assessment tool, monitoring tool, training tool and sometimes assistive tool are not clear – cut. For example some of the tools we use in this study (Yerkes Cubes, Clock Drawing Test) can be used for evaluation as well as for training. Appling different work sheets in order to compare the efficiency as training tools for different levels of spatial orientation and attention deficits, we observed that all subjects improved the score of the Clock Drawing Test with 28% after only two sessions of working two of the four diagrams.

The improvement of working times is seen best when applying simple short computer games. In this case it has been noticed halving of working times for the patients with mild attention and mental calculation deficits and the reduction of the working time with up to 30% for those with moderate attention and mental calculation deficits associated with mild logical thinking deficits.

The results of computer games (quantifiable in scores and working times) are an important variation tool for assessing the progress of distributive and focused attention, spatial orientation, mental calculation and logical thinking.

The possibility to use these short brain computer games for designing a complex instrument for quantifying the cognitive deficits in the specified area can be subject for further studies.

VI. Conclusion

Specific assistive technology is mandatory in order to obtain benefits from cognitive rehabilitation. The impact

of assistive and rehabilitation technology for cognition depends on a lot of factors beginning with patient's age, gender, type and level of disability, family support and financial accessibility. On the other hand it is very important to take into account user's personality and their motivation. Healthcare professionals must select the appropriate technology, in terms of complexity and of output specificity in order to obtain maximum of benefit in terms of cognitive functional gains, for each individual.

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