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A BNCI-based technology for cognitive rehabilitation after stroke: survey on usability

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Abstract

The treatment of cognitive impairment and prevention of further decline are essential aspects of stroke rehabilitation.

A new Brain Neural Computer Interface (BNCI) system was developed adopting user-centered design (UCD) principles, to operate bio- and neuro-feedback based cognitive training modules with the aim of improving post-stroke cognitive rehabilitation outcomes. The usability of such BNCI-based system for cognitive training was tested both with hospitalized patients (first testing phase) and those at home (second testing phase). Questionnaires were administered to 15 experts in rehabilitation, 7 stroke patients and 3 caregivers. Users' needs and requirements have been, and will further be collected, during all the experimental phases to integrate and refine the system according to the iterative cycling of the UCD.

The preliminary findings of this survey indicated that the newly proposed BNCI-assisted training for cognitive rehabilitation was well accepted by the majority of stroke patients (86%) and professionals (70%). The level of usability and acceptability revealed by the survey is encouraging for the system translation in clinical routine usage upon the training proves effective for improving cognition.

1 Introduction

Cognitive deficits occur in the majority of stroke patients (Haring, 2002) and have a high impact on their quality of life and that of their families (Carod-Artal et al., 2009). Currently, neuropsychological rehabilitation lacks in intensity and duration of specific rehabilitation strategies. As yet, patients do not have the opportunity to continue the rehabilitation endeavor after discharge, and they are left with no options for a professional training and monitoring of outcomes at home. The

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EU funded project CONTRAST (www.contrast-project.eu) is currently deploying a Brain Neural Computer Interface (BNCI)-based technology to provide cognitive training modules to improve cognitive rehabilitation outcomes in institutionalized patients, and also to support patient's training at home by remote controlled supervision. The term BNCI denotes for the implementation within the CONTRAST system of several training modules for attention, declarative memory, working memory and executive functions that are operated by biometric signals such as heartbeat (HRV), Electrooculogram (EOG) and Electromyography (EMG) and the Electroencephalogram (EEG). Based on the UCD principles (Maguire, 1998), we iteratively involved different users such as professionals, patients (in the hospital and at home) and caregivers to evaluate the system *usability*. Here we report the preliminary results of the survey based on questionnaire data collected in the rehabilitation facilities.

2 Materials and Methods

2.1 Assessment of system usability

At the current stage of the CONTRAST project, 15 professionals (psychologists, neurologists, neuropsychologists and therapists from several EU countries), 7 stroke patients (admitted to the neurorehabilitation department for standard rehabilitation treatment and the experimental intervention) and 3 caregivers have been involved to evaluate the usability of the training module for declarative memory. Such module relies on EEG sensorimotor rhythm (SMR) self-modulation. The training consists of a 3-minute baseline trial during which the participants are instructed to relax followed by a total of six 3-minute feedback runs where patients instructions are to increase their SMR amplitude (fed back by means of a bar placed in the middle of a screen whose size has to be kept above a predefined threshold) while reducing EOG and EMG artifacts (fed back by means of 2 bars on the left and the right side of the screen whose size has to be kept below predefined thresholds), respectively. Successful trials are also rewarded by means of visual and auditory feedback (point score and a Midi Tone). The EEG signals are recorded for then Cz electrode (2 mastoid electrodes for reference and ground). The Blood Volume Pulse (BVP) and the heart rate (HR) are monitored by means of a finger clip sensor. All modules have been implemented within the NEXUS technology (NeXus-10 MKII, Mind Media BV). Six out of 7 involved patients underwent all the training protocol (10 SMR neurofeedback training sessions) and 4 patients were also able to linearly increase their SMR amplitude over the neurofeedback training runs.

The adopted questionnaire was derived from the results of open interviews previously collected from a group of experts in the rehabilitation fields from different EU countries, and adapted to each category of users. The following main domains (a total of 70 questions related to the two different settings) were investigated: product use, intensity of the training, feedback for professional and patients, market feasibility, individualization, design and easiness to use, safety, and virtual reality. Finally, the professionals were asked to rank the aspects of the technology they considered most important. A shorter form of this questionnaire was then administered to patients and caregivers and it did not deal with cognitive functions, market feasibility, individualization and virtual reality fields whereas it provided questions related to standard rehabilitation program and the needs for interaction with the therapist. All items of the questionnaire required a qualitative response, thus the presented results are only descriptive.

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3 Results

3.1 Questionnaires for professional users

With regard to the BNCI-based system usage, the majority of the 15 interviewed experts (73%) reported it might be used in the facilities only after an initial period of conventional cognitive therapy. For the home-based setting, 70% of the professionals rated the independent system usage (by the patient and/or the caregiver) as the most relevant aspect. The training session duration of 30 minutes was indicated as preferred by 90% of those interviewed. The auditory feedback, the performance score and the smiley face for positive reinforcement were ranked by professionals as the most appropriate type of feedback for patients, while they wished to have fed back the performance and learning curves to estimate patients' progress.

The need for an easy-access was indicated by 45% of those interviewed who indicated that several solutions to access the devices are necessary and should be provided to patients in order to facilitate the basic operation of the system (i.e., select and initiation of the required training module; save data…). With regards to the safety of the BNCI-based technology, the system needed to be certified as medical product for 73% of the professionals. Finally, the professionals were asked to rank the several aspects of system with the indication, if they had considered one issue as important as another, to indicate by giving them the same number. Four professionals had the opinion that all areas were equally important. As illustrated in Figure 1, the most relevant aspects were effectiveness, efficiency, safety and easiness of use.

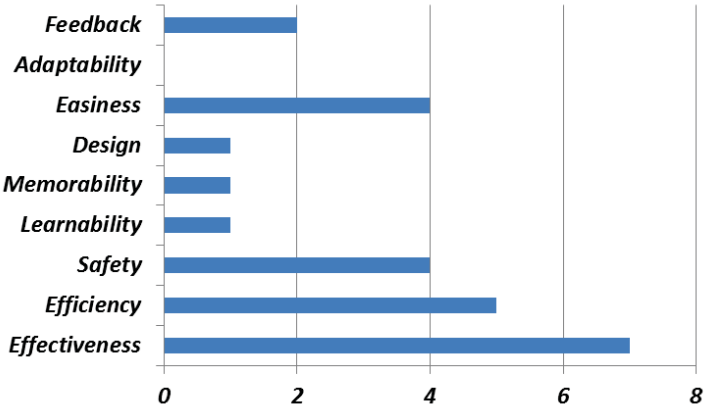

Figure: The histogram illustrates the BNCI-based training system related items (x axis) as ranked by the professional users (y axis = the number of preferences obtained for each item).

3.2 Questionnaires for patients end caregivers

Despite 24% of the patients not being satisfied with the usual cognitive rehabilitative care, most of them (86%) would like to use the system in both hospital and home setting. Patients would be willing to spend money for training modules. As for the home-based usage, 57% of the interviewed patients felt confident to independently use the system at home only after using it during their stay in hospital

whereas 43% of them thought they would need help from family members (60%) or therapists (40%). Most of the patients requested a therapist to be present at least once a week (70%) or 2 times per month (30%). Intensity and duration of the intervention was rated as similar to professionals (average 3 times per week with each session duration of 30 minutes; 57%). The maintenance of a high level of patient's motivation would require to be in contact with the therapist (43%) and/or to provide user-friendly feedbacks (29%). Effectiveness and safety were ranked as the most important areas, followed by efficiency, easiness of use and feedback. Most family members (3 families were interviewed) would like to continue their relatives' rehabilitation at home. They could help patients in their rehabilitation for about 2 hours a day if necessary, but they would like to be trained up to 2 hours to learn the system use. They also would like to have contact with the therapist 2-3 times (67%) or 4-5 times (33%) per month. All family members indicated as potential limits the costs and the difficulties to use the system.

4 Conclusion and outlook

The preliminary findings of this survey indicated that the proposed BNCI-based approach to cognitive rehabilitation was well accepted by the majority of the stroke patients and professionals. The feedbacks obtained from both classes of users are being currently incorporated in the design of the interface between patients and therapists, as more intuitive icons provide a direct access to basic operations such as selecting and running the desired training module, automatic data saving, the possibility for the therapist to control the session (whenever is needed) as soon as the patients switch on the system. The level of usability and acceptability revealed by the survey is the basis for the system application in clinical routine, provided the training proves effective to enhance cognition. The approach is also timely as remote patient's supervision will become more relevant in the future, due to increasing population mean age (i.e. elderly) and the life expectancy of those who have to live with the burden of chronic disease.

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