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RehabVisual: Application on Subjects with Stroke

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Abstract: Strokes are a major cause of motor, perceptual and cognitive dysfunction. Thus, perceptual stimulation in individuals with stroke is a fundamental procedure in the rehabilitation process, since it contributes to improved performance in activities of daily living. Perceptive rehabilitation could be performed with conventional procedures or by applying technology. However, the methods used to evaluate and treat perceptual changes using visual stimuli are generic and not personalized. Therefore, an innovative platform called RehabVisual was developed and already used with little children. It has the objective of stimulating the visuomotor competence. The platform is now applied to 3 subjects with stroke. The purpose of this article is to describe the platform and present the results of the application in stroke patients.

Keywords: Visuomotor skills; Stroke; Rehabilitation.

1 Introduction

Stroke is a leading cause of mortality and disability worldwide and the economic costs of treatment in poststroke care are substantial [1; 2]. The European countries, including Portugal, aren't an exception. Strokes mainly affect individuals at the peak of their productive life [3]. They cause a greater range of disabilities than any other condition [4]. It is estimated that 60% of stroke survivors have visual problems immediately after their stroke [5].

A multitude of stroke presentations with various combinations of visual-perceptual impairments are seen in the poststroke population. The visual changes could be caused by deficits in movement of extraocular muscles or could be caused by lesions in cerebral areas related to visual processing.

In that area, neglect is the most common situation. This is a neurological disorder in which patients fail to detect or respond to contralesional stimuli and has long been considered a failure of attentional orienting mechanisms [6]. Unilateral body neglect may occur independently of visual field cuts or visual inattention or may be compounded by these deficits [7]. Because of safety concerns related to this, neglect should be addressed early in the rehabilitation process [8]. Many patients with mild

neglect have spontaneous improvement of their symptoms within weeks of onset. Those with profound neglect may improve over a period of many months [9]. The literature doesn't reveal a single intervention best suited for addressing neglect. A multifaceted approach can be helpful [5].

In a clinical setting, the therapist manages poststroke subjects with stroke sequelae due to motor disability in ocular muscles and due to damage to visual cortical areas. Human visual behaviour needs attention and visual demand. Visual attention is intentional visual feedback from the environment and visual search is a process of choosing objects and focusing their attention on the environment [10]. Visual attention is a method of meaningful information selection which enables human beings to act correctly in their daily lives [11].

Visuomotor skills are based on the coordination between the reception and processing of visual information with motor activity [12]. In people with stroke sequelae it is necessary to apply multidisciplinary rehabilitation in order to improve the outcomes. In recent years, technology brings an important contribution to the rehabilitation process and can be used with different disabilities.

Perceptive rehabilitation could be performed with conventional procedures or by applying technology. However, the methods used to evaluate and treat perceptual changes using visual stimuli are generic and not personalized. Therefore, our team developed an innovative platform called RehabVisual [13;14]. The platform has the objective of stimulating the visuomotor competence [13].

New technologies have the potential to support clinical evaluation, precisely to control and measure therapy and implement novel forms of mechanical manipulation impossible for therapists to stimulate [15]. The creation and introduction of new tools require an evaluation by representative users of the target audience. Thus, there are several types of questionnaires that can be applied in order to obtain the usability of a new tool.

Usability is defined as the extent to which a product can be used by specific users to achieve specific goals effectively, efficiently and satisfactorily in a specific context of use [16]. There exist different methods to assess the usability of a tool and the system usability scale (SUS) is only one of them. The SUS was created by John Brooke with the aim of quickly obtaining a value relative to the subjective opinion of the individuals who used the tool [17]. This scale is widely used in health applications [18]. The questionnaire consists of ten statements, each of which has five response hypotheses ranging from "strongly disagree" to "strongly agree".

1.1 Motivation

Visual skills are fundamental to human performance in all areas of occupation. They are fundamental through the life span and can be compromised by a wide range of injuries. In that context it is extremely important to improve a patient's function when this is compromised due to acute neurological damage. Rehabilitation could be done in a more classic way, with conventional intervention. In recent years there has been an increase in technological tools, some of them with application in perceptive rehabilitation.

This work is developed under the intention to determine the utility of the RehabVisual platform. It is our goal to know the applicability for rehabilitation of

stroke survivors that have sequelae of visuomotor skills. Another proposed element is to discover the users' opinion about platform usefulness.

For this investigation the research question is to explore the efficacy of the RehabVisual platform in the stimulation of visuomotor skills in stroke patients.

2 Contribution to Life Improvement

The economic, social and individual problems due to stroke are already proven [1]. Particularly devastating are the visuomotor skills and the visual attentional problems [5]. They are respectively related to oculomotor problems and to cerebral visual lesions.

It is urgent to promote the full rehabilitation of these skills in order to contribute to stroke survivors' life improvement. The traditional ways of rehabilitation are predominantly static and based on "paper and pencil" tasks. They also privilege the therapeutic intervention in clinical settings and attribute less importance to home stimulation. With a different background and perspective, younger rehabilitation teams utilized classic strategies but integrated new ones with the use of technology in rehabilitation treatment. An example is the use of virtual reality for poststroke unilateral spatial neglect [19]. However, that systematic review also demonstrated that research is still limited and needs to improve.

Considering the results obtained by the application of the RehabVisual platform to babies with developmental problems [13, 14] it is intended to test the efficacy of RehabVisual in visuomotor skills rehabilitation of patients with stroke sequelae. This technological solution allows the stimulation in clinical settings and in the home environment.

3 Materials and Methods

In this chapter, we describe the technological equipment applied during visual stimulation. We also present the protocol stimulation used and the characteristics of the group of participants.

3.1. RehabVisual Platform

This is a technological platform created in 2017 to promote the stimulation of visuomotor skills in children under 18 months and provide the systematic report [14]. It has already been presented [13, 14] but continues improving according to the findings obtained with the applications in different populations. RehabVisual was created using several programming languages included HTML, CSS, PHP, and JS. To create the database, the language chosen was SQL [13].

The platform should be delivered in a full screen version on a personal computer. It could be installed locally or hosted on a private website, depending on the preference of the rehabilitation team. The main characteristics of platform are:

- Could be used by different members of the team: occupational therapists, ophthalmologist and caregivers / patients. Each one has access to specific parts and some information (like an explanation about visuomotor skills) is accessible to all;
- Professionals have a specific part to record the evaluation of each patient;
- Therapists have access to all stimulation material and can select the specific frames that each patient can use. In that way, the stimulus provided is personalized according to the necessities of the patients;
- The patient / caregiver only has access to some stimuli selected by the therapists, not having access to any information that is in the domains of other users.

The RehabVisual platform has two sessions: database and protocol with the stimuli. In database, it records the clinical information (ophthalmological and behavioral evaluation) related to the patient. The protocol with stimuli is used according to the development of the participant and allows the selection of what is more appropriate for each patient [14]. In Fig. 1 we see the diagram with the platform structure. (Fig. 1).

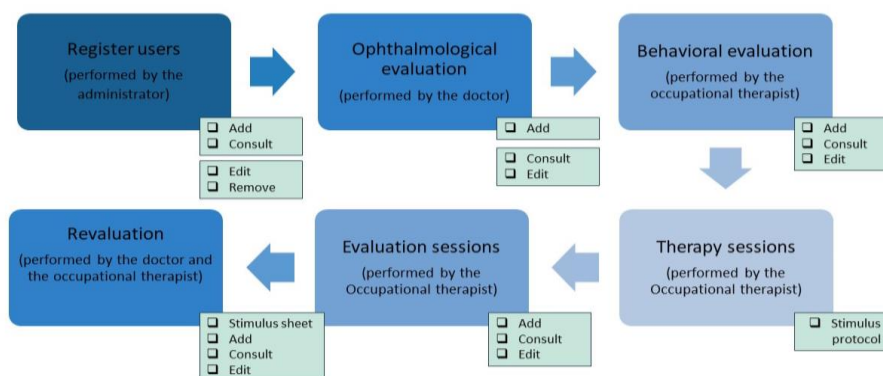


Fig. 1. Diagram with platform structure.

The ophthalmologist and the occupational therapists can record demographic information such as age, diagnosis and clinical issues. The occupational therapist can record all the information concerning the behavioral assessment, the functional evaluation and can choose the stimulus protocol during the procedure. The ophthalmologist can consult this information.

The stimulus protocol is developed based on the bibliography consulted and on the professional experience of collaborators in previous applications. So, the version used in this study is composed of geometrical figures which attributes that change in relation to the following parameters: geometric forms (squares, triangles, circles and mixed patterns); dimension (12cm, 8cm and 4cm); color (red, yellow, blue, green, black and white); movement (static and moving figures – horizontal, vertical, circular and diagonal) and speed (slow, medium and fast).

The set of stimuli available allows the user to choose from a wide range of options with different levels of complexity to stimulate [14]. The information related to the

diagnosis, Ophthalmological condition and behavioral performance was recorded in a database. Thus, it is divided in to patient chart; assessment of ophthalmological parameters; behavioral evaluation; functional evaluation of the vision; monitoring of intervention sessions [13].

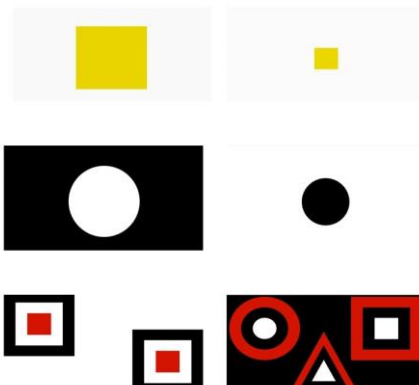


Fig. 2. Different characteristics of geometric figures

It is also important to note that the platform could be used online or offline, depending on the local conditions and goals of the team. When the tool is used by the rehabilitation team, members should register the information via the online platform to ensure that all staff have the most up to date information in real time. However, in another situation the platform could also be used offline. For that the platform is installed in the personal computer of therapist to be presented. In that case the data is recorded locally.

3.2 – Participants in Clinical Investigation

This research is conducted on six post stroke subjects. The subjects are selected based on convenience, in two health units of Alentejo. The subjects have poststroke due to ischemia of middle cerebral artery (MCA) or posterior cerebral artery (PCA), and the distribution is the same in both groups. They are in acute phase and show deficits in visuomotor skills. The exclusion criteria are:

- have cognitive deficits which prevent them from following instructions accurately;
- have language deficits that interfere with the understating of protocol;
- have significant acuity changes, that aren't compensated with glasses or contact lenses.

Is important to note that during the experiments there are 3 dropouts: two participants due to high clinic and one due to cognitive deficits. Three participants (n. 1, 2 and 3) included the experimental group, that have done the conventional occupational therapy treatment and the stimulation with Rehabvisual platform. The other three participants (n.4, 5 and 6) had done the conventional occupational therapy treatment. In both groups, participants are all male. The injured arteries in both groups are the same: 2 participants have lesions in the MCA and 1 in the PCA in each of the

groups. Related to schooling the averages are similar (6,6 years in experimental group comparing to 6,3 years in conventional group). The participants that use the RehabVisual platform had some differences from participants that done isolated the conventional treatment. The main differences are related with:

- Age: average in experimental group is 66 years and in control group is 58 years;
- Days post stroke: average in experimental group is 64 days and in control group is 57 days.

The participants are all assed in the beginning with the Montreal Cognitive Assessment, in order to characterize the cognitive level and exclude the possible participants that had cognitive deficits. To assess the visuomotor skills was used the trail making test in the beginning and in the end of treatment.

The experiment last for 4 weeks, and the participants are exposure to treatment two times per week.

3.3 – Usability Test

The introduction of a new tool in the rehabilitation treatments follow a complex sequence of steps. Is important measure his usability and tests can be used to accomplish this. One of these is the SUS. The questionnaire score scale is from 1 to 100, with an average score of 68. The questionnaire score is affected by the complexity of the system and the tasks the user must perform [20].

Usability assessment was done in the final of protocol application. The questionnaire is delivery to the 4 students of Occupational Therapy Degree and his teacher. All the subjects experience the use of platform during 8 sessions, of protocol application.

4 Results

The results are presented in two sections. First shows the data obtained with the application of the platform on subjects with stroke sequelae. In section 4.2 are presented the results about platform usability.

4.1. Results with the Platform use

As described in section 3.2, this pilot study refers to the platform used to stimulate the visuomotor skills of 3 people with ischemic stroke sequelae in conjunction with conventional occupational therapy treatment. Three other persons with ischemic stroke sequelae were treated at the same time and with the same frequency, with conventional occupational therapy treatment.

In our initial assessment, the people who benefitted from stimulation with the platform demonstrated inferior performance on the trail making test (TMT), but with stimulation all showed great improvement. The changes occurred in both sections A and B, (Table 1). If we do a more personalized analysis, it is noted that subjects with a worse initial time performance showed greater improvement.

The subject (case 3) that suffered the stroke in the PCA had (in both instances) a better performance compared with the other two subjects. When we look at the results of subjects receiving conventional treatment, it is evident there is better performance in the initial assessment compared to the results of the experimental group.

Table 1. Performance in trail making test - experimental group

		Initial Assessment	Final Assessment	Evolution
P 1	Section A	9M 10S	3M 12S	5M 58S faster
	Section B	11M 37S	8M 8S	2M 58S faster
P 2	Section A	3M 1S	1M 3S	1M 38S faster
	Section B	5M 11S	3M 49S	1M 22S faster
P 3	Section A	50S	42S	8S faster
	Section B	1M 20S	1M 1S	9S faster

However, the subjects of the control group had a minor improvement in the final assessment. Additionally, it is noted that case 5 had a worse performance in final assessment. Participant no. 6 performed worse in the final assessment of section B.

Table 2. Performance in trail making test - control group

		Initial Assessment	Final Assessment	Evolution
P 4	Section A	1M 10S	1M 5S	5S faster
	Section B	5 M 20 S	4M 30S	50S faster
P 5	Section A	3M 16S	3M 25S	9S slower
	Section B	4M 10S	5M 5S	1M 22S slower
P 6	Section A	2M 19S	2MS 5S	14S faster
	Section B	3M 40S	4M 45S	1M 5S slower

4.2. Usability Test

When introducing a new rehabilitation tool, it is important to test its usability. In order to study that, the SUS questionnaire was administered. The questionnaire was completed by five persons that were using the platform during the study: four students in the last year of their bachelors and one occupational therapy degree teacher.

The results are quite satisfactory, with an average score of 88,5 which corresponds to an assessment of "Excellent" [21]. Only one participant rated the RehabVisual platform "Excellent". This user classified the platform with a score of 77,5 which corresponds to "Good".

In the qualitative domain the users highlight the RehabVisual positively, and point out these characteristics:

- It's easy to use;
- The platform allows offline access;
- Easy navigation within the platform;
- The customization and adaptability of the stimuli;
- The possibility of increasing the difficulty of stimuli during the sessions.

However, they also identify some aspects that could be improved:

- the stimuli always move in the same direction. In this way, the patient could memorize the movement of the stimuli and answer based on memory;

- The stimuli are all composed of geometric figures, which may not be the most appropriate for this age group. Of the available stimuli, those that best fit the age of the patients were the patterned stimuli;
- Slow-moving stimuli are too slow for this age range and the video of this stimulus is too long, causing patients to lose focus and interest.

5 Discussion of Results and Critical View

The analysis of the results reveals that there was an evolution in visuomotor skills in the three people who would benefit from the use of the platform. Contrarily, in the control group, only one of the subjects showed evolution with the conventional treatment. These data suggest that the evolution of the experimental group is due to the use of platform. These preliminary results are in line with research that has shown positive results for improving motor performance and engaging patients through technology [22]. In the experimental group it is important to note that the participant with the best performance in the initial assessment evolves less, and there seems to be a "ceiling effect".

It is important to note that the cases with the shortest time after stroke, namely case 1 (45 days) and case 5 (35 days), require the longest time to perform the initial assessment. The literature is not totally conclusive about the timeline of recovery from stroke. However, the recovery could be relatively rapid during the 4 weeks after treatment and then to a lesser extent decelerated between 3 and 6 months after stroke [23]. Although this is a recovery pattern, it is not deterministic.

TMT normative data are poorly specific (no disability vs. disability) [24]. This feature precludes a more detailed classification of the performance level of the subjects evaluated in the present investigation.

In all cases in which platform was applied, it was found that there was a better performance of TMT in the final assessment. This test requires skills such as attention span, mental flexibility, executive functions, processing speed, eye-motor coordination, searching, visual scanning and sequencing [24; 25]. The results of the test suggest that platform is effective in stimulating these skills.

Since the platform allows the stimulation of the visuomotor skills [13], the evolution of the participants in TMT performance could be related to the stimulation of these competences through the platform. It has been found that the time taken to perform the TMT varies depending on the injured territory. When this is the MCA, a longer time is needed compared to the cases where the injured territory is the PCA. In a global analysis these time differences could be surprising considering that the primary visual cortex is in occipital lobe. However, it is also known that the territory irrigated by the MCA is more strongly related to spatial attention, difficulties in visuospatial function, and left and right discrimination, than the PCA [26]. Thus, the cases with MCA injury consequently presented a longer time to perform the TMT than the cases with PCA injury.

The usability test results are truly promising. They demonstrate that the platform is already at an advanced stage of development. Utilizing the qualitative results collected in this study, some improvements could be done. It will also be important to

reinforce the possibility of using different tools offline, as this will be in line with the reality of various adult rehabilitation institutions.

6 Conclusion and Further Work

The current investigation has shown positive indications about the effectiveness of the RehabVisual platform to stimulate the visuomotor skills of adults with stroke sequelae.

The small size of group leads to the necessity of future work in order to understand if those indications are valid. In futures studies it is also important to clarify if this tool could be more useful for lesions in specific cortical areas. It is also important to characterize the performance of adults without pathology using the RehabVisual platform to understand if any changes occur in visuomotor skills.

It could also be important to apply this platform to adults with other neurological conditions to understand if this stimulation could be a helpful tool. Considering a framework of rehabilitation and quality of life improvement could be important in order to ascertain if the change in visuomotor skills brings any global performance impact to the subject.

The results of usability are very positive. Although future studies should consider users' suggestions regarding the platform, namely:

- alternate the direction of stimuli movement;
- adjust the stimuli to the adult population, not restricting them to geometrical figures;
- adapt the speeds used to adult skills, in particular, speeding up the slower ones.

The RehabVisual platform is an innovative tool to stimulate visuomotor skills. It allows the personalization of intervention methodology and can be applied in different populations and in distinct clinical settings.

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