Rehabvisual: Validation of an Application to Stimulate Visuomotor Skills in Preterm Babies with Developmental Alterations

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Abstract: The methods of evaluation and intervention related to the visuomotor skills, for children under the age of 18 months with neurological dysfunctions are not systematic and individualized. Hence, the RehabVisual platform was developed. The aim of this article is to present the usability tests applied to the platform validation, as well as describing the application of the platform in the therapy sessions of a baby with a clinical diagnosis of prematurity. The study concludes that the application of the platform allows the treatment to be more individualized and specific to the baby needs through a common method to all service. Through usability tests, it was possible to ascertain that at the level of occupational therapy, this is a useful tool adapted to the needs of its users.

1 INTRODUCTION

The RehabVisual platform was developed with the objective of stimulating the visuomotor competences in children up to 18 months with developmental alterations resulting from preterm birth (Machado et al., 2018). The platform allows to adapt the therapies to the needs of infants and the assessment of their performance over the course of the treatments.

Preterm babies have a higher probability of developing complications related to organ system immaturity and a higher risk of developing ocular problems. So early stimulation is very important, improving the capacity of fixation, follow-up, and oculomotor coordination. This recovery can be justified by the fact that during the first year of life some processes of maturation in the brain still occur, this period is called cerebral plasticity and allows an adaptation and modification of the brain according to the stimuli present (Alimovic, 2012).

The main objective of this article is to describe and analyze the application of usability tests related to the platform performed by occupational therapists. As an example, a case of the application of the intervention program to a child under the age of 18 months and with developmental alterations resulting from preterm birth will be analyzed.

Usability tests are used in order to understand whether the product developed takes into account the needs of its users, not focusing only in the functionalities of the same.

According to ISO 9241-11 (1998) the usability of a product should ensure that a specific user can use it in order to achieve its goals in a manner that is efficient and with satisfaction in a given context of use. These three concepts are defined as:

1. Effectiveness: is the precision capacity with which the user completes his/her tasks interaction with the application;
2. Efficiency: is the amount of resources (cognitive, physical effort, and time) that the user needs to carry out a task in order to obtain a positive result;
3. Satisfaction: Evaluates the degree of contentment that the user demonstrates during the interaction with the application.

More recently, ISO 9126-1 (2003) defines usability as the capacity of the product software to be understood, learned, operated and attractive to the user, when used under specific conditions. Thus, applications are intended to be user-friendly and attractive to their users, which influences their adoption and their use in a common way.

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To ensure that the technological solution developed is useful and that captivate the end user to include it in its daily tasks there are a set of steps that are necessary to fulfill. These steps include conducting surveys during the development phase, in order to understand the needs and preferences of users and to explore solutions that improve the quality of user interaction and the application. After the development phase, usability tests are applied with the purpose of verifying whether the application is in accordance with the requirements previously identified (Lyles et al., 2014), (Kushniruk and Patel, 2004).

Usability questionnaires are a source of collection of opinions and suggestions that allow the researchers to assess certain aspects of application interaction and usability. There are a set of questionnaires already applied in the field of health applications, the most used being the Post-Study System Usability Questionnaire (PSSUQ) and the System Usability Scale (SUS).

Regarding the health area, the developed applications have specific characteristics that limit their usability. Among which, the use of small screens, with reduced font sizes, which can limit the interaction between the user and the application and there are applications that need to be permanently available so as not to compromise the health of patients (Zhou et al., 2017).

The integration of usability assessments also allows the reduction of costs and time associated with product changes after its development, since the entire production process is carried out based on the preferences of the end user (Johnson et al., 2005).

2 MATERIALS AND METHODS

2.1 Platform

The RehabVisual platform intends to accompany the entire rehabilitation process of the baby, by integrating the evaluation components and including an intervention program to be used as a complement to the therapy sessions. RehabVisual is adaptable to the needs of each baby, or customized. It was built taking into account five different types of users: administrator; doctor; technician; occupational therapist and care provider, corresponding to the person accompanying the baby in the consultations and sessions (Machado et al., 2018).

Regarding the functioning of the platform, a record of the clinical information of the patient is performed, which can subsequently be associated with ophthalmologic assessments, behavioral, functional assessments and response to the sessions of Intervention Program.

The evaluation is performed as follows: in the ophthalmologic evaluation the functioning of both eyes and the visual system is described and in the behavioral assessment it is intended to perceive the way the baby uses the vision in performing tasks, the level of focus of objects, visual attention and visuomotor coordination (Alimovic, 2012). The functional assessments and the intervention program are based on the baby's response to a set of stimuli available on the platform.

The stimuli developed allows the user to have a wide range of options with different levels of complexity in order to stimulate the child. This stimulus is adaptable according to its evolution and in order to decrease the probability of habituation and consequent disinterest (Corn and Erin, 2010).

The evaluation of both the intervention program and the functional evaluation is based on indicators such as looking, smiling or balancing. The intention was to perceive the fixation and persecution capacity in relation to the stimuli to which the baby was exposed.

In these assessments, it was adopted an evaluation scale used in visual assessments (Machado et al., 2018). The scale consists of the following parameters:

1. Never - (0%)
2. Rarely - (25%)
3. Occasionally - (50%)
4. Often - (75%)
5. Always - (100%)

In all assessments there is also the possibility of inserting comments that allow the user to add relevant information to the baby's condition.

2.2 Usability Questionnaire

The SUS questionnaire was used as part of this study. This questionnaire consists of a set of 10 items in which the participant should score them in a one to five scale according to the level of agreement. The fact that it is based on positive and negative assertions, in which the participant has to classify them with their level of agreement, makes the participant more alert leading to more consistent results in small population samples (Albert and Tullis, 2010). The choice of this protocol was made because it is reliable, versatile, simple and with a reduced number of parameters questionnaire. The latter being extremely important as users testing the platform could not be available to respond to longer questionnaires. In addition, the final score obtained through this questionnaire is easy to interpret (Klug, 2017).

Regarding the number of participants required to ensure the validation of the usability tests, according to the bibliography, there are at least five people, allowing with this number of people to identify about 85% of possible problems, not at risk of appearing the same type of error several times (Nielsen Norman Group, 2012).

2.3 Platform Validation

The usability tests were performed at the Physical Medicine and Rehabilitation (MFR) Service of Hospital D. Estefânia (HDE). Additionally, they were performed on occupational therapists from the Rehabilitation Medicine Center of Alcoitão.

The script used during the tests describes a scenario to simulate the use of the platform in the context of therapies and consists of several tasks that will be implemented by users in the context of the therapies. The study was approved by the Central Hospital of Lisbon (CHLC) Ethics Committee.

2.3.1 Participants

The usability tests were performed by nine occupational therapists, four from the MFR Service of HDE and the remaining five from the Rehabilitation Medicine Center of Alcoitão. Only two of the HDE service participants had already been in contact with the platform during therapy sessions with the baby test group with development changes and less than 18 months, having already made some suggestions for changes during the development phase of the platform.

2.3.2 Test Protocol

The test session is of an individual character and it is initiated with a brief introduction to the platform, then it is requested the user to perform the tasks indicated in the protocol. Two protocols were elaborated with tasks, one of larger extension for occupational therapists of HDE and a shorter one for occupational therapists of the Rehabilitation Medicine Center of Alcoitão, due to the limited time they had to perform usability testing.

In the larger protocol, there are various tasks performed by occupational therapists since the patient's registration, until the insertion of functional assessments and intervention sessions, where it is also requested to consult and edit previously submitted assessments. In the shorter protocol, only the patient form and the intervention program are approached, which are the most used by occupational therapists.

2.3.3 Evaluation of the Test Protocol

The degree of user satisfaction is assessed throughout the test session (at the end of specific tasks) and in a more global way at the end of the protocol, through the completion of the SUS questionnaire. Additionally, participants can give their opinion and suggestions for improvement.

Over the course of the session, the user is asked about the ease of insertion, edition and research of data regarding the patient's clinical record and assessments.

In the SUS questionnaire, the user's opinion is requested on ten statements, each of which with five hypotheses of response that go from "strongly disagree" to "strongly agree". The assertions are:

1. I think I'd like to use this system often.
2. The system is unnecessarily complex.
3. I think the system is easy to use.
4. I think I need help from a technician to be able to use the system.
5. I thought the various functions of this system were well integrated.
6. I thought there were a lot of inconsistencies in the system.
7. I imagine most people can learn to use the system quickly.
8. I found the system very complicated to use.
9. I felt very confident using the system.
10. I need to learn many things before using the system.

2.4 Use of the Platform in the Therapy Sessions

The platform was also included in the occupational therapy sessions of six babies up to 18 months of age with developmental changes resulting from preterm birth, performed by two occupational therapists included in the validation of the platform.

Informed consent was requested to all parents, and after their authorization, the use of the platform was initiated in the occupational therapy sessions. The choice of stimuli to be used in each session was performed taking into account the analysis of the occupational therapist of the baby's behavior in the previous session and during the stimuli visualized throughout the session, which allows to have a personalized treatment for the needs of each baby. In other words, the choice of stimuli is made taking into account the evaluation of the acquisition of competencies by babies and not according to their diagnosis.

The platform was complemented by the therapy sessions already attended at the HDE of MFR service, and the number of sessions in which it was applied,

Table 1: SUS results.

Participant/affirmation	1	2	3	4	5	6	7	8	9	10	SUS results
Participant 1	4	4	3	4	5	1	3	3	3	3	57,5
Participant 2	4	1	5	1	5	2	5	1	4	1	92,5
Participant 3	2	3	3	3	3	2	2	3	2	4	42,5
Participant 4	5	1	5	2	5	2	4	1	4	2	87,5
Participant 5	4	2	4	2	4	2	5	1	4	4	75
Participant 6	4	2	4	2	5	1	4	1	4	1	85
Participant 7	3	1	5	2	4	3	4	1	3	4	70
Participant 8	3	2	5	2	4	1	5	1	4	2	82,5
Participant 9	5	1	5	4	5	1	4	1	4	1	87,5
SUS mean score											75,6
Confidence interval (95%)											12,63

which depended on the number of weekly therapy sessions of each baby.

3 RESULTS

3.1 Usability Test

3.1.1 Results

Knowing that in the SUS questionnaire half of the statements are of a positive nature and the remaining negative ones, it is necessary to convert them into a single result, as well: in the questions associated with the odd number (positive questions) the answer is subtracted by the value of 1 and in the questions associated with the even number (negative questions) the answer is subtracted by the value of 5. The values are then summed, and this result is multiplied by the value 2.5 in order to generate the SUS score, which is between 0 and 100 (McLellan et al., 2012). The average SUS score is 68, which corresponds to the 50th percentile. This score is affected by the complexity of the system and the tasks that the user has to perform (Klug, 2017).

A color map was used in table 1 in order to more easily identify the positive responses so in the case of the assertions of positive character the values 4 and 5 are marked green, the 3 is identified in yellow and 1 and 2 in orange. In the case of negative responses, the representation is assigned inversely, as such the green color is assigned to the scores of 1 and 2, the yellow color is assigned to 3 and the orange color to scores of 4 and 5 (McLellan et al., 2012).

With regard to participants, participants 1, 2, 3 and 4 correspond to the therapists of the HDE´s MFR service who were already aware of the platform before the day they performed the usability test, although only two had used the platform in occupational therapy environment. The remainder correspond to the occupational therapists of the Rehabilitation Medicine Center of Alcoitão, who were only aware of the platform on the day they performed the usability test.

Participants 1 and 4 followed the use of the platform throughout the occupational therapies of the test group.

From the analysis of the table 1 it is concluded that the assessment made by users is generally positive, and only two users (participant 1 and 3) rated the platform negatively (SUS value less than 68). It should be noted that only participant 3 shows a very negative result (SUS value less than 51). Of all the participants with positive results, two classify the platform as good (SUS value higher than 68 and less than 80.3) and the remainder as excellent (SUS value exceeding 80.3) (UX research, 2017).

The two participants with a SUS rating of less than 68, during the test both stated that they do not often use the computer which may have compromised the answers given in the questionnaire.

The participants who have a positive SUS value, participants 5, 7 and 9 present the following justifications for the statements of the questionnaire on which they disagree (presented in the table with the orange color):

1. Participant 5, in statement 10 agrees that he needs to learn many things before using the system, justifying that the answer was given

not because he needs to learn many things in the perspective of using the system, but in the area of ophthalmology and problems including assessments, intervention and problems. The reason that leads to this response may be related to the fact that this participant did not have knowledge of the project before the day of the usability test, another possible reason was the fact that the Participant belonged to the group that held a more summarizing task protocol not addressing all available menus on the platform.

2. Participant 7 presents the same opinion as participant 5 in the statement 10, having justified the answer given in the same way. Additionally, he also justifies the answer given in statement 6 where he does not agree or disagree with the assertion: "I found that there are many inconsistencies in the system" clarifying that although he does not detect inconsistencies in the system itself, he considers very important that the criteria/conditions under which the stimulation program should be applied is defined, so that the results of system assessments are
3. reliable.
4. Participant 9 only negatively classifies claim 4: "I think I need help from a technician to be able to use the system ", justifying that this help would be for an initial phase of use.

In general, it appears that the statements that have caused more negative results were the statements 4 and 10, which can be explained by being people who did not feel comfortable using technological applications or to being part of the participants who had no prior knowledge of the project.

3.1.2 Suggested Alterations

The changes suggested by the participants are mainly centered on the aesthetics of the platform, especially in the increase of the size of the letters and the colors used in order to contrast more with the background. Additionally, it was suggested to change the name of some buttons in order to be more intuitive.

3.2 Example of a Participant in Therapy Sessions

This article describes the application of the intervention program in one of the participants in a detailed manner.

The participant is male, aged 8 months at the beginning of the study. It presents a clinical diagnosis prematurity of 31 weeks and very low birth weight (1020g). In the application of stimuli throughout all sessions, the baby was in a room where there were no other therapies taking place (which caused no noise) and no adjustments were made to the luminosity of the room.

In the first session, the black and white stimulation program was applied, with the highest contrast. In this session, it was analyzed the number of videos that could be visualized without showing signs of fatigue. In the protocol used a gradual increase of the complexity of the videos was made, they were visualized simple videos (with a single figure) of the 4 figures established (circle, square, triangle and mixed pattern) and one of the patterns of minor complexity of the circular form (figure 1). The baby showed signs of fatigue in the video with the pattern, which is why the intervention program was interrupted.

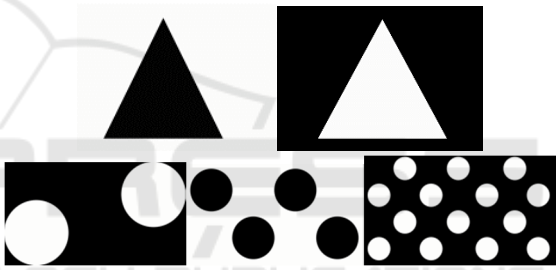

Figure 1: Examples of the videos used on the first session (triangle simple video and pattern with minor complexity).

In the second session, four days later, the program is adapted to the baby's response, a simple figure video and a smaller complexity pattern in black-and-white protocol was repeated. The choice of the videos was made to confirm the consistency with the previous session. The baby's answer in the simple figure videos continued to be the maximum of the scale, the response to the video with a smaller pattern of complexity was slightly inferior.

In the third session, one week later, as the baby had greater basic motor agitation, it was decided by the therapist that it would not increase the level of difficulty of the videos in relation to the previous sessions.

In the fourth session, three days later, the behavior of the baby remained agitated, the lower complexity pattern stimuli were again introduced, in the black and white protocol. However, the answer in this category was better than in the previous session. Therefore, a video of greater complexity with movement was introduced with the aim of stimulating

the baby (figure 2). In this video the baby only kept the attentional focus in the larger figure.

In the fifth session, four days later, in addition to the colors black and white the red color was introduced. The simple stimulus was resumed, since when introducing, in the previous session,

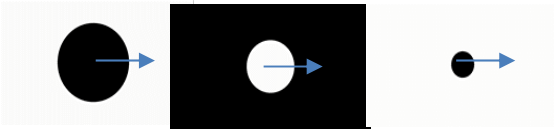

Figure 2: Fourth session, introduction of horizontal movement with circular form.

the videos with movement (which correspond to the videos of greatest demand) there was a decline in the provision of the baby. So, it was attempted to realize if starting with a video of inferior requirement to the first visualized in the previous session, the installment in the videos with motion would be better. There was a slight improvement in the video with horizontal motion although he had not kept the focus all the time. The introduction of the red color was made in the last video (diagonal movement with slow speed), in order to stimulate the baby who begins to recognize this color around 2/3 months of age, although the baby never pursued or fixed the stimulus, which can be justified by being a too demanding video for the baby or for the stipulated time, not to be adjusted to the attentional capacity of the baby (figure 3).

Figure 3: Fifth session, diagonal movement.

In the sixth session, two weeks and three days later, stimuli of the black-and-white and color-colored protocol were performed. Only medium speed videos for horizontal movement (circular figure) and fast speed (diagonal movement of mixed pattern with fast speed) were used in order to verify that the loss of attentional focus in previous sessions was due to the speed of movement. The introduction of the mixed pattern had the objective to perceive whether with the change of figures during the video, the baby was able to regain attentional focus. The baby's visual response to the horizontal motion video was better than in the diagonal motion video, although in both, an improvement was registered in relation to previous sessions.

In the seventh session, a week and four days later, videos of the program of red color and blue color were visualized. In this session we only opted for motion videos with fast speed (vertical movement of fast speed, fast diagonal movement with mixed pattern and circular movement with fast speed). The choice of the vertical motion video was made for being a movement with a degree of complexity similar to that of the horizontal movement and thus be able to change the simplest stimulus introduced in this session, since the horizontal motion video was presented during three consecutive sessions. The red color in this video was used instead of the blue color subsequently were introduced two more complex videos and so the red color allows to make the initial stimulus easier because it is the first color recognized by the baby. In vertical motion the baby pursued and always fixed the stimulus (figure 4). In the diagonal

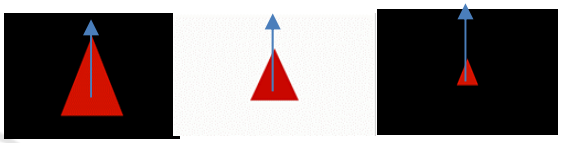

Figure 4: Seventh session, vertical movement.

movement, even though the fast speed video was introduced. It is concluded that it is too long for the baby to be able to visualize without losing its attentional focus. For the circular motion the baby pursued all the figures presented occasionally, but lost the attentional focus along the movement of the same figure (figure 5).

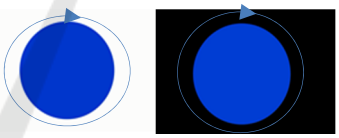

Figure 5: Seventh session, circular movement.

In the eighth session, a week and three days after the previous, were only chosen videos of the blue color program. The standard videos with medium complexity of mixed pattern (video of less complexity for this session) and the diagonal motion with fast speed of mixed pattern were selected.

In the video with medium complexity pattern, the baby occasionally pursued, altering the attentional focus between the various figures presented in although not during the entire time of the pattern display. When the pattern altered, he regained attentional focus. In the diagonal movement, he pursued and focused only part of the movement of each of the figures, not being able to follow any of the movements to the end.

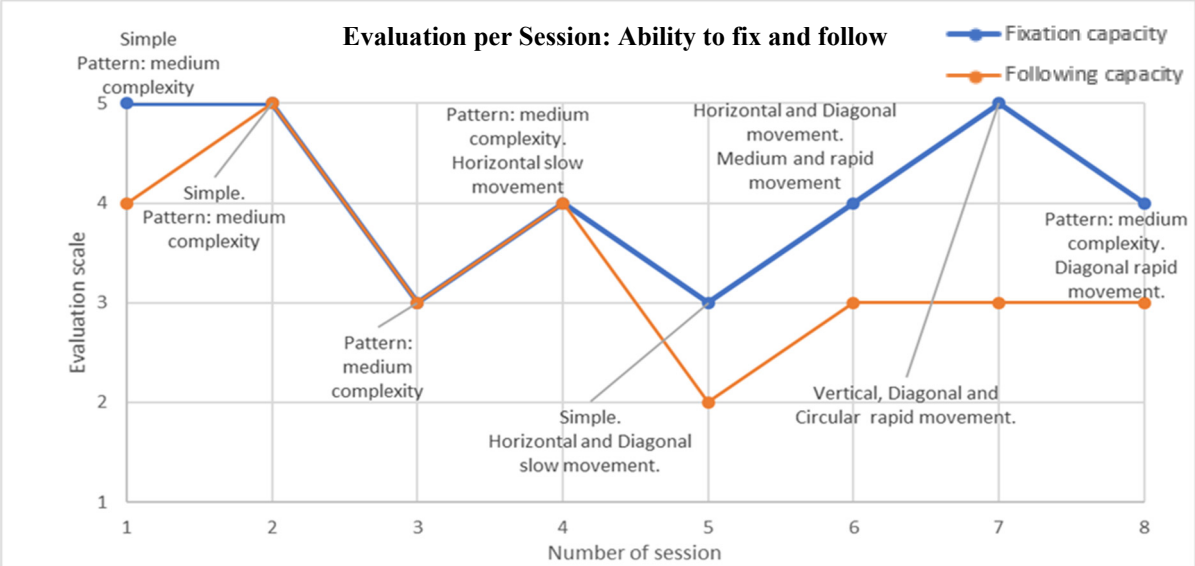

Figure 6: Results of the patient (fixation and following capacity) during therapy sessions.

Generally speaking, during the sessions, it is concluded that the parameter of fixing the stimuli is the one that presents the best results, which on one hand can be explained by initially the baby acquire the ability to fix and only after the ability to pursue an object. It is also noted that in relation to simple figures, the baby always has a very positive response throughout the sessions. In the videos with medium complexity, the response was also generally improving as they were being inserted in the therapies. In relation to stimuli with movement it is concluded that the most adjusted to the baby are the medium and fast speed, although in the case of videos with diagonal motion these two speeds need to be misadjusted to the baby's attention period (figure 6).

4 CONCLUSIONS

Through the usability tests it was possible to ascertain that at the level of occupational therapy, this is a useful tool and is adapted to the needs of its users (since the average result of the SUS questionnaire and the result of the questions made after the performing the tasks were positive). However, it is necessary to pay attention to the sample of the platform users, to what people who are not familiar with computer tools might sense in the introduction of the application on their work.

At the level of therapy sessions, the tool is quite versatile since new stimuli can be easily introduced more adapted to the needs of the infants and their ages, making the treatment more individualized and specific to the population in question.

Currently, the included stimuli already provides a very wide choice that allows the therapist to adapt the sessions according to the baby's response throughout the treatment so that no signs of habituation arise or that the level of difficulty is misadjusted to the baby.

The platform also allows obtaining a standardized evaluation that facilitates registration, as well as the subsequent interpretation of the results during the real-time monitoring of the baby along the treatment so that it can always be adapted whenever possible.

5 FUTURE WORK

As future work it would be interesting to add an eye tracker to the platform in order to verify if the infant is really fixating or pursuing the image, which would make the assessment easier and more correct.

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