
José-Antonio Gil-Gómez¹,
Herme Gil-Gómez², José-Antonio Lozano-Quilis¹
¹Instituto Universitario de Automática e Informática Industrial, Universitat Politècnica de València, C. Vera s/n, Valencia, SPAIN
²Hospital S. José, Av. Zaragoza 16, Teruel, SPAIN
³Dpto. de Informática e Ingeniería de Sistemas Universidad de Zaragoza, C. Escolar s/n, Teruel, SPAIN

Abstract—Usability, acceptance and security of use are key factors in the validation of Virtual Rehabilitation system. Current literature offers different questionnaires for this purpose, but many of them do not consider some important issues and other are inadequate for patients. In this paper, we present SEQ (Suitability Evaluation Questionnaire) a novel questionnaire designed specifically for Virtual Rehabilitation systems. SEQ is based on a questionnaire with proven efficacy (SFQ) but with new questions that cover fundamental items not covered by SFQ. SEQ is an easy to understand questionnaire, with an affordable number of questions (14), which is being currently validated. This contribution presents also the study that is being carried out, and the preliminary results obtained from patients who have already completed the study (N=13). These initial results show an acceptable internal consistency of SEQ. As a secondary result, this contribution also indicates initial suitability evaluation of a Virtual Rehabilitation system designed for balance recovery.

Keywords: Suitability, usability, acceptance, questionnaire, virtual rehabilitation.

I. INTRODUCTION

Integration of technology in rehabilitation has led to the appearance of Virtual Rehabilitation (VR). VR offers great advantages for both patients and specialists. Current VR systems help clinical specialists, generating objective data and providing enjoyable rehabilitation to patients. Also, VR systems allow the efficient rehabilitation of more patients with lower total cost [1]. The playful approach frequently associated to VR systems and the integrated technology improves patient’s experience, increasing motivation and adherence to the treatment. This bigger motivation results in better motor and psychological recovery [2], [3].

Clinical validity of VR systems has been demonstrated in many studies. Most of these studies conclude that the recovery of patients that follow a VR based program is greater than the recovery with traditional rehabilitation programs [4], [5].

Usually, these systems probe their clinical efficacy Vs traditional rehabilitation, but it is necessary to ensure first their adequacy in aspects such as usability, acceptance and security.

II. RELATED WORK

The importance of usability, acceptance and security of use in VR systems, has been previously indicated by many authors. Thus, the current background offers us various studies on VR systems that evaluate almost some of these items.

Fitzgerald et al. [6] carry out a usability evaluation of a VR system. This evaluation is done with VRUSE [7], a computerized usability questionnaire designed for Virtual reality applications. This questionnaire is very complete but it has an important problem: the great number of questions included. VRUSE is composed of 100 questions, too many questions especially considering that VR systems are targeted to patients, most of them with cognitive or attentional problems [8].

In [9], authors carried out an assessment of the usability of the Nintendo Wii Fit Plus for virtual reality rehabilitation of balance. To evaluate usability, Meldrum et al. uses the System Usability Scale (SUS) [10]; SUS has a limited number of questions (only 10), which is very appropriate for patients. On the other hand, SUS is too general, because it is designed to test hardware, cell-phones, websites… and also it is a usability scale that not consider adequately problems frequently associated with virtual reality systems, such us dizziness or nausea.

In other studies, many authors presented different questionnaires to evaluate the subjective responses of the patients to their specific VR systems [11], [12].

Among these questionnaires we find especially interesting the questionnaire presented by Kizony et al. in [13], the Short Feedback Questionnaire (SFQ). SFQ is based in Witmer and Singer’s Presence Questionnaire [14]; SFQ consists in eight questions graded on a 5-point Likert scale. Authors demonstrated the suitability of this questionnaire to various virtual environments and with different clinical populations [15]. Also, Kizony and colleagues applied successfully SFQ for testing some of their systems [16].
III. SUITABILITY EVALUATION QUESTIONNAIRE (SEQ)

Based on SFQ, we present in this contribution SEQ (see Table I), designed especially to test VR systems. Basically, SEQ extends SFQ, including questions to get responses for patients in specific items related with VR.

SEQ includes 14 questions, 13 of them with a response graded on a 5-point Likert Scale, and a last open question. Following the SFQ scheme, the first seven questions measure enjoyment, sense of being in the system, feeling of success and control, realism, easy-to-understand instructions and general discomfort.

After, four new questions (Q8-Q11) are included to detect issues frequently associated with virtual rehabilitation systems: dizziness or nausea symptoms, eye discomfort, disorientation or confusion symptoms and sense of progress in rehabilitation.

These first eleven questions are graded from “Not at all” to “Very much”.

The last two 5-point Likert scale questions are focused on difficulty: Q12 evaluates the perceived difficulty of the task (as the last question of the SFQ) and Q13 evaluate the observed difficulty related with the physical interface used in the system. Q12 and Q13 are graded from “Very easy” to “Very difficult”.

The global score of SEQ ranges from 13 (poor suitability) to 65 (excellent suitability). In their calculation it is necessary to consider that items Q7, Q8, Q9, Q10, Q12 and Q13 are negative items (that is, a response of 1 has a value of 5, a response of 2 has a value of 4, …).

Finally, an open question (Q14) asks patients if they felt uncomfortable, requesting the reasons why.

The questionnaire has a convenient number of questions (14), enough to measure the suitability of the system but not too many for the patients. Questions are direct and clear, and SEQ also takes into account issues concerning VR system.

TABLE 1. SUITABILITY EVALUATION QUESTIONNAIRE (SEQ)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. How much did you enjoy your experience with the system?</td>
<td>Not at all</td>
</tr>
<tr>
<td>Q2. How much did you sense to be in the environment of the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q3. How successful were you in the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q4. To what extent were you able to control the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q5. How real is the virtual environment of the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q6. Is the information provided by the system clear?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q7. Did you feel discomfort during your experience with the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q8. Did you experience dizziness or nausea during your practice with the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q9. Did you experience eye discomfort during your practice with the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q10. Did you feel confused or disoriented during your experience with the system?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q11. Do you think that this system will be helpful for your rehabilitation?</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Q12. Did you find the task difficult?</td>
<td></td>
</tr>
<tr>
<td>Q13. Did you find the devices of the system difficult to use?</td>
<td></td>
</tr>
<tr>
<td>Q14. If you felt uncomfortable during the task, please indicate the reasons.</td>
<td>Open response: (No) or (Yes + reasons)</td>
</tr>
</tbody>
</table>
ABAR uses the Nintendo® Wii Balance Board® (WBB) for the interaction patient-system. WBB is a low cost device used in many VR systems to obtain the center-of-pressure (COP) of the patient.

Table II summarize the aim of the games, with screenshots.

### Study procedures

The study is being carried out in a specialized rehabilitation service of a metropolitan hospital. Each patient complete 20 ABAR sessions of 30 minutes each with 3-5 sessions per week (see Fig 1).

In the study, clinical assessment is done before and after the rehabilitation program, and also one month after the end of the program (follow-up evaluation). SEQ is completed immediately after the first session with ABAR.

### Outcome measures

For this study SEQ provides the primary outcome measures. With these measures we want to test the internal consistency reliability of SEQ to ensure the reliability of the questionnaire.

Out of the main objective of this work, there are other outcome measures, such as clinical measures, to quantify the clinical efficacy of ABAR. Clinical condition is assessed by Anterior Reach Test [19], Unipedal Stance Time [20], Berg Balance Scale test [21], Tinetti Test [22], Time “Up and Go” Test [23], Timed 10-Meter Walking Test [24], and 30-second Sit-to-Stand Test [25].

### RESULTS

Currently, only thirteen patients have completed SEQ. This value is not enough to evaluate adequately the internal consistency of the questionnaire, but initial results are very promising. Initial results showed an acceptable internal consistency reliability of SEQ (Cronbach’s alpha = 0.7).

Relating suitability of ABAR system, SEQ shows very good results (see Table 3). The global score ranged from 44 to 60 with a mean score of 54.85 (normalized suitability score, mean ± SD = 0.80 ± 0.01). Relating particular items, patients enjoyed the system (Q1, mean ± SD = 4.54 ± 0.66), they did not felt confused or disoriented (Q8, mean ± SD = 1.23 ± 0.60) and patients thought that ABAR will be helpful for their rehabilitation (Q11, mean ± SD = 4.08 ± 0.76).

Only one of the thirteen patients felt uncomfortable due to neck pain, but the patient experienced this pain also in other cases.
This paper introduces SEQ, a novel questionnaire designed specifically for VR systems. SEQ is based on a questionnaire covered by SFQ. DATA obtained from patients who have currently completed ABAR system. Preliminary results (N=13) confirmed very good results for most of the SEQ questions.

VI. DISCUSSION AND CONCLUSIONS

This paper introduces SEQ, a novel questionnaire designed specifically for VR systems. SEQ is based on a questionnaire with proven efficacy and with good internal consistency reliability (SFQ) but covering other fundamental items not covered by SFQ.

SEQ is an easy to understand questionnaire, with an affordable number of questions (14) that is currently being validated.

Data obtained from patients who have currently completed SEQ (N=13) shows an acceptable internal consistency. A secondary result of the study is related with the suitability of ABAR system. Preliminary results (N=13) confirmed very good results for most of the SEQ questions.

VII. ACKNOWLEDGEMENTS

Authors would like to thank patients and clinical specialists from S. José Hospital for their suggestions and collaborations.

REFERENCES


