Proposal for a spanish translation of cybersickness questionnaires

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***Abstract*—Research on the use of the Simulator Sickness Questionnaire (SSQ) has shown that this tool has a number of important weaknesses when it comes to measuring cybersickness. In recent years, two alternatives to the SSQ have been published and externally generated evidence indicates they might be promising substitutes. However, their usage with Spanish-speaking demographics is currently limited given that no suitable translation is available. This proposal presents Spanish versions of the Cybersickness Questionnaire and Virtual Reality Sickness Questionnaire based on an existing translation of the SSQ. Additionally we provide a plan for an experimental design which aims to compare these new versions against the SSQ to test their validity. This will be accomplished by selecting virtual environments with different likelihoods to induce cybersickness and then using them as experimental conditions in the study.**

***Index Terms*—Cybersickness, Virtual reality, SSQ, CSQ, VRSQ, Spanish translation**

I. Introduction

CYBERSICKNESS (CS) is a collection of diverse symptoms that affects a majority of virtual reality users and is regarded as an important research topic in virtual reality research. Although its exact nature is still unclear, it is currently believed that CS has a strong link to vection (illusion of self-motion) and postural instability [1]. In the literature regarding this ailment, the most commonly used tool to assess the severity of symptoms is the Simulator Sickness Questionnaire (SSQ), developed by Kennedy et al. [2]. This tool consists of 16 items rated on a 4-point scale according to their severity. These ratings are then used to calculate sub-scores for three factors: nausea, oculomotor, and disorientation, as well as a total score.

While the SSQ has seen widespread usage in the field, several studies have identified important pitfalls that suggest it might not be the best tool to use in this type of research [3]. Along with an analysis of its limitations, some authors have also provided revisions and alternatives to the SSQ that are better suited for measuring CS [4]–[8]. In particular, the Cybersickness Questionnaire (CSQ) [7] and the VR Sickness Questionnaire (VRSQ) [8] have had some externally generated evidence that supports their fitness for the task[9].

Given their novelty, these two alternatives have still not been translated into the Spanish language, which limits the scenarios in which they can be used. On the other hand, Campo-Prieto et al. [10] recently published a Spanish version of the SSQ (S-SSQ). This version was generated through a multi-stage process involving professional translators, professors specialized in English-Spanish translation, and a panel of experts in related areas. The authors experimentally validated the resulting questionnaire to be equivalent to the original set of items. While a similarly rigorous process is out of the scope of this proposal, we consider it possible to generate valid translations by subsetting the S-SSQ. This is due to the fact that both questionnaires employ only 9-item subsets of the original SSQ with the same 4-point scale [7] [8].

This document presents the translations of these two instruments generated by this exact process. Additionally, it defines the experimental design of a study intended to validate the translations against the S-SSQ. The rest of the paper is structured as follows: section II provides a review of the limitations of the SSQ and the available alternatives, and section III provides a detailed description of the planned experimental design.

II. Background

A. Pitfalls of the SSQ

The SSQ has been criticized by several authors due to apparent weaknesses inherent in its design and development. Despite this, a majority of researchers continue to use it as a standard tool for measuring CS [7]. An initial cause for concern was discovered by Stanney et al. [11], whose findings suggest an important difference in the symptom profile of CS against other motion sickness-related ailments. In the case of CS, the severity of each factor is in the order of Disorientation $>$ Nausea $>$ Oculomotor. This represents an issue with the SSQ as it was designed for measuring simulator sickness, where the predominant set of symptoms is those of the oculomotor type.

Bouchard et al. [5] have also argued that the SSQ's origin from a military sample is incompatible with its current application with a general, VR-user audience. One evident consequence of this is that the originally proposed thresholds that define a "bad" simulator experience can be easily reached by even mild cases of CS [3]. Additionally, these authors criticize the factor structure of the questionnaire in which certain items contribute towards two categories at the same time, and thus, are counted twice in the total scoring. They provided further evidence by analyzing a sample of SSQ responses from 371 participants. Their results suggested that a two-factor model was a better fit for the data than the original three factors of the SSQ. Similar studies that perform a factor analysis such as those by Bruck and Watters [6], Stone III [7],

and Kim et al. [8] also seem to support the need for a better fitting model.

More recently, Bimberg et al. [3] generated a review on the usage of the SSQ which includes a list of common challenges. Aside from those we have already mentioned, they point out the erroneous notation in the scoring formula of the original SSQ paper. In practice this doesn't seem to constitute a significant point of confusion, however, it might still act as a pitfall for new researchers in the field. Another limitation is the lack of pre-exposure baselines by which to compare the measured symptoms after a session. Currently, this is accounted for by applying the SSQ before and after VR immersion, however, Kennedy et al. [2] have explicitly recommended against this practice since the inception of the tool.

B. Alternatives to the SSQ

In light of the seemingly poor fit of the SSQ to the problem of CS, a few authors have attempted to create new versions designed specifically for this illness. One such example is the Virtual Reality Symptom Questionnaire by Ames et al. [4]. This tool however has seen little adoption by the community due to weak evidence in favor of its generalization capability and a lack of proper psychometric evaluation [7].

More recently, two CS-specific questionnaires have been published by different authors. First is the Cybersickness Questionnaire (CSQ) by Stone III [7]. The CSQ is a nine-item subset of the original SSQ which applies a different factor structure and scoring system. In this questionnaire, the two main factors for which a score is computed are "Dizziness" and "Difficulty focusing", and in contrast with its originator, there isn't a calculation for a total score. The other recent alternative was proposed by Kim et al. [8] in the form of the Virtual Reality Sickness Questionnaire (VRSQ, not to be confused with the previously mentioned Symptom Questionnaire). The VRSQ also consists of nine items that contribute to the similarly named groups of "Oculomotor" and "Disorientation", and to a total score calculated from the subscores of said factors. In contrast with the SSQ, the scoring in this instrument applies an equal weighting scheme to all items and factors.

In a study conducted by Sevinc and Berkman [9], the CSQ and VRSQ were compared to the original SSQ and an alternative version known as the F-SSQ. The purpose of this study was to analyze the difference in psychometric qualities such as reliability, validity, and sensitivity. Their results suggest that the CSQ and VRSQ models fit the dimensions of CS better than the other two questionnaires. Additionally, the tools show a sufficient level of reliability and sensitivity toward different virtual environments. Although scarce and conducted with a limited sample of 32 participants, we consider that this evidence points towards the potential of these new instruments as sound alternatives to the SSQ.

III. Experimental design proposal

A. Goal and hypothesis

This study aims to test the Spanish translations of the CSQ and VRSQ by analyzing their performance when applied in experimental conditions and by comparing them to the SSQ results. As such, our hypothesis can be expressed in the following manner:

Given that the CSQ and VRSQ have been evaluated to be adequate tools for measuring CS, and that their items are subsets of the SSQ, their Spanish versions should be equally adequate for said task. This adequacy is determined by their capacity to distinguish between virtual environments with different likelihoods to induce CS and by their correlation to the scores of the SSQ.

B. Materials

Síntoma	Ninguno	Ligero	Moderado	Severo
1. Malestar general	◯	◯	◯	◯
2. Cansancio	◯	◯	◯	◯
3. Dolor de cabeza	◯	◯	◯	◯
4. Vista cansada	◯	◯	◯	◯
5. Dificultad para enfocar	◯	◯	◯	◯
6. Aumento de salivación	◯	◯	◯	◯
7. Sudoración	◯	◯	◯	◯
8. Náusea	◯	◯	◯	◯
9. Dificultad para concentrarse	◯	◯	◯	◯
10. Pesadez de cabeza	◯	◯	◯	◯
11. Visión borrosa	◯	◯	◯	◯
12. Mareos con ojos abiertos	◯	◯	◯	◯
13. Mareos con ojos cerrados	◯	◯	◯	◯
14. Vértigo	◯	◯	◯	◯
15. Estómago revuelto	◯	◯	◯	◯
16. Eructos	◯	◯	◯	◯

TABLE I
MOCK-UP OF THE SPANISH-TRANSLATED SSQ [10] TO BE USED IN THE PRELIMINARY AND MAIN STUDY. THE SCORING FORMULA IS THE SAME AS THE ONE PRESENTED BY KENNEDY ET AL. [2].

Síntoma	Ninguno	Ligero	Moderado	Severo
1. Dolor de cabeza	◯	◯	◯	◯
2. Vista cansada	◯	◯	◯	◯
3. Dificultad para enfocar	◯	◯	◯	◯
4. Náusea	◯	◯	◯	◯
5. Pesadez de cabeza	◯	◯	◯	◯
6. Visión borrosa	◯	◯	◯	◯
7. Mareos con ojos abiertos	◯	◯	◯	◯
8. Mareos con ojos cerrados	◯	◯	◯	◯
9. Vértigo	◯	◯	◯	◯

TABLE II
MOCK-UP OF THE SPANISH-TRANSLATED CSQ TO BE USED IN THE MAIN STUDY. THE SCORING FORMULA IS THE SAME AS THE ONE PRESENTED BY STONE III [7].

The apparatus selected for our study is the Oculus Rift S Head-Mounted Display device. The Rift S has a 1280x1440 per-eye resolution, 88° field-of-view, 80Hz refresh rate, and an adjustable virtual interpupillary distance (IPD) range between 58-72 mm. All interaction with the environments will be conducted via the Oculus Touch 6-DoF controllers. The HMD

Síntoma	Ninguno	Ligero	Moderado	Severo
1. Malestar general	◯	◯	◯	◯
2. Cansancio	◯	◯	◯	◯
3. Vista cansada	◯	◯	◯	◯
4. Dificultad para enfocar	◯	◯	◯	◯
5. Dolor de cabeza	◯	◯	◯	◯
6. Pesadez de cabeza	◯	◯	◯	◯
7. Visión borrosa	◯	◯	◯	◯
8. Mareos con ojos cerrados	◯	◯	◯	◯
9. Vértigo	◯	◯	◯	◯

TABLE III
MOCK-UP OF THE SPANISH-TRANSLATED VRSQ TO BE USED IN THE MAIN STUDY. THE SCORING FORMULA IS THE SAME AS THE ONE PRESENTED BY KIM ET AL. [8].

will be connected to a desktop system running an AMD Ryzen 5 3600 processor, and a NVidia RTX 2070 Super graphics card.

The other relevant materials are the various questionnaires that will be used to measure cybersickness before and after exposure: SSQ, CSQ, and VRSQ. The Spanish version of the SSQ (S-SSQ) will be the one created by Campo-Prieto et al. [10] and is shown in table I. As for the CSQ and VRSQ, we have generated their Spanish translations by selecting the appropriate item subsets from the S-SSQ. These newly-translated version are shown in tables II and III.

Aside from the obvious aspect of language, our versions of the CSQ and VRSQ differ from their original counterparts in that they will be applied as standalone instruments. This is in contrast to their usage by the original authors, where they apply only the full 16-item SSQ and then derive the CSQ/VRSQ scores by selecting the relevant subset of data [7] [8]. While this may result in a confounding variable, it also provides us with an opportunity to analyze the standalone viability of the questionnaires.

C. Selection of VR environments

We intend to conduct a preliminary study with the aim of selecting 3 virtual environments (VEs) with different likelihoods of inducing CS: low, medium, and high. The initial pool of candidate applications is shown in table IV along with a brief description. The participants for this preliminary study will be recruited by setting up an information stand and booth in the Cartago campus of the Costa Rican Institute of Technology. Individuals who approach the stand will be given a briefing about CS and its effects. In this stage, participants will be randomly selected for one of the available VEs, ensuring an equal or at least similar number of data points is collected for each condition. Immersion will last 10 minutes maximum. Immediately after finishing, the participants will fill out the Spanish SSQ and receive a briefing about CS aftereffects and precautions.

Once the data is collected, we will perform an analysis of variance and post hoc testing of the sub and total scores of the SSQ to identify significantly different groups among the VEs. The low and high likelihood conditions will be selected from the VEs that show correspondingly the lowest and highest scores. Meanwhile, the medium likelihood condition will be selected by picking the significantly different group that is farthest from the two other conditions.

D. Sampling method

Participants for the main study will be recruited via email shared in academic mailing lists of the Costa Rica Institute of Technology and University of Costa Rica. Ideally, we aim to recruit professors, staff, and students to ensure a wide range of ages and backgrounds. Before confirming their participation, individuals will be informed of basic aspects such as availability requirements and warnings for VR usage, as well as given a summary of cybersickness and its possible effects. The only exclusion criteria are the individuals who attended the preliminary study for environment selection.

Each participant will be exposed to 9 total conditions (3 environments x 3 questionnaires). As such, a total of 43 participants are required to achieve a confidence interval of 95%, precision of 5% and 50% variability according to Cochran's formula [13].

E. Procedure

Before starting a session, the participants will be reminded of the effects of CS, asked to sign an informed consent form, and fill out a pre-immersion SSQ. Each session will consist of 4 immersions into one of the available VR environments: 1 for training and 3 for taking measurements with the SSQ, CSQ, and VRSQ. The training immersion will be followed by a 10-minute waiting period for resting. In the case of measurement immersions, the waiting period will consist of 5 minutes of rest and 5 for filling out the questionnaire. While CS effects are know to be long-lasting [1], we consider that the initial training segment and frequent breaks can help in creating equal conditions for each questionnaire. Figure 1 shows the procedure of a given session.

Each participant will attend 3 sessions, one for each VR environment, in days taking place at least 24 hours apart to minimize a possible bias of CS aftereffects. This will ensure that all participants are exposed to all 3 environments. The order of environments (sessions) and questionnaires will be randomized to account for bias. At any point, the participants will be allowed to abandon the study by terminating the current session or abstaining from attending future ones.

F. Measurements and analysis

The measurements of the main study are given by the factors of each of the questionnaires:

- **SSQ**: nausea, oculomotor, disorientation, and total scores. To be taken pre and post-immersion.
- **CSQ**: dizziness and difficulty focusing scores. To be taken post-immersion only.
- **VRSQ**: oculomotor, disorientation, and total scores. To be taken post-immersion only.

ANOVA and post hoc testing will be used to identify differences in groups of VR environments and questionnaires. In the case that our hypothesis was true, we should be able

Title	Description	Notes	
Bigscreen VR	The user watches a first-person, 2D video in a large virtual screen (e.g. living room, movie theater).	No movement, video might create vection.	Link
Virtual Desktop	The user interfaces with the standard desktop environment via virtual screens.	None.	Link
Conscious Existence	Short film with a continuously changing environment and slow forwards or sideways movement. Rendered in 3D, 360° format.	Change in environments might induce postural instability [1]. Possible mild vection.	Link
Kayak VR: Mirage	Kayak simulation in a photo-realistic environment. User controls movement with virtual paddles.	Possible mild to strong vection	Link
Rush	Wing-suit flying simulator. The user traverses environments at high altitude and speed.	Possible strong vection	Link
Superhot VR	First-person, gallery (fixed location) shooter with a slow-motion mechanic and minimalist environments.	Natural walking, game discourages extreme movement.	Link
Talos Principle VR (T)	Puzzle game in photo-realistic environments. Locomotion via teleport controls.	None.	Link
Talos Principle VR (F)	Puzzle game in photo-realistic environments. Locomotion via free joystick control.	Slowest movement speed is faster than natural walking [12]. Possible strong vection.	Link
Tilt Brush	Brush-based, 3D painting application in a blank environment.	None.	Link

TABLE IV
CANDIDATE VR ENVIRONMENTS TO BE USED IN THE PRELIMINARY STUDY. ALL THE TITLES WERE CHOSEN ARBITRARILY FROM THE STEAM AND OCULUS (META) STORE PAGES.

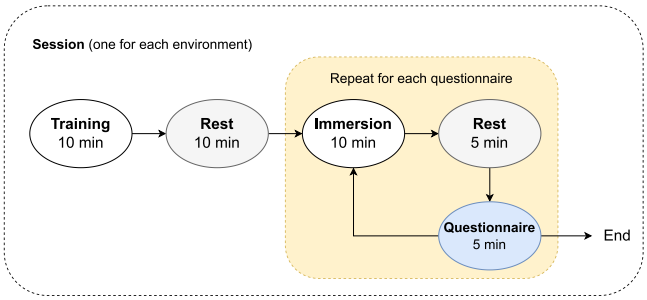

Fig. 1. Procedure for a trial session. Each participant will attend 3 sessions, one for each VR environment.

to observe significant differences between the 3 environments for the scores of the CSQ and VRSQ.

We will also be conducting a correlation test such as Pearson's, Kendall's, or Spearman's between the scores of the SSQ and the other two questionnaires. Given the different factor structures of all three instruments, we will be testing for correlation only between the total scores of each, with the exception of the CSQ where we will compute the mean of the two factors as a pseudo-total.

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