Virtual Reality Human-Human Interface to deliver psychotherapy to people experiencing auditory verbal hallucinations, a development and usability study.

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Abstract

Background: Digital technologies have expanded the possibilities of Psychotherapy, especially for the treatment of Schizophrenia with the Avatar Therapy. Despite its vast possibilities, this treatment method is still not disseminated; the operability and functionality are unknow.

Objective: We aim to study the usability of a therapeutic virtual reality human-human interface created in a game engine with psychiatric hospital staff.

Methods: Participants introduced to the therapeutic platform in a "hands-on" mode. The System Usability Scale (SUS) was employed for the evaluation of the system. We will conduct descriptive statistics, chi-square test, an ANOVA, and multilevel factor analysis for statistical evaluation.

Results: In total, 109 staff members were introduced to the therapeutic tool and completed the SUS. The mean SUS global score was 81.49±11.1. Among the professional groups, psychotherapists (86.44±8.79) scored significantly higher (F (2, 106) = 6.136; p = 0.003) than nursing staff (79.01±13.30) and administrative personnel (77.98 ± 10.72). A Multilevel Factorial Analysis (MLFA) shows a different factor structure for each profession.

Conclusions: By different professions, the usability of a digital psychotherapeutic tool developed using a game engine achieves the benchmark for an excellent system, scoring even highest among the professional target group. The usability of the system, therefore, also depending on the professional background of the operator. With gaming technology and platforms, it is possible to create and customisation of novel therapeutic psychotherapeutic approaches. Clinical Trial: clinicaltrials.gov (NCT04099940)

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Abstract:

Background:

Digital technologies have expanded the options for delivering psychotherapy, particularly for the treatment of schizophrenia using Avatar Therapy. Despite its considerable potential, this treatment method has not been widely disseminated. As a result, its operability and functionality remain largely unknown.

Objectives:

We aim to study the usability of a therapeutic virtual reality human-human interface, created in a game engine, with psychiatric hospital staff.

Methods:

Participants were introduced to the therapeutic platform in a "hands-on" session. The System Usability Scale (SUS) was employed for evaluation purposes. Statistical evaluation was conducted using descriptive statistics, including chi-square test, ANOVA, and multilevel factor analysis.

Results:

In total, 109 staff members were introduced to the therapeutic tool and completed the SUS. The mean SUS global score was 81.49±11.1. Across professional groups, psychotherapists (86.44±8.79) scored significantly higher ($F(2, 106) = 6.136$; $p = 0.003$) than nursing staff (79.01±13.30) and administrative personnel (77.98 ± 10.72). A Multilevel Factor Analysis (MLFA) demonstrates a different factor structure for each profession.

Conclusions:

In all professional groups in this study, the usability of a digital psychotherapeutic tool developed using a game engine achieved the benchmark for an excellent system, scoring highest among the professional target group (Psychotherapists). The usability of the system, therefore, seems to some extent to be dependent on the professional background of the user. Using gaming technology and platforms, it is possible to create and customise novel psychotherapeutic approaches.

Trial Registration: clinicaltrials.gov (NCT04099940)

Keyword: system usability; virtual reality psychotherapy; verbal auditory hallucinations

Introduction:

Psychotherapy is an effective and cost-efficient method for the treatment of psychiatric and psychological disorders [1]. Over the last few decades, it has been evolving continuously, demonstrating both feasibility and efficacy in practically all diagnostic categories. Indeed, in several categories, it has become the first line of treatment [2, 3]. In patients with schizophrenia, psychotherapy as a treatment option has been largely neglected. Recently, however, it has gained recognition as an effective treatment when used in conjunction with pharmacotherapy [4, 5]. Furthermore, current guidelines now recommend the early implementation of psychotherapy in the treatment process [6, 7].

In several pioneer studies, psychotherapeutic treatment using digital technologies, virtual reality in particular, has been shown to be at least as efficacious as other treatments [8]. In some fields, particularly schizophrenia, digital technologies have considerably extended therapeutic options[9-11], with the novel implementation of Avatar Therapy, whereby psychotherapy is delivered through a computer interface [12, 13]. Patients with auditory verbal hallucinations create an avatar of a human entity, to which they attribute the voices. With the help of a therapist, they progressively gain control over the voices, which leads to a reduction of symptoms and distress whilst increasing quality of life [14].

Despite encouraging early studies and its vast potential, this treatment method has still not been widely disseminated in research or clinical practice [10]. We attribute the limited deployment partially to its unavailability as off the shelf tools, making implementation difficult [15, 16]. From previous research, it is known that for the optimal delivery of therapy through digital technologies, besides availability, the operability and functionality of the technology are crucial; only once these are well established can the therapist confidently utilise digital technology [16, 17]. Moreover, the proper use of such technology is essential for the optimal delivery of the therapy, thus allowing the therapist to develop their therapeutic skills [10].

In this paper, we present a human-human interface that we developed for use in the treatment of patients experiencing verbal acoustic hallucinations. As the usability of the system is a prerequisite for its clinical application, we systematically sought input from non-patient users [18]. Within mixed skill- grade users, we sought to determine what influence professional background and therapeutic skills have in relation to the use of the therapeutic system. We aim to study the usability of this

virtual reality human-human interface, created in the Unity game engine, with psychiatric hospital staff irrespective of their clinical-therapeutic skills.

Methods:

Virtual Reality Human-Human Interface

Building upon previous studies, we have created a virtual reality human-human interface using the Unity game engine to deliver Avatar Therapy for people experiencing auditory verbal hallucinations [12, 19, 20]. The basic design employs two separate applications running on different devices connected via a network, including bi-directional audio (full-duplex VoIP connection) communication. The first computer hosts a personal avatar creation tool (VRAT-CT) to design and customise a humanoid avatar, to whom patients attribute their auditory verbal hallucinations. This computer also renders the Virtual Reality (VR) through a Head Mounted Display (HMD) for the therapeutic session. The voice of the therapist is modulated through a voice transformer (Roland VT-4) to match the auditory verbal hallucination. The therapeutic session is initialised and controlled from the second computer with a Control Center (VRAT-CC) which allows the therapist to control the Avatar and to speak through the Avatar using lip synchronization.

Software and Hardware

The Unity game engine is a freely available platform for game development. Over 60 percent of current Virtual and Augmented Reality content has been created with Unity [21]. It provides a 3D editor, a scripting API written in C# which allows all components to be brought together, and supports 3D-graphics, socket communication, and VR. Both applications are created with Unity 2019.3.7 and the associated scripts are written in C# with Microsoft Visual Studio 2017, an Integrated development environment (IDE) from Microsoft. For the 3D character, the Unity Multipurpose Avatar (UMA) package (version 2.11.5) is used. To increase the impression that the avatar is speaking, the SALSA LipSync Suite package (version 2.5.0.92) is used to synchronise lip and mouth movements to the voice input of the therapist.

The HP Reverb headset is used as a HMD. It provides a resolution of 2160 x 2160 per eye at 90Hz and with a 114° field of view. However, this comes with a series of computational requirements. The producer recommends, at minimum, a Nvidia GeForce GTX 1080 graphic card or an AMD Radeon Pro WX 8200, an Intel Core i7 processor, and 16 GB of RAM. For the operating system, Windows 10 (Version 1809 or later) is needed. For this project a Roland VT-4 voice transformer is used. It provides a set of different options to manipulate a voice in real-time. Relevant for creating the avatar voice are the pitch and format frequency, which can be set with sliders, resulting in a deeper or higher voice. Figure 1 shows an overview of the software and hardware setup (a video as online

supplementary material is available).

Insert Figure 1 around here.

The System Usability Scale (SUS)

The System Usability Scale (SUS) is a tool for measuring the usability of a wide variety of products and services including hardware, software, mobile devices, websites and applications [20, 22]. It is a ten-item questionnaire, with a five-point Likert Scale from 1 (strongly disagree) to 5 (strongly agree). Scale items alternate between positive and negative statements. Therefore, correction is required for scoring purposes. For odd-numbered items 1 is subtracted from the user's response whereas for even-numbered items, the user's response is subtracted from 5, yielding a score from 0 to 4 for each item. For interpretation, scores are summed and multiplied by a factor of 2.5. The final score ranges from 0 to 100 [22].

Textbox 1: The System Usability Scale

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Participants and Assessment

Employees (irrespective of professional background and occupation) of the Psychiatric University Hospital of Zürich were invited to view and test the virtual reality human-human interface used to deliver Avatar Therapy to people experiencing auditory verbal hallucinations. Basic demographic characteristics (age, gender and occupation) were gathered. According to their professional background, participants were divided into three categories: psychotherapists (either psychiatrists or psychologists), nursing staff, and administrative personnel.

Procedure

Participants were individually informed about the nature of the study and introduced to the therapeutic platform in a "hands-on" session. They were provided with information about the theoretical-therapeutic background to the therapy and the design and implementation process of the virtual reality human-human interface in practice. Each step of the therapeutic process was explained. Following this, they created an avatar and customised its voice before experiencing it through virtual reality (VR). Thus, they first created and customised their Avatar for therapy in the patient's role, following which they carried out a session in the therapeutic role. Following the session participants completed the System Usability Scale for each component.

Statistical Analysis

Descriptive statistics (percentages, means, standard deviations) were used to represent the demographic characteristics of the sample. Differences in the sample were calculated using the chi-square test for proportions. An ANOVA was performed on continuous variables. The SUS score for the system was calculated: Scores for the avatar creation tool (VRAT-CT) and the control center (VRAT-CC) were evaluated separately. The system's SUS was evaluated at both item level and global score.

Additionally, a multilevel factor analysis was conducted. Results are presented as graphics and tables. Statistical analysis was performed using the statistical language program "R" (Version 4.0.3, *http://www.R-project.org*).

Ethics:

The study was designed to comply with current ethical standards and local regulations. The ethics committee of the Canton of Zurich approved the study protocol (BASEC 2019-01386). The study is registered at clinicaltrials.gov (NCT04099940).

Results:

Sample Demographics

In total, 109 staff members were introduced to the therapy. The sample comprised of: psychotherapists *(n*=40), nursing staff (*n*=43), and administrative personnel (*n*=26); with a mean age of 34.76 ± 12.69; 74 participants were female (67.89%). There were no statistically significant differences regarding age or gender distribution among the different professions. Further details of the sample are summarised in Table 1.

Table 1: Sample characteristics and outcome evaluation.

	Profession				
	Psychotherapists	Nursing Staff	Administrative Personnel		
	n = 40	n = 43	n = 26	Statistics	p
Age (mean±SD)	33.25 ± 9.00	33.51 ± 15.85	30.15 ± 10.60	F (2, 106) = 2.09	0.129
Gender					
Female (%)	21 (52.50%)	31 (72.09%)	19 (73.08%)	X^2 (2, 109) = 4.451	0.108
SUS- Score					
Global (mean±SD)	86.44 ± 8.79 [a, b]	79.01 ± 13.30	77.98 ± 10.72	F (2, 106) = 6.136	0.003
VR- Avatar (mean±SD)	87.00 ± 9.83 [a, b]	79.71 ± 13.56	78.08 ± 12.50	F (2, 106) = 5.597	0.005
Control Center (mean±SD)	85.88 ± 9.53 [a, b]	78.31 ± 14.54	77.88 ± 11.68	F (2, 106) = 5.064	0.008

Post-hoc analysis, with Bonferroni Correction. [a] Psychotherapists > Nursing Staff. [b] Psychotherapists > Administrative Personnel

Evaluation Outcomes, System Usability Scale

There were no missing items, therefore, no imputation of values was necessary. The SUS scores were normally distributed with few outliers. The mean SUS global score was 81.49 ± 11.10. The mean score for the VRAT-CT was 82.00 ± 12.55 and the mean for the VRAT-CC 80.99 ± 12.67. Male participants scored slightly higher (81.71 ± 15.24) than female participants (81.39 ± 11.19), but this difference was not statistically significant (See Table 1). Among the professional groups, psychotherapists (86.44 ± 8.79) scored higher than nursing staff (79.01 ± 13.30) and administrative personnel (77.98 ± 10.72). The difference between psychotherapists and other professional groups reached statistical significance (F (2, 106) = 6.136; p = 0.003) (See Table 1 and Figure 2).

Insert Figure 2

Multilevel Factorial Analysis (MLFA)

The System Usability Scale produced a Cronbach's alpha value of 0.80 with good correlation between single items. Item loadings ranged from 0.2 to 0.8. The MLFA performed with Chi-Square < 0.001; a Comparative Fit Index (CFI) of 0.905, Sample-size adjusted Bayesian Information Criterion (BIC) of 5028.078 and a Root Mean Square Error of Approximation (RMSEA) of 0.075

demonstrated different factor structures for each profession (See Table 2).

Table 2: Mean Score on the System Usability Scale and Loadings for each Item.

	Profession							
	Psychotherapists		Nursing Staff		Administrative Personnel			
	Loadings	Mean (SD)	Loadings	Mean (SD)	Loadings	Mean (SD)	Statistic	p
Item 01	0.489	4.42±0.67[b]	0.356	4.16±0.79	0.396	3.92±1.04	F (2, 215) = 6.048	0.003
Item 02	0.591	1.25±0.46[b]	0.670	1.35±0.59[c]	0.687	1.60±0.66	F (2, 215) = 5.993	0.003
Item 03	0.672	4.453±0.57	0.665	4.28±1.01	0.565	4.33±0.86	F (2, 205) = 1.929	0.148
Item 04	0.520	2.00±1.07[a,b]	0.428	2.49±1.26	0.328	2.81±1.28	F (2, 215) = 97.663	<0.001
Item 05	0.500	4.44±0.65	0.405	4.31±0.58	0.575	4.38±0.53	F (2, 215) = 0.896	0.410
Item 06	0.523	1.30±0.54[a,b]	0.513	1.73±0.90	0.579	1.79±0.64	F (2, 215) = 10.070	<0.001
Item 07	0.335	4.31±0.76	0.805	4.24±0.85	0.554	4.08±0.62	F (2, 215) = 1.3510	0.223
Item 08	0.501	1.30±0.58[a]	0.506	1.71±1.13	0.793	1.40±0.57	F (2, 215) = 4.946	0.008
Item 09	0.561	4.22±0.73[b]	0.523	3.90±1.01	0.5552	3.81±0.97	F (2, 215) = 4.219	0.016
Item 10	0.291	1.50±0.78[b]	0.566	2.02±1.13[c]	0.535	1.73±0.79	F (2, 215) = 6.519	0.002

Post-hoc analysis, with Bonferroni Correction. [a] Psychotherapists > Nursing Staff; [b] Psychotherapists > Administrative Personnel; [c] Nursing Staff > Administrative Personnel

Discussion:

The usability, of a digital psychotherapeutic tool developed using a game engine was studied in different professions. The SUS score obtained for the virtual reality human-human interface achieved the benchmark for an excellent system [23, 24], scoring highest among the professional target group. The sample's demographic characteristics did not affect these results: the SUS score was similar regardless of age or gender. To the best of our knowledge this is the first study assessing the usability of a psychotherapeutic VR treatment tool for people experiencing acoustic verbal hallucinations.

Our study's main strengths are the large sample size and the naturalistic design, particularly the personalised introduction and the practical “hands-on” approach to the system [16, 17]. We chose this approach to emulate the introduction and instruction used by psychotherapists in research and clinical practice. Furthermore, through the personalised introduction to the system, we sought to compensate for differences in theoretical background between professional groups.

The system usability scale was originally developed to evaluate the usability of products and services, including hardware, software, mobile devices, websites and applications. Due to the nature of the product developed, together with the previous use of the SUS to test medical devices and products [25-27], we selected this tool, thus enabling easy comparison with both similar and dissimilar products or devices [23]. In this comparison, the digital therapeutic system tested yielded a score ranging from good to excellent depending on professional background [23, 24].

The virtual reality human-human interface achieved a higher score amongst those professions with psychotherapeutic backgrounds (i.e. Psychiatrists and Psychologists). Since all participants were naive to the system, differences cannot be attributed to user experience [28]. In our opinion, this difference underscores the requirement for relevant training and professional background in order to fully understand and use the virtual reality therapeutic tool which we have created [16]. Post hoc analysis revealed no differences between psychiatrists and psychologists. We therefore consider this a unique group with psychotherapeutic training as (foreseen in Switzerland) the common factor [29-31]. Beside this, the similarities between psychologists and psychiatrists regarding educational level and awareness of relevant research should also be taken into account [32].

The SUS scale was designed as a global measure of perceived usability. Attempts thus far to identify an underlying factor analysis have, however, been misleading and mainly reflected its

alternating structure [33]. Nonetheless, we analysed the SUS at item level to discern differences potentially attributable to the skill- grade mix of the participants. The SUS scale yields similar scores between psychotherapists and non-psychotherapists only for items 3, 5, and 7. These items are more closely related to the handling of the system than to its actual implementation and use in research and clinical practice. The SUS scale also has a different factor structure for each profession, indicating different evaluation patterns for the usability of the system. This leads us to believe that the system is generally easy to use, allowing therapists to quickly become familiar with it and develop confidence, thereby increasing the likelihood of incorporating this system into their therapeutic repertoire and using it to deliver therapy [17, 34].

Our study has several limitations, which must be acknowledged. Firstly, we did not include a clinical population. Although people experiencing verbal acoustic hallucinations were involved in the development process [18], they were not systematically involved in evaluating the system. At this stage we chose to focus on the therapeutic end user, since they will be responsible for introducing and guiding patients through the system and afterwards conducting the therapy sessions. Another factor in our study was the use of only a single session for evaluation purposes. This approach was chosen with the intention of assessing the intuitive usability of the system and to avoid learning effects. We did not compare our therapeutic system with other technical possibilities, such as a non-VR presentation of the Avatar or the use of mobile or handheld devices. It is possible that such technical alternatives may yield a higher usability score. Finally, although no discomfort or side effects were reported, we did not systematically assess these important issues related to the use of VR technology [18].

We were able to demonstrate that a virtual reality human-human interface for research and clinical practice can be developed using an existing and widely available game engine. The results show that the usability of the digital therapeutic tools depends not only on the system itself but also on the user's professional background. We believe this system may enable and encourage psychotherapists to expand their therapeutic skills, routinely using this technology in research and clinical practice [15, 35-37]. In summary, gaming technology and platforms seem to be suitable for the creation and customisation of novel therapeutic approaches in psychiatry with high usability scores.

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Conflicts of interest

"None declared."

Multimedia Appendix 1: [Virtual Reality Human-Human Interface]

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Figure 1: Virtual Reality Human-Human Interface.

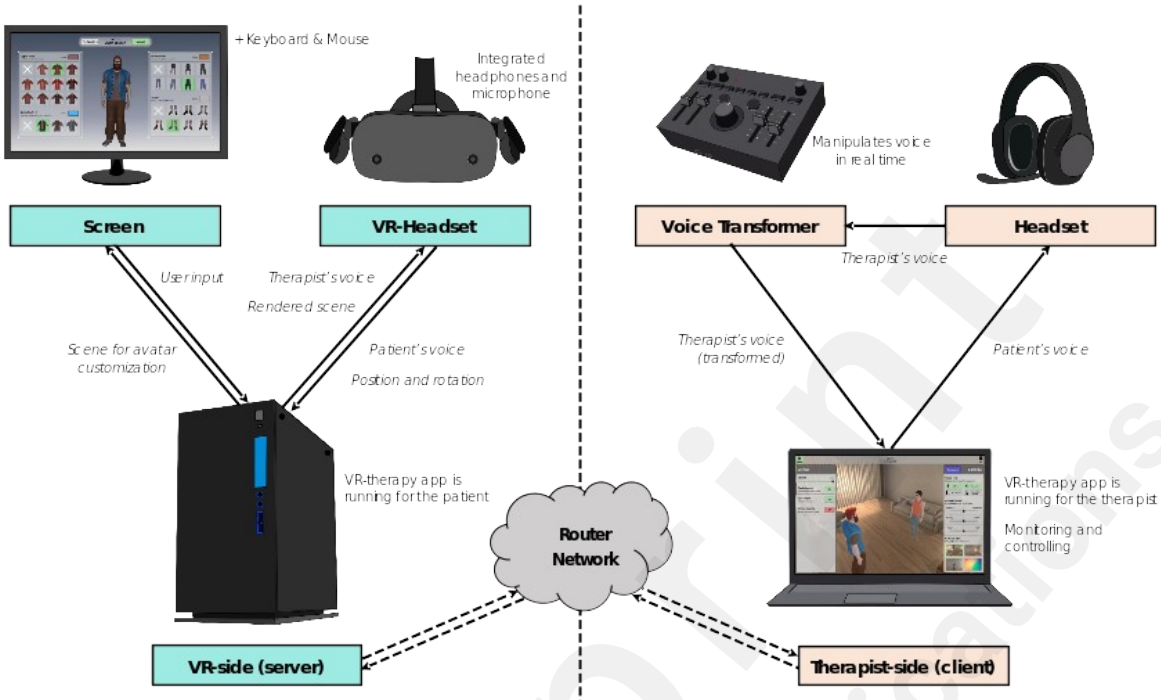
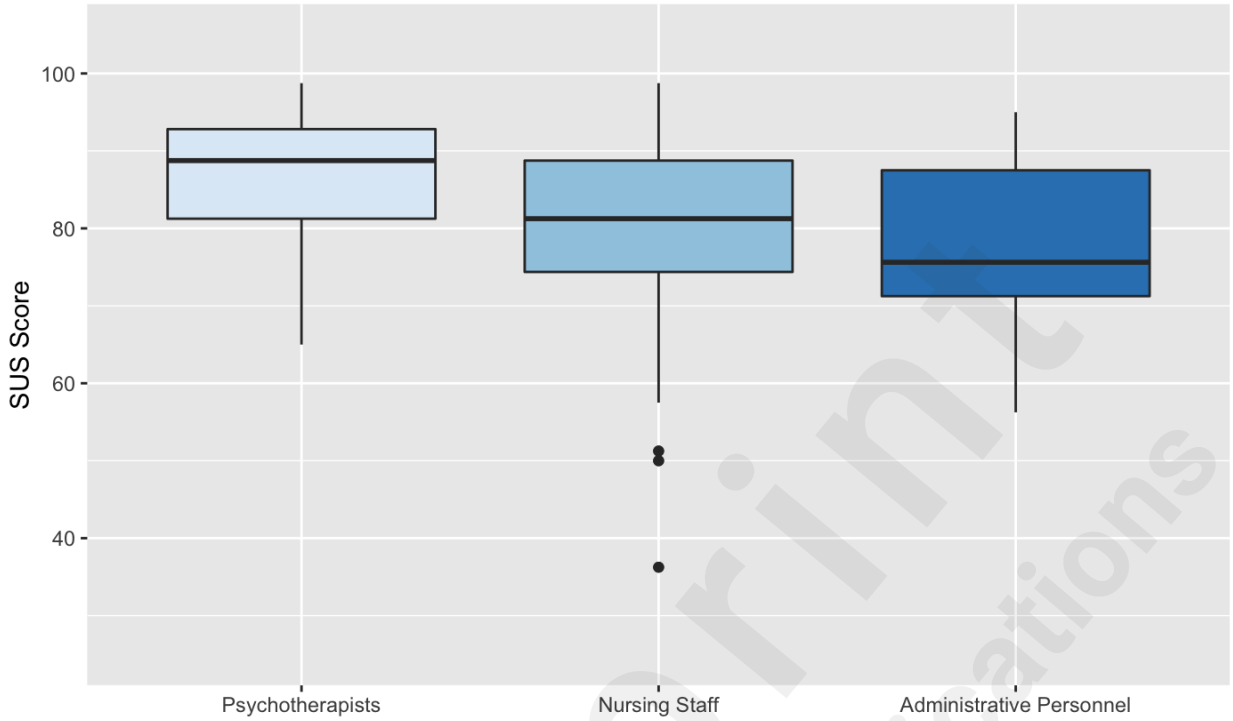


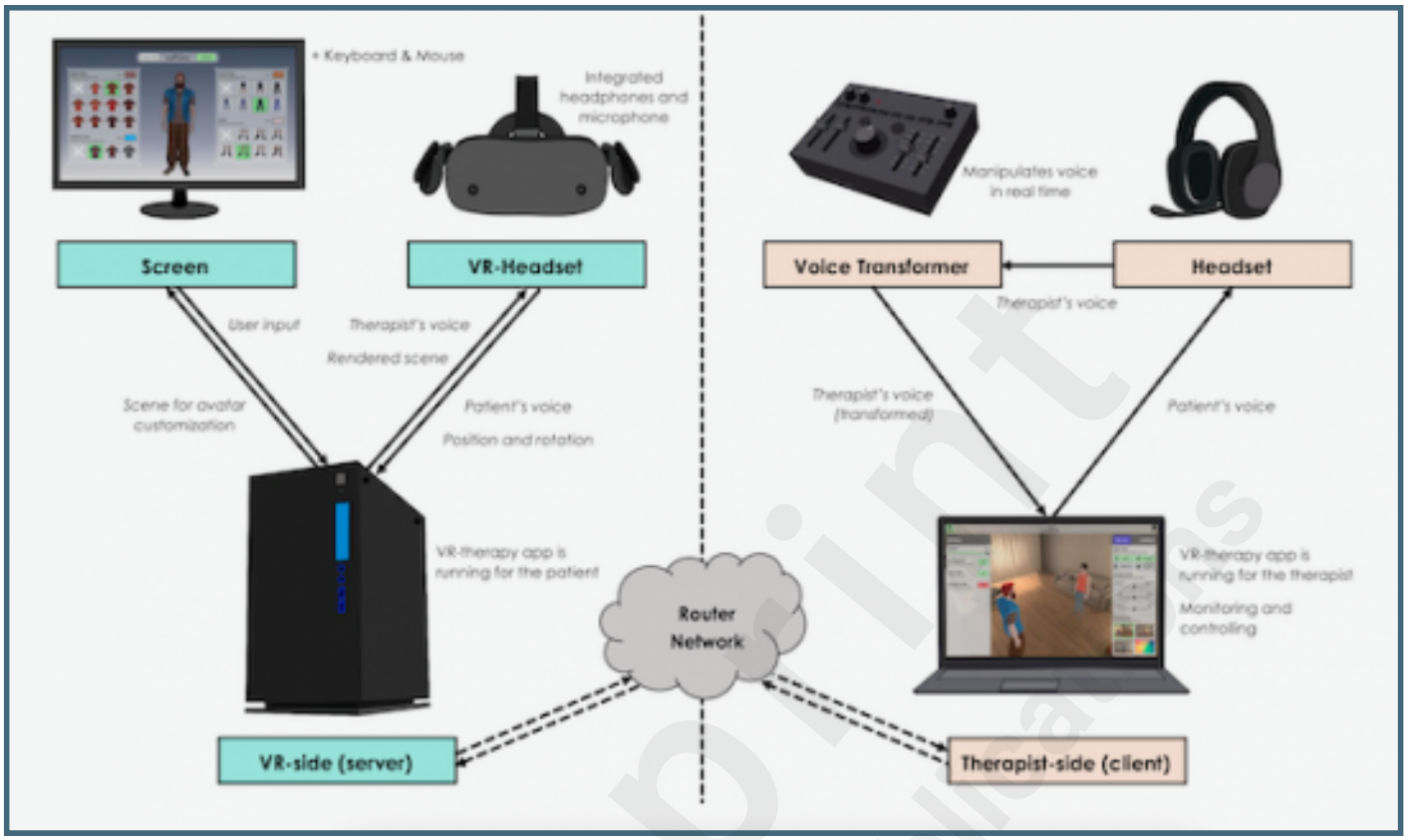
Figure 2: SUS-Scores, according to the participants' profession and the virtual reality Human-Human Interface System Component. Psychotherapists scored significantly higher than nursing staff and administrative personnel (F (2, 106) = 6.136; p = 0.003).



Supplementary Files

Figures

Virtual Reality Human-Human Interface.



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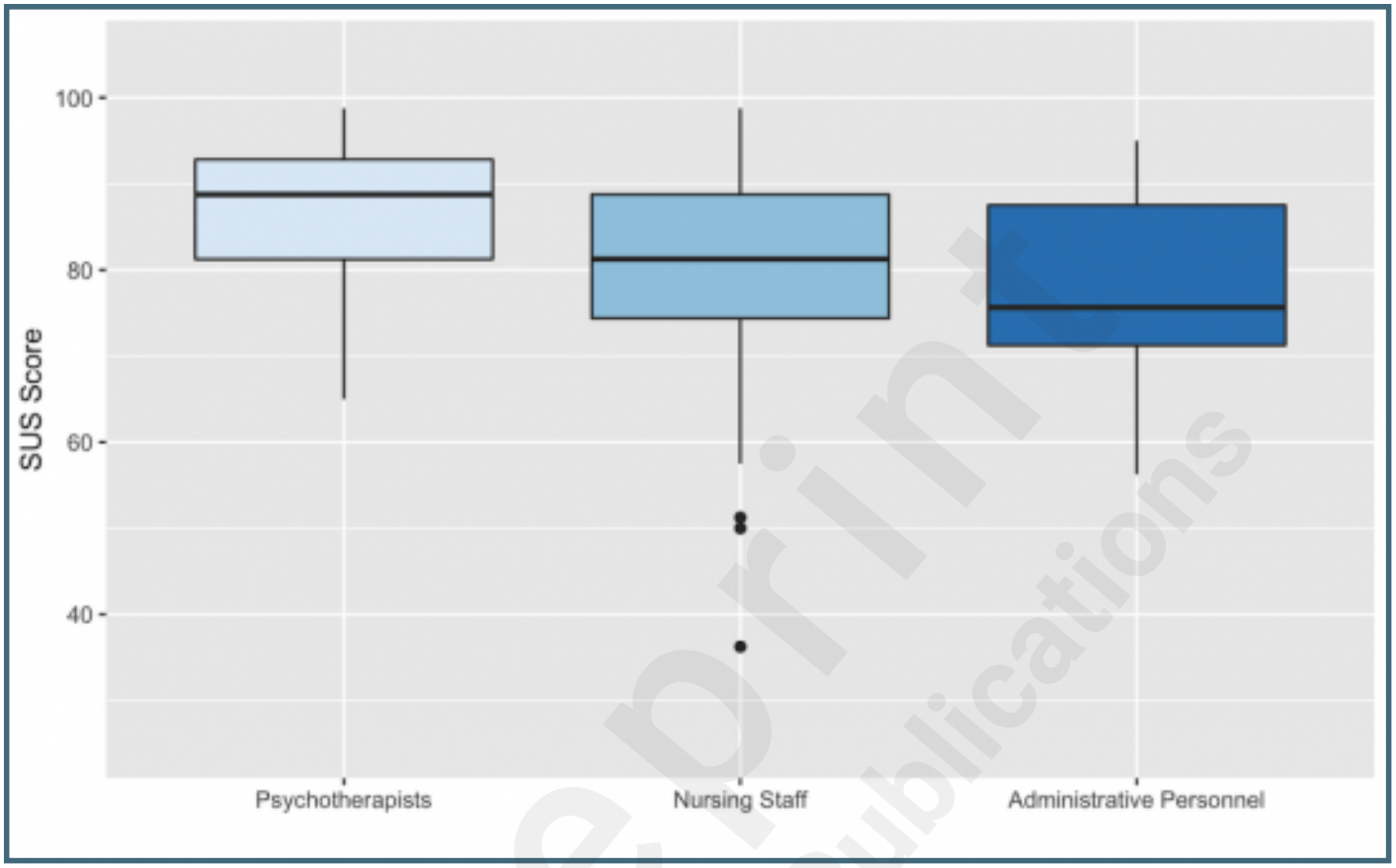

Multimedia Appendixes

Virtual Reality Human-Human Interface.
URL: http://asset.jmir.pub/assets/a906d97acbe91eb8a6b0da16191ab4a7.mp4