Measuring Co-Presence and Social Presence in Virtual Environments - Psychometric Construction of a German Scale for a Fear of Public Speaking Scenario

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Measuring Co-Presence and Social Presence in Virtual Environments – Psychometric Construction of a German Scale for a Fear of Public Speaking Scenario

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Abstract. Virtual reality exposure therapy (VRET) applications use high levels of fidelity in order to produce high levels of presence and thereby elicit an emotional response for the user (like fear for phobia treatment). State of research shows mixed results for the correlation between anxiety and presence in virtual reality exposure, with differing results depending on specific anxiety disorders. A positive correlation for anxiety and presence for social anxiety disorder is not proven up to now. One reason might be that plausibility of the simulation, namely including key triggers for social anxiety (for example verbal and non-verbal behavior of virtual agents that reflects potentially negative human evaluation) might not be acknowledged in current presence questionnaires. A German scale for measuring co-presence and social presence for virtual reality (VR) fear of public speaking scenarios was developed based on a translation and adaption of existing co-presence and social presence questionnaires. A sample of N = 151 students rated co-presence and social presence after using a fear of public speaking application. Four correlated factors were derived by item- and principle axis factor analysis (Promax rotation), representing the presenter's reaction to virtual agents, the reactions of the virtual agents as perceived by the presenter, impression of interaction possibilities, and (co-)presence of other people in the virtual environment. The scale developed can be used as a starting point for future research and test construction for VR applications with a social context.

Keywords. Co-presence, social presence, social anxiety, virtual environments, psychometrics

1. Introduction

Virtual Reality Exposure Therapy (VRET) has been proven to be a successful means and a promising supplement for conventional interventions like cognitive behavioral therapy [1]. Applications for anxiety disorder treatment often use high levels of fidelity with the goal of producing a realistic experience for the user, thereby creating high levels of presence [2]. Researchers state that presence has a key role in VRET for anxiety disorders [1]. It is assumed that presence leads to the experience of fear and

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anxiety as emotional states in virtual environments [1, 3]. These states have to be induced in order for the clients to confront them and train certain skills to overcome their fear [4]. However, state of research shows mixed results for a correlation between anxiety and presence. Maybe key triggers for social anxiety - verbal and non-verbal behavior that reflects potentially negative human evaluation – might not be acknowledged in current presence questionnaires [3]. The paper presented deals with the psychometric development of a German scale measuring co-presence and social presence for a fear of public speaking scenario, intending to do a first step in order to close this research gap.

2. Related Work and Rationale

Presence can be described as a user's subjective psychological response to a VR system or the sense of "being there" [5]. Virtual presence is well researched, which has led to many proposed measures (especially self-report questionnaires; for an overview see [6]). However, a meta-analysis [3] found a medium correlation between presence and anxiety, but the effect size differed strongly across anxiety disorders, with a null-effect for social anxiety. Ling et al. [3] argue that "one might conclude that subjective presence measures do not capture the essential sense of presence that is responsible for activating fear related to social anxiety in individuals." (p. 8f.), as most presence questionnaires focus on virtual presence or place illusion [7]. According to Slater [7], another presence component has to be taken into account: plausibility refers to the impression that what happens in the virtual world really happens - in spite of the knowledge that it is mediated by technology [3]. In the case of social anxiety, a simulation should include virtual human behavior actions that can be used as indicators for positive or negative human evaluation. Recent developments include more or less realistic virtual human behavior actions (for fear of public speaking see for example [8]), and the state of research underlines the effectiveness of VRET and training applications for fear of public speaking treatment [9, 10]. In order to capture related presence experiences in this social context, researchers recognize two additional types of presence: co-presence and social presence [6] that are seen as interrelated [11].

According to Youngblut [6], co-presence is defined as "[…] the subjective experience of being together with others in a computer-generated environment, even when participants are physically situated in different sites." (p. 4). The "others" named in the definition don't have to be human beings but may also be computer-generated agents [6]. Social presence goes a step further than co-presence to address the social psychological idea of personal interaction. Youngblut defines social presence following Biocca's suggestion [12] as follows: "Social presence occurs when users feel that a form, behavior, or sensory experience indicates the presence of another individual. The amount of social presence is the degree to which a user feels access to the intelligence, intentions, and sensory impressions of another". Following Biocca, Harms, and Gregg [13], social presence is a multidimensional construct in itself, comprising perception of co-presence, psychological involvement, and behavioral engagement.

In the following sections, a psychometric questionnaire construction for co-presence and social presence for a virtual fear of public speaking scenario is presented.

3. Method

Items from the Networked Minds Measure of Social Presence [13], GlobalED Questionnaire [14], Para-Social Presence Questionnaire [15], as well as items from related work [11, 16–19] measuring co-presence and social presence were translated into German and adapted to a fear of public speaking scenario. The questionnaire draft focused on audience behavior cues, the speakers perception of the audience, and perceived speaker-audience interaction possibilities. A student sample (N = 151) used a virtual training application for fear of public speaking by giving a presentation in front of a virtual audience and was then asked to rate co-presence and social presence by means of a 28-item questionnaire. The subscales were derived by item- and principal axis factor analysis (PFA) with Promax rotation (K = 4). Fourteen items were deleted due to cross-loadings and theoretical plausibility, another item was deleted during the item analysis due to corrected item-total correlation < .30.

4. Results

Four correlated factors (r > .08) were derived in accordance to the eigenvalue criterion > 1, explaining a total of 55.55 % of variance (see Table 1). Factor loadings for the four resulting subscales and their respective items are illustrated in Table 2.

Table 1. Eigenvalues, Percentages of Variance, and Cumulative Percentages for PFA Promax Four-Factor Solution for Co-Presence and Social Presence (KMO = .75).

Factor	Eigenvalue	% of variance	Cumulative %
1. Presenter's Reaction to Virtual Agents	3.68	24.53	24.53
2. Perceived Virtual Agents' Reaction	2.25	15.01	39.54
3. Impression of Interaction Possibilities	1.26	8.40	47.94
4. (Co-)Presence of other people	1.14	7.61	55.55

The first factor can be summarized as the presenter's reaction to the virtual agents, measuring behavioral engagement (that the audience's behavior influenced the speaker's style of presentation), the speaker's psychological involvement, including emotional (mood) as well as cognitive responses (distraction).

The next factor measured the virtual agents' reactions to the speaker, or rather as they are interpreted by the speaker. Again, behavioral engagement (the audience is perceived as being influenced by the speaker's actions) and psychological involvement (the audience is influenced by the speaker's mood) load on this factor. It has to be noted though, that some of the items loading on this factor are mirror items for factor 1: addressing the same aspects of social presence, but the speaker attributes psychological and behavioral involvement to the virtual agents.

The third factor addresses what social presence distinguishes from co-presence, the perception of interaction possibilities that go beyond the mere acknowledgement of other people's presence in a virtual environment. The factor addresses that the speaker is perceived by the audience, as well as feelings of connectedness, and potential interaction.

The last factor corresponds to the definition of co-presence given above: the feeling that other human beings share the same virtual space, with a negative item of feeling alone in the environment.

All items showed sufficient corrected item-total correlations > .41 for their respective scales, with a decrease of Cronbach's alpha if items would have been excluded.

Table 2. Factor Loadings for PFA Promax Four-Factor Solution for Co-Presence and Social Presence Scales (Items translated into English)

Item	Factor Loading
Factor 1: Presenter's Reaction to Virtual Agents (α = .85; n = 141)	
The people's behavior influenced my style of presentation.	.869
The people's behavior had an influence on my mood.	.799
I reacted to the people's behavior.	.729
I was easily distracted by the people.	.628
Factor 2: Perceived Virtual Agents' Reaction (α = .81; n = 82)	
Sometimes the people were influenced by my mood.	.875
Sometimes the people were influenced by my style of presentation.	.821
The people reacted to my actions.	.734
I was able to interpret the people's reactions.	.500
Factor 3: Impression of Interaction Possibilities (α = .80; n = 139)	
I had the feeling to interact with other human beings.	.796
I felt connected to the other people.	.762
I had the feeling that I was able to interact with people in the virtual room.	.753
I had the impression that the audience noticed me in the virtual room.	.625
Factor 4: (Co-)Presence of other people (α = .71; n = 140)	
I was aware that other people were with me in the virtual room.	.699
I had the feeling that I perceived other people in the virtual room.	.680
I felt alone in the virtual environment.	.543

Note: N = 75 (due to listwise case exclusion) and α = .77 for entire measure.

Factor 1 to 3 showed sufficient reliability with Cronbach's α > 80. This criterion was not met by the fourth factor (Presence of other people), showing Cronbach's α = .71, probably due to the low item number. However, the other dimensions of social presence (psychological involvement and behavioral engagement) as postulated by Biocca et al. [13], are also presented in the factor structure. Therefore, co-presence was included nevertheless, forming a basis for further item development and future scale construction.

5. Discussion

A German scale measuring co-presence and social presence for fear of public speaking scenarios was developed based on items of existing questionnaires and items from the state of research. Four correlated subscales were derived, measuring the presenter's reaction to virtual agents, perceived virtual agents' reaction to the presenter, impression of interaction possibilities, and presence of other people in the virtual space (co-presence). However, the work presented has several limitations. A student sample rated co-presence and social presence with a German questionnaire. Further, the questionnaire was used to evaluate an alpha-version prototype of a fear of public speaking application including an audience of 30 people. Different settings (raters, VR applications and cultural background and questionnaire language) as well as a more advanced prototype may lead to different ratings. Future research should replicate and supplement our test construction findings for different settings. Still, the study can serve as a starting point for future research and on-going test construction, helping to analyze the interrelations between social anxiety and presence in more detail.

Acknowledgements

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