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A virtual reality application in role-plays of social skills training for schizophrenia: A randomized, controlled trial

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ABSTRACT

Although social skills training (SST) is an effective approach for improving social skills for schizophrenia, the motivational deficit attenuates its efficacy. Virtual reality (VR) applications have allowed individuals with mental disabilities to enhance their motivation for rehabilitations. We compared SST using VR role-playing (SST-VR) to SST using traditional role-playing (SST-TR). This randomized, controlled trial included 91 inpatients with schizophrenia who were assigned to either SST-VR ($n=46$) or SST-TR ($n=45$). Both groups were administered over 10 semiweekly group sessions. An experienced, blinded rater assessed vocal, nonverbal and conversational skills. We also obtained data on motivation for SST and various social abilities. Throughout the 10 sessions, the SST-VR group ($n=33$) showed greater interest in SST and generalization of the skills than the SST-TR group ($n=31$). After SST, the SST-VR group improved more in conversational skills and assertiveness than the SST-TR group, but less in nonverbal skills. The VR application in role-plays of SST for schizophrenia may be particularly beneficial in terms of improving the conversational skills and assertiveness, possibly through its advantages in enhancing motivation for SST and generalization of the skills, and thus it may be a useful supplement to traditional SST.

1. Introduction

Although there is general agreement that social skills training (SST) is one of the beneficial approaches in improving social functioning in patients with schizophrenia, the motivational deficit attenuates its efficacy (Bustillo et al., 2001; Kopelowicz et al., 2006; Pfammatter et al., 2006; Kurtz and Mueser, 2008). Some board-game featured SST programs have been developed to overcome this difficulty and have been suggested to be effective (Liberman, 1972; Torres et al., 2002). Furthermore, it was suggested that using virtual reality (VR) technology during SST might be effective in improving the motivational problem (Ku et al., 2007).

A VR system has been recognized as a promising tool for assessment and treatment of mental illnesses (Gregg and Tarrier, 2007). For example, the virtual environment can facilitate role-playing as participants do not have to rely on imagination for the given social context of the scenario. A user of the VR system feels like he/she is in the virtual environment rather than his/her actual physical location, a feature called the "presence". Thus, VR technology creates not simply "look-like" but rather "real-like" environments and allows social interaction with avatars or virtual humans (Tarr and Warren, 2002; Riva et al., 2004; Rizzo et al., 2004; Sanchez-Vives and Slater, 2005).

Our group has shown that VR can be used to assess cognitive (Ku et al., 2003), emotional (Ku et al., 2005), and behavioral (Ku et al., 2006) characteristics of patients with schizophrenia. Furthermore, it is also useful for enhancing attention (Cho et al., 2002) and daily living activities (Lee et al., 2003). Other researchers have proposed that VR can provide a tool for cognitive training in individuals with physical or mental disabilities to improve attention, memory and learning abilities (Riva et al., 2004; Jiang et al., 2005).

In order to examine the usefulness of VR in social rehabilitation, this study was designed to compare SST using VR role-playing (SST-VR) to that using traditional role-playing (SST-TR). A learning method focused on motivational enhancement is a well-established approach to improve attention and the outcomes of skills training in patients with schizophrenia (Silverstein et al., 2009). Our pilot study (Ku et al., 2007) addressed that the VR application in role-playing of skills training for schizophrenia was beneficial in terms of enhancing their motivations.

The aim of this study was to find advantages of the use of VR in social rehabilitation for patients with schizophrenia. Based on our previous study, we hypothesized that the use of VR role-play for SST for schizophrenia could enhance training outcomes by boosting the participants' motivation for SST. In addition, we expected to find some

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advantages of the VR application in other social behaviors such as voice, nonverbal and conversational skills or social abilities such as assertiveness, interpersonal relationship skills, social problem solving, and generalization.

2. Methods

2.1. Participants

This study enrolled 91 participants with schizophrenia who were all inpatients of the Severance Mental Health Hospital, Yonsei University College of Medicine. They were evaluated using the Structural Clinical Interview for DSM-IV Axis I, Patient Edition (SCID-P) (First et al., 1996), administered by a trained psychiatrist. In order to select subjects who were most likely to benefit from the use of VR technology, all participants were recruited between the ages of 18 and 45 years old. They had no problems such as substance abuse or dependence, head trauma history, neurological illness, or physical illness that could affect brain functioning as well as other Axis I diagnosis.

Participants were treated with intensive psychiatric care for two to four weeks, and stabilized enough to learn the skills without disrupting a session at the time when the baseline assessment was performed. Then, they were randomly assigned to either SST-TR ($n=45$) or SST-VR ($n=46$). Prior to and after SST, severities of symptoms were assessed by an experienced psychiatrist using the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987). This study was conducted under the guidelines established by the institutional review board. After completely describing this study to participants, written consent was obtained.

2.2. Interventions

For each session of the two types of SST, rationale, steps of the skill, scenes used in role-plays, and special considerations were manualized on the basis of the guides suggested by Bellack et al. (2004). Both types of SST were administered over 10 semiweekly sessions for five weeks, which were a modified version to complete the training in the inpatient setting. The sessions consisted of three consecutive trainings: five sessions of conversation skills training ("Introduce yourself", "Find a common concern and listen to the other person", "Start a conversation", "Maintain a conversation", and "End a conversation"), three sessions of assertiveness skills training ("Make a demand", "Reject a demand of another person", and "Make a compromise"), and two sessions of emotional expression skills training ("Express positive emotions" and "Express negative emotions"). Homework from the previous session was reviewed in the beginning of the next session. Every session included a therapist modeling followed by the participant's role-playing, and then positive and corrective feedback from the therapists. After identifying deficient skills, the participant was engaged again in another role-play of the same scene, and also was provided with feedback. Every session included three role-plays with different scenes per participant. Therapists consisted of a main therapist (HJJ) and co-therapists who were skilled social workers, and the main therapist performed both types of SST.

A difference between the two SST types was in the method for a role-play. The virtual environments as simulators of the scenes and avatars as the actors were used in VR role-plays, whereas verbal, writing, picture, and video supplies as simulators of the scenes and SST therapists as the actors were used in TR role-plays. Thus, except for the materials used in role-plays, there were no differences in the details of training including time spent for instructions, orientation, and contact with the main therapist. To examine the effects of role-plays (VR vs. TR), we controlled potential confounding effects of the other SST constituents. For example, both types of SST were conducted within 90 min with a similar number of group members (four to five) in every session. Because the attendance rate reflects motivation for SST, we controlled the effects of passive attendance by performing the same sequential processes to encourage attendance: waiting until the set time, broadcasting of announcements, and a therapist's simple recommendation.

2.3. VR devices and VR role-plays

The VR system included a personal computer for rendering and providing the virtual environment, a head mounted display (HMD; Eye Trek FMD 250W, OLYMPUS) for displaying the virtual environment in a more immersive manner, and a position tracker (InterTrax2, InterSense) for following the head direction in real time. The participants were able to move their heads to direct their gaze in a natural manner, and the display of the virtual environment depended on the orientation data obtained from the participants' head direction as measured by the fixed tracker attached to the HMD. VR role-plays were displayed through two different panels: an HMD and a 120 inch-screen. The participant wore the HMD and the position tracker, which provided "immersive" virtual environments, and the rest of the group members observed the same scenes on the big screen.

SST-VR was different from SST-TR in that it included core features of role-playing games. For example, the participant wearing the HMD was provided with a joystick and buttons to operate his/her avatar, which produced the first-person perspective view. By using the joystick and buttons, he/she freely moved and interacted with avatars in the virtual space.

Fig. 1 presents the examples of SST with VR role-plays. Some parts of conversation skills training provided multiple choices on the questions so that the participants searched through a list of possible answers and selected an answer using the button. Helper avatars were included for positive feedback when the participants performed an advisable play and corrective feedback for an unadvisable play. On the other hand, real execution such as speaking and expressing emotion toward avatars was encouraged as a response during other parts of conversation skills training and whole parts of assertiveness and emotional expression skills trainings. After the role-playing part was completed, additional feedback was provided by the therapists as was given in SST-TR. After each session, "simulator sickness" which consists of autonomic symptoms such as nausea, sweating, and dizziness related to the use of an immersive HMD was checked, and a post-session questionnaire and test were performed.

2.4. Outcome measures

2.4.1. Social skills

In terms of primary outcomes, we measured social skills such as voice quality, nonverbal skill and conversational properties using a performance-based measure of social competence. Social skills were assessed in the laboratory with unstructured role-play tests. An unstructured role-play test was used in the present study because a prior study suggested that such a format provided a more ecologically valid measure of social competence than briefer, highly structured role-play test (Torgrud and Holbom, 1992).

After one of the two therapists described the scenes, the participants were asked to perform the role-plays with the other therapist. We used the 10 role-play tests, of which each resembled one of the three scenes that were used in the role-plays in the corresponding session. An assistant was given a list of prompt lines (e.g., "Tell me about yourself" and "What are you going to do?") to be delivered should there been silence lasting more than 10 s. All participants' performances on the 10 role-plays were recorded on videotapes (audio and video). Behavioral ratings of social skills on the role-plays were made by another research assistant (JYP) who was with masters-level education in mental health social work. The two therapists knew the participants' SST conditions, whereas the behavioral rater was blind to the conditions.

Voice, nonverbal and conversational skills were rated using 29-items of the Trower's Social Behavior Scales (SBS) (Trower et al., 1978). The SBS used in this study consisted of six items on voice quality (volume, tone, pitch, clarity, pace, and speech disturbance), nine items on nonverbal skills (proximity, orientation, appearance, face, gaze, posture tonus, position, gesture, and autistic gesture of the nonverbal behaviors), and 14 items on conversational properties (length, generality, formality, variety, humor, nonverbal grammar, feedback, meshing, turn tasking, question, supportive routines, assertive routines, behavior in public, and situation-specific routines). The conversational skills represent the characteristics of contents and the contextual processing of conversation and are separate from the vocal or nonverbal skills during conversation. Overall skill was defined as an average of the three skill categories. Each item was rated on a scale of one to five. Scores on the overall skill and the three skill categories were converted into a 100-point scale, with higher scores indicating better skills.

For secondary outcomes, we selected three self-reports, each of which reflects a particular social ability with a weighted proximity to the site of the intervention. The first one was the Rathus Assertiveness Schedule (RAS) for assessing assertiveness (Rathus, 1973) on a six-point Likert scale. The report included 30 items such as "Most people seem to be more aggressive and assertive than I am." The next one was the Relationship Change Scale (RCS), which measures interpersonal relationship skills (Schlein and Guerney, 1977) on a five-point Likert scale. The report consisted of 25 items such as "In comparison with four weeks ago, my satisfaction with myself as a person is ( )." The last one was a short version of the Social Problem Solving Inventory-Revised (SPSI-R) to measure the individual's cognitive, affective, or behavioral responses to real life problem-solving situations (D'Zurilla et al., 2002). It was also a five-point Likert scale questionnaire with 25 items such as "When I have a problem, I usually believe that there is a solution for it." Scores on the three self reports were converted into a 100-point scale, with higher scores corresponding to better abilities.

2.4.2. Proxy measures of motivation and generalization

We made the post-session questionnaires and tests to obtain participants' opinions on motivation and generalization for each session. The two-item Interest-in-Participation Questionnaire evaluated participants' interest in the current session and their expectation for the next session on a scale of one to five, and the average score of the two items was used as a proxy measure of motivation. The post-session test of five questions with right-or-wrong answers related to the topics of the corresponding sessions was performed for a proxy measure of generalization (e.g., "You can get to know each other better when you share a conversation on a common subject", "The final goal of a compromise is to find a solution that can be accepted by both parties"). Higher scores on the post-session tests indicated that the participant more efficiently applied the learned skills into specific social knowledge. The scores of the two post-session measures were also converted into a 100-point scale, and were defined as the interest-in-participation score and the generalization score, respectively. Each of them was used as an index of motivation for SST or application of the skills to social knowledge.

2.4.3. Measures of overall skill changes

Using the post-SST questionnaire, we obtained scores on the contribution of four SST constituents (material, content, therapist, and structure) to overall skill

Fig. 1. Examples of social skills training with virtual reality role-plays.

improvement on a five-point Likert scale. These were defined as constituent-contribution (e.g., material-contribution) scores, each of which was an average of two items (e.g., material-contribution score was an average of the contribution of the satisfaction about the material and that of the material's applicability), with higher scores corresponding to greater contributions. The questionnaire also asked participants to identify which session was most helpful.

2.5. Statistical analysis

The final analysis included 33 participants in the SST-VR group and 31 participants in the SST-TR group. Scores on the baseline characteristics were compared using independent *t* test for continuous variables and χ^2 test for categorical variables. Scores on the post-session questionnaires and post-SST questionnaire were compared using analysis of covariance (ANCOVA) with the attendance rate as covariate. Data from the post-SST questionnaire of three SST-VR patients in session 10 and four SST-TR patients in session 10 were not included in the analysis due to loss of data. All missing values in the post-session questionnaire and test were due to the participants' absences. These were substituted by a within-group average. Pearson correlations were used to analyze relationships among the interest-in-participation score, the generalization score, and the change in overall skill. Significance was defined as $p<0.05$ (two-tailed) in all analyses.

3. Results

Fig. 2 describes the participants' progress in this study. There were no health problems such as simulator sickness that were related to the use of immersive HMD in the SST-VR group. Although there was no difference between the two groups in the drop-out rate, the SST-VR group showed a higher attendance rate than the SST-TR group (95.3 ± 6.8% and 91.0 ± 7.3%, respectively; $t_{62}=2.411$, $p=0.019$). As shown in Table 1, there were no differences in the baseline demographic and clinical characteristics.

There were no differences in positive, negative, and general symptoms of the PANSS in the post-SST evaluation, and there was no difference in the change in chlorpromazine equivalent dose from the baseline to the post-SST assessment between the two groups.

3.1. Social skills

For the primary outcomes of the SBS scores, there were significant group effects on the nonverbal skills ($F_{1,62}=6.981$, $p=0.010$, partial $\eta^2=0.101$) and time effect on all three of the outcomes ($F_{1,62}=89.364$, $p<0.001$, partial $\eta^2=0.590$ on the vocal skills; $F_{1,62}=22.664$, $p<0.001$, partial $\eta^2=0.268$ on the nonverbal skills; $F_{1,62}=101.227$, $p<0.001$, partial $\eta^2=0.620$ on the conversational skills). In addition, there were time × group interaction effects on the nonverbal ($F_{1,62}=6.201$, $p=0.015$, partial $\eta^2=0.091$) and conversational skills ($F_{1,62}=17.261$, $p<0.001$, partial $\eta^2=0.218$) of the SBS. Fig. 3 shows that the SST-VR group had greater improvement in the conversational skills than the SST-TR group, but lesser improvement

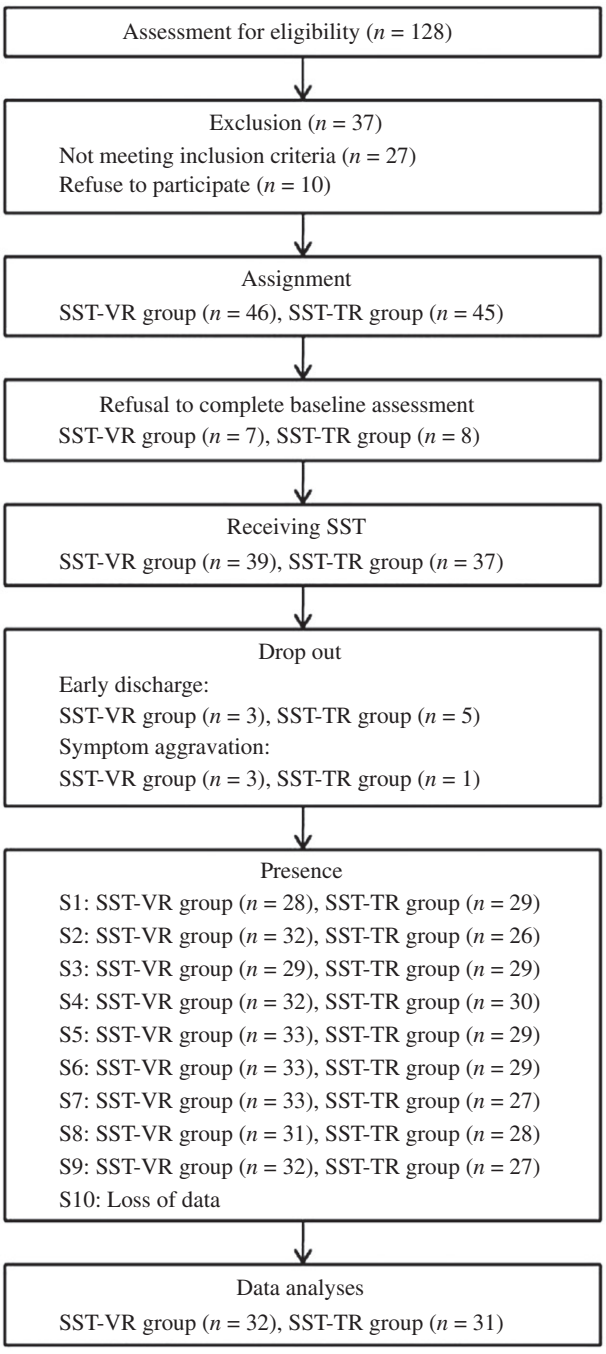

Fig. 2. Participants' progress in the study.

Table 1
Baseline characteristics in inpatients with schizophrenia who received either SST using virtual reality role-plays or SST using traditional role-plays.

	SST-VR group (n = 33)		SST-TR group (n = 31)		Statistics		
	n	%	n	%	χ^2	d.f.	p
Female	17	51.5	13	41.9	0.589	1	0.443
Unmarried	31	93.9	25	80.6	2.583	1	0.108
Patients with previous SST experience	7	21.2	9	29.0	0.521	1	0.470
Medications							
Atypical antipsychotics	30	90.9	29	93.5	0.155	1	0.694
Typical antipsychotics	6	18.2	5	16.5	0.047	1	0.828
Mood stabilizers	1	3.0	1	3.2	0.002	1	0.964
Antidepressants	1	3.0	3	9.7	1.205	1	0.272
Benzodiazepines	9	27.3	7	22.6	0.188	1	0.665
	Mean	S.D.	Mean	S.D.	t	d.f.	p
Age (years)	28.1	7.7	31.2	7.7	−1.581	62	0.119
Age at illness onset (years old)	22.3	5.9	25.4	7.0	−1.914	62	0.060
Duration of education (years)	13.7	2.2	13.7	2.1	−0.020	62	0.984
Duration of illness (years)	6.0	5.7	5.9	6.3	0.085	62	0.933
Previous psychiatric admissions	2.3	1.9	3.1	3.2	−1.236	62	0.221
PANSS (total)	73.3	12.6	71.4	12.7	0.615	62	0.541
Positive symptoms	18.1	5.3	17.0	5.1	0.787	62	0.434
Negative symptoms	18.9	4.8	18.4	4.7	0.496	62	0.622
General symptoms	36.3	8.6	36.0	8.9	0.879	62	0.153
SBS (overall skill)[a, b]	60.2	6.9	61.9	6.7	−0.976	62	0.333
Vocal skill[a]	58.4	11.7	58.7	12.3	−0.091	62	0.928
Nonverbal skill[a]	64.3	7.5	66.3	7.2	−1.088	62	0.281
Conversational skill[a]	58.1	11.9	60.7	9.1	−1.012	62	0.316
Rathus Assertiveness Schedule[a]	59.9	6.9	59.3	6.1	0.360	62	0.720
Relationship Change Scale[a]	62.9	12.0	64.9	11.8	−0.677	62	0.501
Social Problem Solving Inventory-R[a]	63.6	9.0	65.9	11.8	−0.880	62	0.382

Note: SST, social skills training; VR, virtual reality; TR, traditional; S.D., standard deviation; PANSS, Positive and Negative Syndrome Scale; SBS, Social Behavior Scale.
[a] Score was converted into a 100-point scale, with higher scores corresponding to better skills.
[b] Overall skill was defined as an average of the scores of the vocal, nonverbal, and conversational skills.

in the nonverbal skills. Moreover, these interaction effects were also observed even after the change in positive, negative, general, and total symptoms was considered a covariate ($p<0.05$).

For the secondary outcomes of the three self-reports, there were significant group effects on the RAS score ($F_{1,62}=4.391$, $p=0.040$, partial $\eta^2=0.066$) and time effect on all three of the outcomes ($F_{1,62}=26.167$, $p<0.001$, partial $\eta^2=0.297$ on the RAS score; $F_{1,62}=5.537$, $p=0.022$, partial $\eta^2=0.087$ on the RCS score; $F_{1,62}=715.374$, $p<0.001$, partial $\eta^2=0.920$ on the SPSI-R score). There was a time×group interaction effect on the RAS score ($F_{1,62}=4.957$, $p=0.030$, partial $\eta^2=0.074$). This effect was also found after controlling the change in the symptoms as a covariate ($p<0.05$), and showed that the SST-VR group had a greater improvement on the RAS score.

3.2. Interest, generalization and others

As shown in Table 2, the SST-VR group scored higher on interest-in-participation and generalization than the SST-TR group. Among the four contribution scores, only the material-contribution factor showed a difference between two groups; the SST-VR group reported higher scores on the material factors contributing to the efficacy of SST. For the question of which session was most helpful, participants in the SST-VR group (60.0%) more frequently indicated two sessions than the SST-TR group (18.5%): "session 7, reject a demand of another person" or "session 10, express negative emotion" ($\chi^2=10.159$, d.f. = 1, $p=0.003$).

3.3. Correlation analyses

Both groups exhibited relationships between the interest-in-participation score and the generalization score ($r=0.538$, $n=33$, $p=0.001$ in the SST-VR group; $r=0.587$, $n=31$, $p=0.001$ in the SST-TR group); between the interest-in-participation score and the change in overall skill ($r=0.430$, $n=33$, $p=0.012$ in the SST-VR group; $r=0.371$, $n=31$, $p=0.040$ in the SST-TR group); and between the generalization score and the change in overall skill ($r=0.482$, $n=33$, $p=0.005$ in the SST-VR group; $r=0.485$, $n=31$, $p=0.006$ in the SST-TR group). However, there were no relationships between the change in overall skill (and also those of the self-report measures) and either the changes in symptoms or that in the chlorpromazine equivalent dose ($p>0.05$).

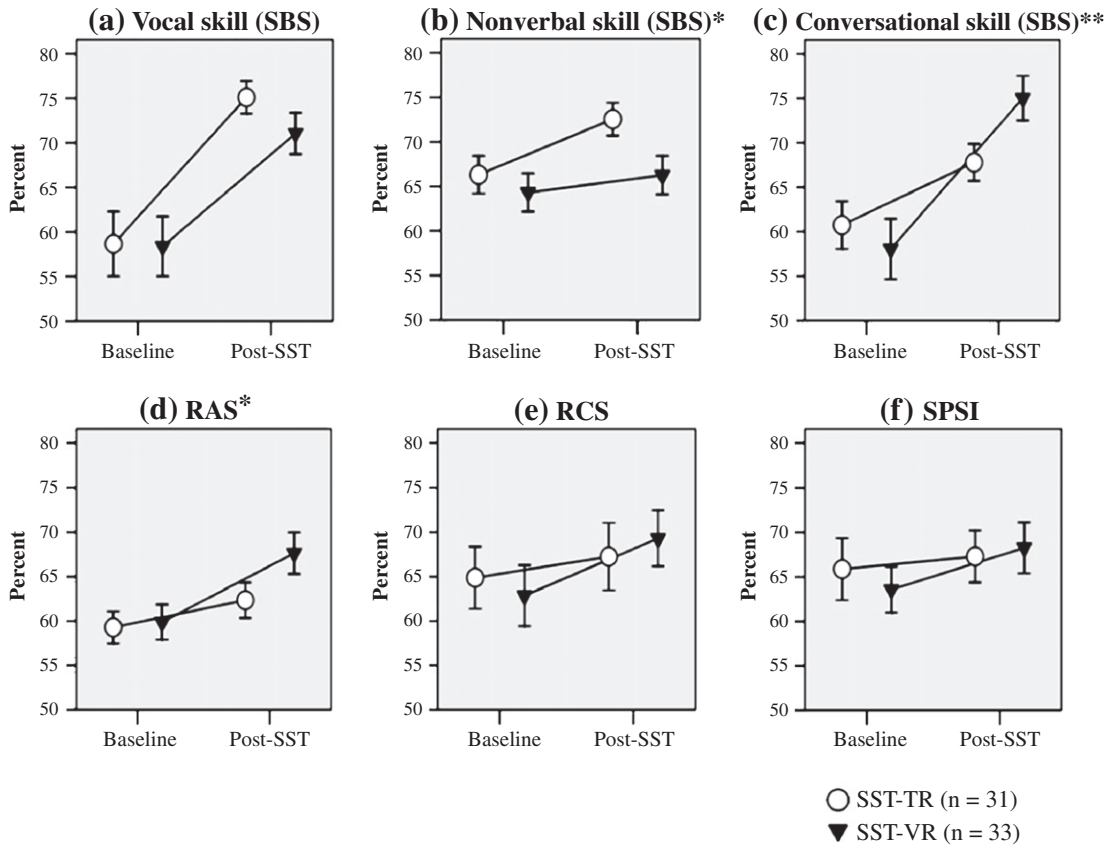

Fig. 3. Improvements in social skills of inpatients with schizophrenia who received either SST using virtual reality role-plays or SST using traditional role-plays. Significant time × group interaction effects were observed in (b) the nonverbal and (c) conversational skill of the SBS, and (d) on the RAS. SBS, Social Behavior Scale; SST, social skills training; RAS, Rathus Assertiveness Schedule; RCS, Relationship Change Scale; SPSI-R, Social Problem Solving Inventory-Revised; TR, traditional; VR, virtual reality. * = $p<0.05$. ** = $p<0.01$.

4. Discussion

The main hypothesis of this study was that the VR application would be advantageous in terms of enhancing motivation for SST. As hypothesized, patients who received SST-VR recorded higher interest-in-participation scores than SST-TR participants. In addition, the finding of a better attendance rate in the SST-VR group than the SST-TR group may also be evidence of motivational superiority of the VR application.

Table 2
Interest in SST, generalization of the skills, and factors contributing to the efficacy of SST in inpatients with schizophrenia who received either the SST using virtual reality role-plays or SST using traditional role-plays.

	SST-VR group ($n=33$)		SST-TR group ($n=31$)		Statistics[c]	
	Mean	S.D.	Mean	S.D.	F	p
Interest in social skills training[a]	81.5	10.0	75.5	8.8	7.176	0.009
Generalization of the skill[a]	88.0	6.0	82.9	10.0	4.778	0.033
Factors contributing to the efficacy of SST						
Material[b]	4.4	0.8	3.9	0.6	6.648	0.013
Therapist[b]	4.0	0.7	4.1	0.8	0.010	0.921
Content[b]	4.2	0.6	4.0	0.8	0.969	0.329
Structure[b]	4.2	0.7	3.9	0.9	1.720	0.195

Note: SST, social skills training; VR, virtual reality; TR, traditional; S.D., standard deviation.

[a] Scores, which were converted into a 100-point scale, indicates an average of the scores on all sessions, with higher scores corresponding to better interest and generalization.

[b] Data from three patients in the SST-VR group and four patients in the SST-TR group were lost. Scores were rated on a scale of one to five, with higher scores indicating greater contributions.

[c] Group difference were analyzed using the attendance rate as a covariate.

Some previous studies reported that motivation accounted for the relationship between social functioning and cognition in schizophrenia (Barch, 2005; Nakagami et al., 2008). Therefore, the motivational superiority of SST-VR can play an additional role in improving social skills via its relationship with cognition.

In fact, our findings showed that, in terms of overall social skills, the SST interventions produced meaningful improvement regardless of the type of SST. Instead, there were discriminative improvements on the subcategories of the social skills according to SST type. The SST-VR group showed an advantage in the conversational skills, whereas the SST-TR group showed a benefit in the nonverbal skills. In other words, the use of VR produced greater improvement in the conversational skills than SST-TR, but it was not as effective in enhancing the vocal and nonverbal skills. Still the VR application seems to be helpful for more effective application of the learned skills to social knowledge. Therefore, SST-VR may have also some advantages over SST-TR in terms of the skills improvements. In particular, the VR application may be clinically feasible for conversational skills training for patients with schizophrenia.

It was not directly evident why the advantage of the VR application was observed only in the conversational skills but not in the vocal and nonverbal skills. It seems worthy of notice that the items of the conversational skills reflected either reciprocal natures of social interactions (i.e., response length, use of social reinforcers, and turn taking) or social intelligence (i.e., behavior in public and situation-specific routines). In contrast, the items of the vocal and nonverbal skills included unidirectional natures of social interactions (Bellack et al., 2004). Similar to the commercial role-playing games (Rilstone, 1994), the gaming features of VR role-plays were based on the reciprocal nature and social intelligence rather than on the unidirectional nature of social interactions. In addition, providing multiple-

choice questions and immediate feedback by helper avatars in some parts of sessions were factors that helped participants more easily learn the conversational skills. Because of this, the gaming features of the VR role-plays appear to offer remarkable benefits for improving the conversational skills that are intimately linked with the reciprocal nature and social intelligence rather than those more related to the unidirectional nature of social interactions.

In contrast, the findings of this study indicated that SST-TR was advantageous with respect to nonverbal skills improvement than SST-VR. According to the "social learning theory," one of the theoretical bases of SST, people can learn through observation as well as positive reinforcement (Bandura, 1969). To improve the nonverbal skills such as proximity, gaze and posture tonus, interaction with real human and modeling by a therapist would play a crucial role. In addition, throughout the sessions of SST-VR, the evaluation of the participant's eye gazes and the facial expressions could be disturbed by the HMD covering the upper half of participant's face, and the evaluation of his/her postures, proxemics and kinetics could be hampered by the electric wires attached to the HMD. Because these limitations were relevant to the evaluation of the nonverbal skills, the SST therapists had particular difficulties in providing effective feedback to the nonverbal skills rather than the vocal and conversational skills. To date, therefore, VR role-plays seem unable to entirely replace TR role-plays. However, the technological advances in VR have opened research applications in behavioral neuroscience and rehabilitations of patients with severe physical or mental disabilities (Tarr and Warren, 2002; Riva et al., 2004; Rizzo et al., 2004; Sanchez-Vives and Slater, 2005). As the VR technology advances, it may be more effectively applied in SST for schizophrenia in the near future, and then a replication study controlling all components of vocal, nonverbal, and conversational trainings needs to be performed.

On the other hand, our findings suggested that the VR application has an advantage over SST-TR in terms of assertiveness training outcome. Throughout the sessions of SST-VR, many participants reported that when interacting with avatars in the virtual environments, they felt less anxious and more powerful than usual. This can be equivalent with the fact that more patients in the SST-VR group than those in the SST-TR group found that either the "reject a demand of the other person" session or the "express a negative emotion" session among the 10 sessions was most helpful. They can manage their interactions with avatars in the virtual environments using the joystick and button when participating in VR role-plays. In other words, the VR application can allow them to control their interpersonal anxieties and to feel a sense of control. In this sense, VR provides more empowering environments (Riva et al., 2004), and thus may be particularly applicable to assertiveness training in patients with schizophrenia.

In our study, one concern was that the results could be biased by therapist and rater factors. In order to control these, both types of SST were delivered by the same main therapist. The ratings on the SBS through videotaped role-plays were administered by the experienced rater who was blinded to the SST condition. The interest in SST, the generalization of the skills and the change of overall skill in the SST-VR group were accounted for by only the VR materials but not the therapists. These supported that the benefits of SST-VR were mainly based on the VR application rather than the factors related to the SST therapists. Inpatient participants showed significant improvements in the clinical symptoms after SST was completed. Another concern was that the findings of this study could be biased by the relationship between skill improvement and symptom changes or change in medication dose. However, the two groups did not differ in the severity of symptoms and the chlorpromazine equivalent dose at the baseline assessment and their changes at the time of the post-SST assessment, and both groups showed no relationship between the two clinical variables and skills changes measured using all scales.

Bias in behavioral ratings of social skills on the role-plays was also a concern. There was only one rater to maintain a blind state for the SST conditions, and thus the inter-rater reliability could not be calculated. One of the major limitations was that because the interest-in-participation and generalization scales were developed by our own research team, reliability and validity of the tests have not been confirmed. Another concern was whether our generalization test could assess participants' actual generalization skills. Although some participants showed high generalization score and thus were considered to have efficiently applied the skills they learned through the trainings into specific social knowledge, they might not apply this knowledge in a real-life situation because of poor self-efficacy.

In summary, the findings of this study suggested that VR application in role-plays for SST for schizophrenia can have several clinical implications. VR application can be especially beneficial in enhancing conversational and assertiveness skills, though it can be less effective for nonverbal skills in schizophrenia. Therefore, VR can be applicable to patients with impaired conversational and/or assertiveness skills rather than those with impaired nonverbal skills. In addition, VR application allowed schizophrenia patients with inpatient status to enhance their motivation for SST in such a short period of time (semiweekly 10 sessions). In this sense, SST-VR can be an effective first step to engage the patients in a longer period skills training in the community settings later.

Despite several advantages of the VR intervention as proved in this study, it should be noted that there are some obstacles for the technology to be widely used in clinical practice. The technology, while innovative, is still expensive and would require additional resources. In addition, the technology is less flexible than the traditional approach because some of the avatar interactions are standardized. For these reasons, the technology cannot likely replace traditional SST, but may serve as a useful supplementary tool.

The cost for the VR system is gradually declining, and the technology is advancing almost every day. Slow pace of dissemination of SST for schizophrenia is another important limitation of currently available SST approaches, which could be at least partly ascribed to the insufficiency of the skilled SST therapists (Kopelowicz et al., 2006). The findings of this study indicated that improvements in interest in SST, generalization of the skills, and change in overall skill in patients who received SST-VR were mainly ascribed to the VR application. Meanwhile, improvements in patients who received SST-TR were primarily attributed to therapist factors. Thus, it could be possible that VR application will contribute to wider use of SST for schizophrenia in the future.

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