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Virtual Reality-Based Assessment of Social Skills and Its Application to Mental Illnesses

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1. Introduction

Appropriate usage of social skills by individual members ensures the survival of communities in the human society. Social skills include the cognitive abilities as well as verbal and nonverbal behaviors indispensable for interpersonal interactions. Abnormal social skills have been reported in patients with mental illnesses including schizophrenia and bipolar disorder. Various methods, including self-report, interviews, behavioral observation, and clinical rating scales, have been used for the assessment of social skills, but their usefulness has been undermined by subjective or observational biases. Given that a virtual reality system could provide viable environments for individuals to interact with social avatars, it may be one of the most promising tools for assessing social skills that can minimize concerns of assessment related biases.

2. Characteristic and significance of social skills in patients with mental illnesses

Social skills encompass a set of cognitive abilities and interactive behaviors that facilitate efficient social interaction among individuals in a shared environment. Even though social skills as a whole cannot be claimed as a feature exclusive to human behavior, they nevertheless constitute an irreplaceable part of human interaction by making social communication among one another more articulate and intelligible. This is made possible because social skills can help convey and decode extra information not carried by direct communication using verbal means. As such, social skills can be likened to adding multiple layers of communicative information to relevant social messages (Couture et al., 2006). For example, imagine introducing yourself to someone you have never seen before. In such occasion, it is certainly not considered unusual to smile at the person you are introducing yourself to while offering a handshake as a gesture of salutation. You may even add a cheerful intonation on top of the customary "Nice to meet you" that one might verbalize to a stranger. In this example, the ability to initiate an interaction, smile with your face and to offer your hand to an unfamiliar person can be regarded as non-verbal social skills whereas one's ability to use the idiomatic expression, "Nice to meet you", and aptly topping it with a cheerful intonation when vocalizing the phrase can be regarded as part of a verbal social

skill set. These verbal as well as non-verbal usages of social skills in combination convey a cogent social message of geniality and hospitality.

As evident from the example above, social skills can take verbal as well as non-verbal forms, and may be additionally and simultaneously manifested through different sensory channels (e.g., visual, auditory, or tactile) of conveying the relevant information. By simultaneously utilizing multiple channels available, individuals involved in social interactions could use the information to more easily disambiguate other's intentions and may also strengthen the potency of their social communication. In the previous example of introducing oneself to an unfamiliar person, it would seem quite bizarre to merely offer one's hand for a handshake without displaying any affect through facial expressions (or worse, make an angry face). In a similar vein, it would probably seem rather odd to say "Nice to meet you" in a very monotonous tone, even with the smiling and the offering of your hand. In fact, such incongruence in manifestation of social cues may evoke a different interpretation from the observer and trigger suspicions of an ulterior message beneath the superficial friendliness This, however, extends the scope of our discussion to a whole another realm of issues relating to irony and deception in social communication, which will not cover in this chapter.

Social skills usage is not necessarily confined to one specific sensory modality, but can be embedded in multiple kinds. In fact, simultaneously using a wide array of social skills through various sensory modalities can be regarded as an indication of the integrative nature of social skills. "Verbal" social skills are often received through auditory channels. But "non-verbal" social skills such as facial expressions and social gestures are produced via motor output and received through visual input. Having multiple nodes of social skills available at one's disposal for interpersonal interactions allows exploiting individuals to exploit varigated combinations of different social cues and tack subtleties onto relevant communicable messages. What follows from human kinds' such an extraordinary ability to operate social skills using multiple channels is the complexity of the task to decode social messages.

Depending on the manifested symptoms and their severity, a mental illness can take its toll on the quality of very different types of social skills. Taking a detailed account regarding the effect of a mental illness on the affected individual's social skills and vice versa thus becomes all the more critical in order to fully appreciate a patient's mental health status. For example, patients experiencing depressive episodes from bipolar disorder or major depressive disorder often lack the interest to initiate and engage in social interaction, whereas patients with schizophrenia have difficulty in maintaining a meaningful social interaction due to their abnormal thought content and disorganization of speech (Brüne et al., 2010). In both cases, the quality of social interaction should be greatly reduced, however for disparate reasons. The former maybe more heavily influenced by the lack of motivation albeit having intact social skills, whereas the latter should be more affected by aberrant behaviors.

A specific social skills deficit in patients suffering from a mental illness may be an important indicator of how severely they are affected by the disorder. For example, lack of sustained eye contact during interpersonal interaction has long been regarded as a hallmark of social skills deficit in autistic disorders. The degree to which their eye contact is lacking has shown to correlate with their difficulty in social interaction (Pelphrey et al., 2005). Not surprisingly, measuring one's competency in social skills has been widely recognized as a critical step for a comprehensive assessment of a mental illness by scholars across the field of psychiatry and clinical psychology (Harvey et al., 2007). Moreover, assessment of social skills based on our knowledge of diverse elements of social interaction could help us trace mentally ill

patients' ability to recognize and generate socially salient cues, ability to use linguistic means of producing and comprehending social messages, as well as the ability to recognize one another's intentions and emotions through non-verbal means such as gestures, facial expressions, eye-gaze, and so on.

3. Limitations of conventional methods of social skills assessment

Despite their acknowledgeable contribution to measuring and documenting of social skill competency in mentally ill patients, traditional measures of social skills have often come short of the expectation scholars have projected onto them (Bedell et al., 1998). The contexts in which social skills are used are inherently interactive, since social interaction by definition involves two or more parties. Naturally, such interactive nature of social skills has contributed to the difficulty assessing social skills that reflect multi-faceted features of a "real-life" social interaction. Even with such difficulty, there still have been different approaches developed to assess individual social skills. Two conventional measures of social skill competency come from clinician's assessment and self/peer-reports. Both of these reports are based on anecdotal and retrospective evidence retrieved from the rote memory of a patient or a patient's peer. Therefore, data acquired using this method may often not reflect an accurate assessment of the patient's social skills, but rather indicate a record of the memory of social skills being used. This is not to claim that the measure is entirely useless, however, they still seem at times incomplete and inexact given we would like as precise assessment of the patient's social skills as possible.

Moreover, even though these measures are useful in gauging rough levels of social functioning in patients, they are not entirely unadulterated measures of social skills as one might assume. Because these measures are subjectively rated by clinicians or told to them laden with the personal feelings of patients and patient peers, the assessment can be subject to at least a moderate degree of human interpretation, if not more. Unless a specific assessment of patients is based on direct observation of social skills being used in a naturalistic context, the assessment is only as good as "second-hand" information filtered through another individual's interpretation. Clinicians are not free from biases of their own when meeting with patients for an assessment. Their prior beliefs about specific mental illnesses or evaluation of the patient's previous assessment record can provide a context in which the assessment can be more thoroughly executed but at the same time unwittingly engender biases that go along with one's prior experiences. Such clinicians' subjective interpretations and biases can occur against the clinicians' best intention and judgment not to influence the measure with subjectivity.

Additionally, the conventional paper and pencil method of clinician-driven social skills assessment have limited range of quantifying the acquired data. Needless to say these measures neglect to reflect the multi-sensory and interactive nature of the context in which social skills are often used by individuals. But central to the problem is that proper record keeping of quantitative measurements acquired using human senses is not an easy feat. For example, one could mention in the clinical report of a child autism patient that she exhibits very little sustained eye contact. But what if she was to later show slight improvement on the duration of eye contact after a cognitive behavioral treatment, but then the clinician might not notice? If there was a way to track the patient's eye movement and the duration while engaging another person, it would provide a more accurate and reliable data that could be an informative indicator of a tangible improvement.

4. Virtual reality-based social skills assessments as complements to conventional methods

Recent development and technological advances have allowed the use of the virtual reality system to present socio-affective stimuli to human subjects, thus enabling scholars to measure behavioral characteristics of participants during social interaction with virtual avatars. Technological advancements in graphics and other human motion tracking hardware should be able to promote pushing "virtual reality" closer to "reality," and thus virtual reality can be used to assess social cognition and behavior in real life-like situations (Tarr and Warren, 2002). Subjects in a virtual environment tend to treat virtual persons as actual humans, and respond to them in a naturalistic way regarding personal space, social presence and affect (Blascovich et al., 2002; Bailenson et al., 2003). Virtual reality's faithful renditions of the real world provide a tremendous advantage in terms of offering human subject users a realistic experience.

In particular, virtual reality can provide a more realistic and convincing sensory environment in which mentally ill patients may be able to engage in social interaction that clinicians could later base their assessment on. The author's research team performed a pilot study to examine whether a virtual avatar could be applied to acquiring the patients' behavioral characteristics in a short conversation situation (Ku et al., 2006). Tasks to approach to a visually presented avatar on a screen using a joystick, initiate a talk, and answer to avatar's questions was assigned to patients with schizophrenia, and one of the behavioral parameters was the interpersonal distance. The results showed that the interpersonal distance was negatively correlated with the negative syndrome scale, which was consistent with a previous research reporting a similar relationship in the interpersonal distance using a real person's image (Nechamkin et al., 2003). We concluded, therefore, that the virtual avatar could be perceived as a real human by patients with schizophrenia and the avatar could draw the patients' behavior characteristics. This pilot study suggested that virtual reality would be useful in investigating the interpersonal behavior of mentally ill patients when a virtual environment populated by virtual avatars is properly used.

Based on the findings from this pilot study, our works were extended to various assessing tools evaluating social characteristics on the virtual environment. In another pilot study, using a morphing technique, we were able to evoke varied perception of emotional faces of virtual avatars by effectively manipulating affective information on the virtual avatar's faces and to validate the prototype for further use (Ku et al., 2005). In order to further test hypotheses about social cognition in mentally ill patients, we have developed these virtual reality based sociality-measuring systems for evaluating communication skills, eye gaze behavior, social cue perception, social problem solving, and emotional expression (Han et al., 2009). Using these systems which were set in specially fitted room (Fig 1), we have used virtual avatars for various applications which need to communicate with other person or to educate by showing humanlike behavior.

5. Measuring personal space using the virtual reality system

Our main work for social assessment was a system for measuring personal space. Personal space, an invisible boundary surrounding an individual that others cannot intrude upon, is an important nonverbal component of social skills (Hayduk, 1983; Bellack et al., 1997). It is a good, measurable parameter of social cognition in mentally ill patients, and virtual reality can be a favorable way to objectively study it. In order to investigate personal space, we

Fig. 1. Virtual reality presentation chamber. The chamber consists of the meeting room and the monitoring room. The meeting room is equipped with a head mounted display, a tracker, a beam projector, a screen, a camcorder, a speaker, and so on. In the monitoring room, a computer system controls all facilities in the meeting room and a situation in the meeting room can be observed through a one-way mirror.
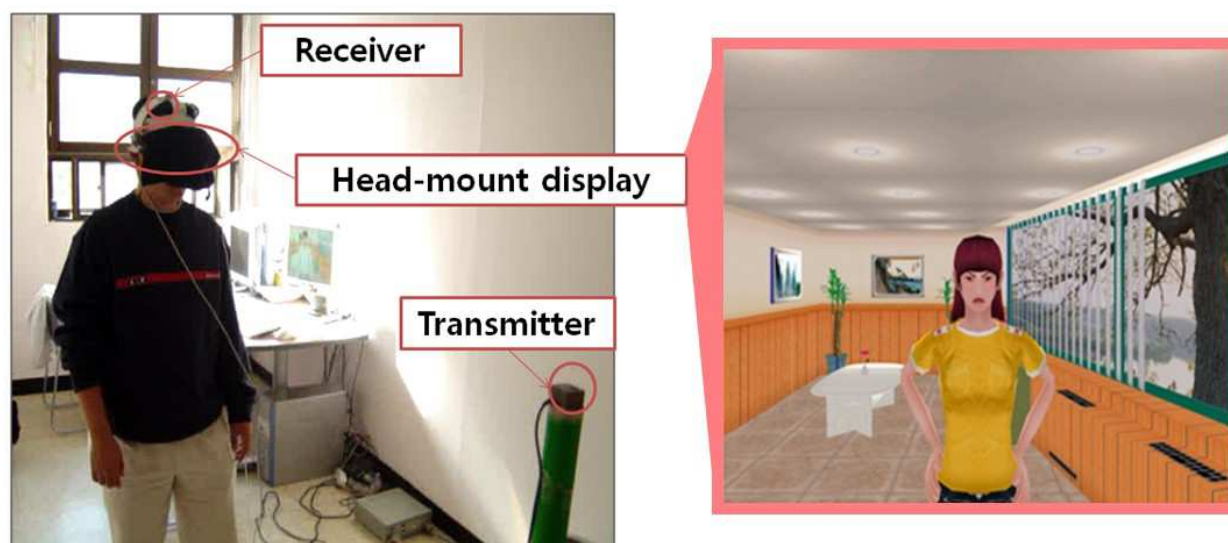

Fig. 2. Virtual reality social encounter task for measuring personal space. A participant is wearing a head-mounted display and enters into a virtual room. A receiver is placed on the vertex of the participant and represents the position and head orientation from a transmitter. A computer system calculates the distance and angle of head orientation from an avatar on the basis of the information from the receiver.

developed a virtual reality social encounter task (Kim et al., 2009; Park et al., 2009a; Park et al., 2009d). As shown in Fig. 1, the behavioral task assigned to the participant was to talk to an avatar in a virtual room. To present visual stimuli, participants put on a head-mounted display (HMD) that included a display monitor over each eye. The receiver that is needed to compute the position and head orientation in the virtual environment was placed on the vertex of the participant, and earphones were used for auditory stimuli.

To start the task, participants were instructed to walk in front of the avatar and to say "hello." The avatar was programmed to respond by saying "hello", introduce itself by talking about where it was born, where it lived, what it liked or detested, its hobbies and family members, and then ask participants to introduce themselves. There were three male

and 3 female avatars displaying happy, neutral, and angry facial expressions, and thus the task consisted of 6 sessions for which six different scripts were prepared. To make the introduction more naturalistic, an experimenter controlled the timing that the avatars would start introducing themselves. In order to increase the degree of realism, the avatars were made to look at participants, blink their eyes seemingly spontaneously, open their mouths in accordance with the recorded voices, and make gestures that matched their facial expressions. All avatars displayed a manner of talk, prosodic expressions, facial expressions, and gestures that were matched in happy, neutral, or angry emotions.

Participants' verbal response onset time and duration were measured during each session. Participants' viewpoint in the virtual environment was rendered by tracking the head position and orientation by the receiver worn on the head. The distance and angle of head orientation were indexed as the average distance and the average angle during the conversation with the avatar in each of six task conditions. The angle of head orientation was used as an indirect measure of the eye gaze of the participant.

In an empirical research for patients with bipolar disorder experiencing manic episodes, the virtual reality social encounter task permitted us to demonstrate negativistic social cognition behavior indicated by increased interpersonal distance as measured by how far the patients were in relation to the avatar in the virtual reality environment, as well as through increased aversion of eye gaze compared to healthy normal control subjects (Kim et al., 2009). In a separate study using the same system, we could confirm that patients with schizophrenia also showed increased personal space, and further their disturbances in personal space had a close relationship with negative symptoms (Park et al., 2009d). The severity of negative symptoms had significant inverse correlations with the distance from the angry and neutral avatars and with the angle of head orientation toward the happy and angry avatars.

A novel finding that patients with bipolar disorders and patients with schizophrenia tended to show significantly increased personal space in relation to a virtual avatar could only be properly obtained using the virtual reality system. Even though anecdotal evidence existed, these studies were the first of its kind to parametrically demonstrate the existence of a meaningful tangible difference displayed in mentally ill patients' social interaction patterns. Larger personal space of the patients may reflect their discomfort in close situations or cognitive deficits. Showing these profiles to patients could help them realize the amount of personal space they need.

In addition, emotional responses including social anxiety are very important factors in a social situation. By using the virtual reality social encounter task, we tried to elucidate the relationship between emotional perception and response during social interactions in patients with schizophrenia (Park et al., 2009a). In this study, emotional valence and arousal of the avatars were rated after completing the task, and the patients significantly underestimated the valence and arousal of angry emotions (Fig. 3A). While valence and arousal ratings of happy avatars were comparable between the patient group and the normal group, the patients reported significantly higher state anxiety in response to happy avatars (Fig. 3B). State anxiety ratings significantly decreased from encounters with neutral to happy avatars in normal controls while no significant decrease was observed in the patient group. Negative symptoms including anhedonia, blunted affect, emotional withdrawal, and passive/apathetic social withdrawal items were significantly correlated with state anxiety ratings of the encounters with happy avatars. These results suggest that patients with schizophrenia may encounter interference with the experience of pleasure in virtual social interactions, and their interference may be associated with negative symptoms.
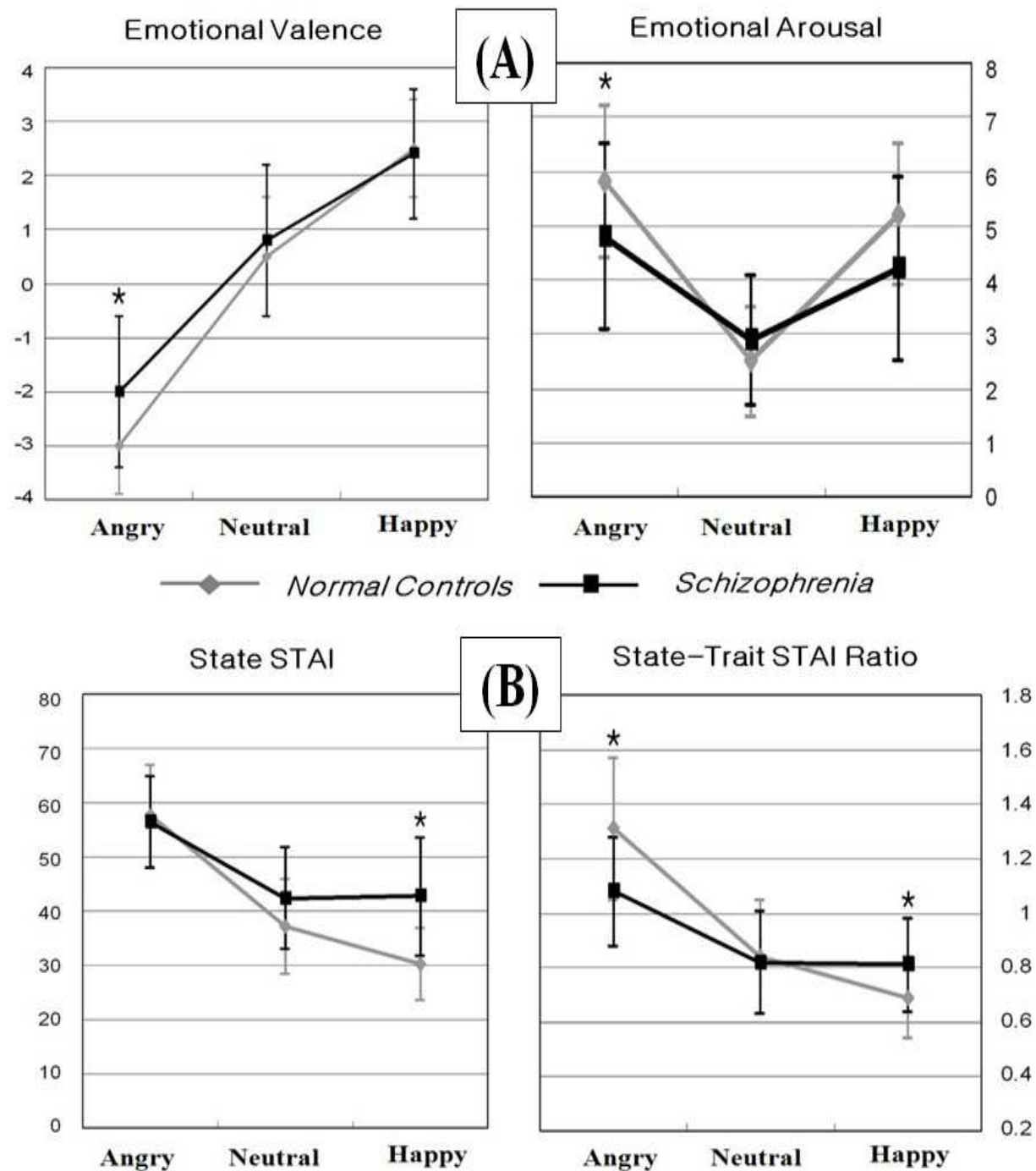
Fig. 3. Emotional perception and anxiety response during the virtual reality social encounter task with angry, happy and neutral emotion-expressing avatars. (A) Significant between-group difference (*) in both valance and arousal was observed at p < 0.05. (B) The State-Trait Anxiety Inventory (STAI) score representing the state anxiety experienced during the task. State-Trait STAI ratio represents the state anxiety experienced during the task divided by trait anxiety. Group x condition interaction was significant (F=15.2, df=1.67, p<0.001) without significant anxiety decrease from neutral to happy conditions only in the patient group (patients t=0.32, df=26, p=0.75; controls t=3.81, df=26, p<0.01).

Our next study taking advantage of the customizability of the virtual reality system examined eye gaze patterns of patients with schizophrenia towards agents involved in multi-person interpersonal interaction (Song et al., 2010). Presented with two avatars at the same time, one as the main avatar and the other as the assistant avatar, patients with schizophrenia or healthy normal controls performed a mock conversation (both listening to and speaking to) with avatars in both positive and negative affect-related scenarios (Fig. 4A). Eye gaze to both the main and the assistant avatar were measured and compared between the two groups. Interestingly, for conversation engagement during both scenarios, the patients showed aberrant distribution of eye gaze manifested by shorter eye gaze duration spent towards the main avatar and longer duration towards the assistant avatar compared to healthy controls (Fig. 4B). This pattern of result was more pronounced during the negative affect related scenario. This research not only once again demonstrated the possibility of using virtual reality to measure behavioral correlates of social cognition but additionally exhibited the potential that customizability of the virtual reality system such as utilizing multiple avatars in this case can be of great service to research methods.
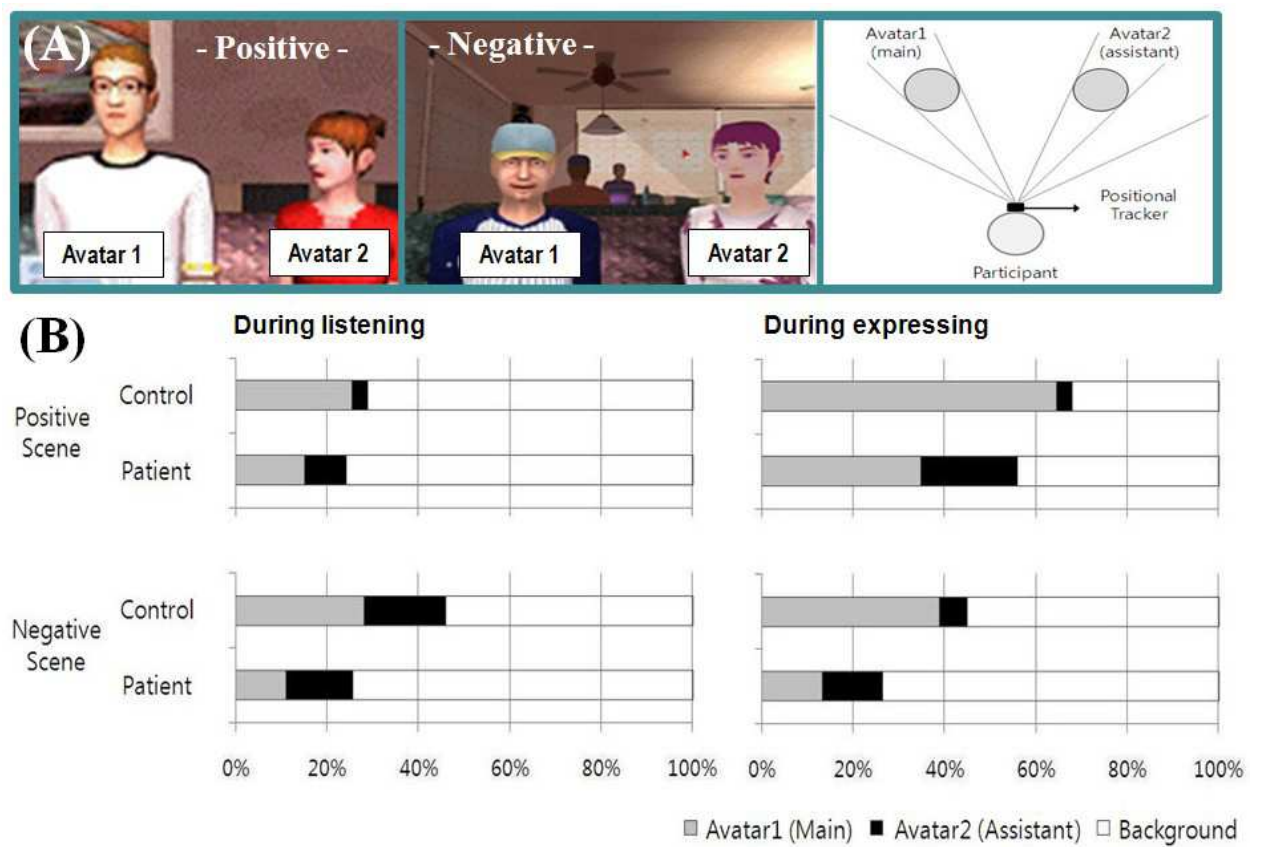

Fig. 4. A virtual reality task for measuring multi-person interpersonal interaction. (A) Positive emotion provoking scene was a conversation with family members who celebrate of father's promotion in the living room, whereas negative emotion provoking scene was a conversation with friends who make fun with participant's nickname at Café. A sectioned diagram on the right represents the experimental setting. (B) Proportion of watching time during listening and expressing showed decreases in staring at the main avatar and increases in staring at the assistant avatar in patients with schizophrenia when compared with normal controls.

6. Expanded uses of virtual reality-based social skills assessments for clinical trials

The utility of the virtual reality system as an assessment tool has also been demonstrated for measuring the effectiveness of therapy or clinical trials of new medications. Such utility has been particularly noticeable in research programs that test the efficacy of antipsychotics that supposedly help rehabilitate social competence in schizophrenia. Most clinical trials for social functioning in patients with schizophrenia have depended on reports from either patients or caregivers and direct observations of patients, but these measures are likely to be influenced not only by antipsychotic medication but also by environmental factors that encourage performance of the skills (McKibbin et al., 2004). On the other hand, performance-based measures of functional skills seem to occur more closely in time with changes in underlying cognitive performance, and thus these unbiased measures are considered to be suitable in clinical trials for schizophrenia to date (Buchanan et al., 2005; Harvey et al., 2007). Using such performance-based measures, one study indicated that treatment with both risperidone and quetiapine resulted in medium to large improvement in social competence (Harvey et al., 2006), whereas another study showed that medication with both clozapine and risperidone produced only very small improvement in social competence (Bellack et al., 1994). The contradictory findings on the effectiveness of atypical antipsychotics to social competence in schizophrenia may be at least in part attributable to the performance-based measure's limitations that rating distributions can vary by the raters' ability and the raters may be unable to discriminate subtle changes of functional skills (Bellack et al., 2006).

In order to avoid such shortcomings, automatic assessment of patients' performances is more likely to be advantageous. Not surprisingly, the author's research team devised the virtual reality system to provide an automatic assessment of patients' performance (Fig. 5), which was named the virtual reality functional skills assessment (VRFSA) (Park et al., 2009c). The VRFSA consisted of six virtual reality scenarios that were produced to represent common conversational situations. Two scenarios included a conversation concerned with a self-introduction with a stranger, two scenarios included a conversation related to making an appointment with a friend, and the final two included a conversation about the conduct of business with a co-worker. Each scenario consisted of two consecutive skills phases: the receptive skills phase during which the subjects listened to the avatar's narration, and the expressive skills phase during which they expressed their answers after the avatar asked questions. Four parameters representing a distinct functional skill were obtained; initiation (the response latency to the avatar's voice for the receptive skills phase and to the avatar's question for the expressive skills phase), duration (the percentage of time spent watching the avatar), proxemics (the average distance from the avatar), and eye contact (the average angle of head orientation from the avatar's eyes).

In a 6-week, randomized, open-label, and flexible dose study for 24 patients with paranoid schizophrenia and 15 healthy controls (Park et al., 2009c), there was a significant difference in the VRFSA between the patients and the healthy controls (p < 0.05). Significant treatment skills phase group interaction effect was found, and particularly, compared with risperidone, aripiprazole was more effective in improving social skills competency.

This study suggests that the virtual reality based measures are strongly sensitive to changes in social competence and thus especially well-suited for short-term clinical trials. Here, utilizing the virtual reality system has other several advantages over other conventional choices such as self-report and clinician's assessment. Importantly, virtual reality allows
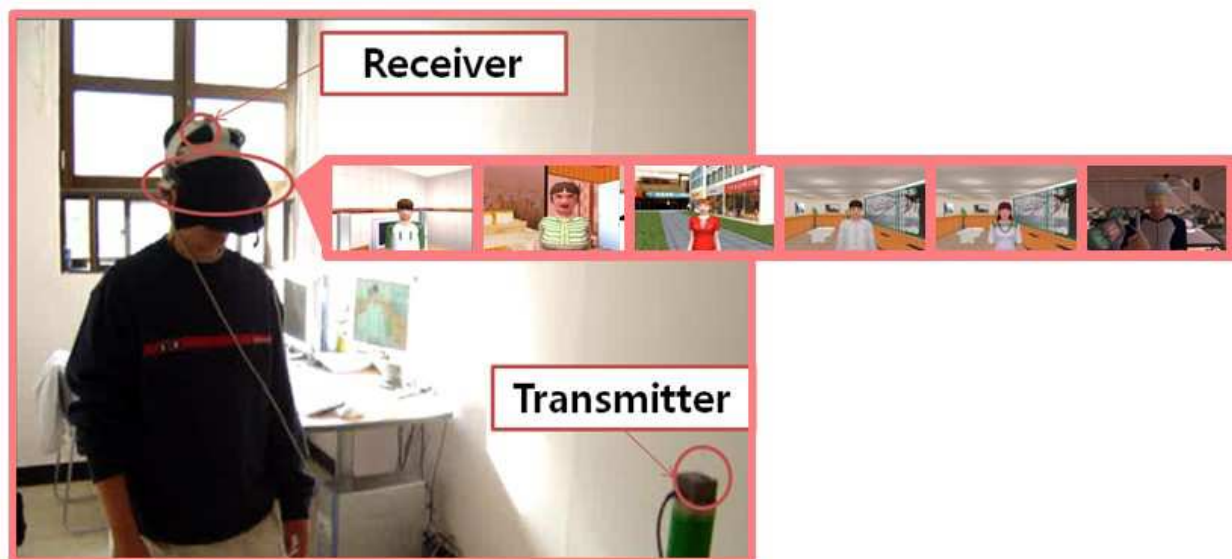
Fig. 5. Virtual Reality Functional Skills Assessment. The system consisted of a head-mount display with a receiver, a transmitter and connections to the computer system. Participants had a conversation with an avatar in the three-dimensional virtual environments with 6 scenarios, and a therapist monitored them using a video screen image captured by a video camera and input data of the times that they initiated and ended their response. The receiver measured the distance between the participants and the transmitter and the angle of the participants' head orientation from the transmitter. Next, the computer system calculated 4 parameters such as initiation, duration, proxemics, and eye contact, based on the information from the therapist's input and the receiver.

raters to present consistent social and affective stimuli, which on the other hand can be very difficult with human raters due to potential noise from various sources including raters' bias towards a specific experimental condition/group (not being blind to the subject assignment) or knowledge about the hypothesis (not being blind to the hypothesis). This is an especially weighty issue for clinical trials because subjectivity during social skills assessment when using conventional assessment methods can be a strong point of criticism in assessment involving human raters. Providing consistent social stimuli using virtual reality can adeptly address the subjectivity issue of effectiveness of a clinical treatment whether it be medications or behavioral therapy.

7. Assessment of problem-solving ability during a social situation

Our next work was to develop an easily applicable tool for an assessment of problem-solving function in various social situations using the virtual reality technique. Social problem-solving is a multidimensional psychosocial variable in the pathogenesis of mental health problems (Elliott et al., 2004) and a cognitive-behavioral process by which a person attempts to discover effective solutions for problems encountered during the course of everyday living (Nezu, 2004). We expected that virtual reality would also be useful for assessing social problem-solving, and made four virtual reality tasks including decision-making after the situational change, getting on an appropriate bus, making judgment against an inadequate request, and coping in the negatively emotional situation. Fig. 6A showed scenes from a task of getting on an appropriate bus. Using such realistic scenarios

that are probable in real life, we could investigate the cognitive inflexibility that mentally ill patients might show during situations of social interaction.

Actually, a pilot study was performed to investigate characteristics of patients with schizophrenia for problem-solving in the social situations (Chun et al., 2006). In this study, 30 patients with schizophrenia and 30 healthy normal controls were to make choice judgments on each of 4 scenarios, and social problem-solving abilities of the patients were compared to those of the controls. In the results, the patients tended to consider mother's asking to be less important than meeting with a friend, and to select a deviated choice rather than a flexible solving. They made significantly less appropriate choices in the task of getting on the bus, and felt more intense negative emotion than the control group on the task of copying in the negatively emotional situation. Those results were interpreted to suggest that the patients with schizophrenia have a deficit of problem-solving function in the social situations.

Especially, as shown in Fig. 6B, the patients did show patterns of inflexibility subsequent to situational change. They had a tendency to obsess over the bus a virtual mother proposed in spite of the existence of more appropriate bus. Concreteness attributed to cognitive inflexibility is considered to be an important factor for the deficits in patients with schizophrenia. Providing realistic visual as well as auditory stimuli, this experiment capitalized on another example of the advantage that virtual reality has on its capacity to immerse human subjects to the virtual environment as if it were a real situation.

8. Uses of virtual reality for social skills training

Beyond considering virtual reality systems as a mere assessment tool, recent studies suggest the virtual reality system's potential utility as a therapeutic and social skills training tool. The author's group reported a novel method of implementing a role playing conversational skills training program using virtual avatars (Ku et al., 2007). In this study, computer generated virtual avatar's emotional stimuli could complement or even overcome the shortcomings of conventional role playing approach to social skills training. The strength of using virtual avatar for role playing training came from taking advantage of the fact that computer generated avatars can consistently present emotional stimuli at will of the clinician whereas the efficacy of conventional role playing methods are often limited to the expressive capacity of the clinician/trainer.

Another strength of using virtual reality and virtual avatars for social skills training of patients with mental illness is that they provide a safe, harmless, and well-controlled environment in which to practice social interaction without repercussions of emotional frustration and feeling of failure expected in the real world. Stigma associated with mental illness can be detrimental to rehabilitation training in mental health patients (Link et al., 2001; Rüsch et al., 2005). Especially for patients with severe symptoms, utilizing a virtual environment without the expectation of negative consequences of the real world may be a favorable method that readily allows behavioral activation which can jump start the social skills training among other rehabilitation processes that the patients are encouraged to engage in.

It is also very encouraging to note that the vast majority of patients who underwent social skills training using the virtual reality based conversation training program evaluated the program positively after it was finished (Ku et al., 2007). Providing an extra motivation to the patient is another factor that cannot be ignored when counting the efficacy of social skills

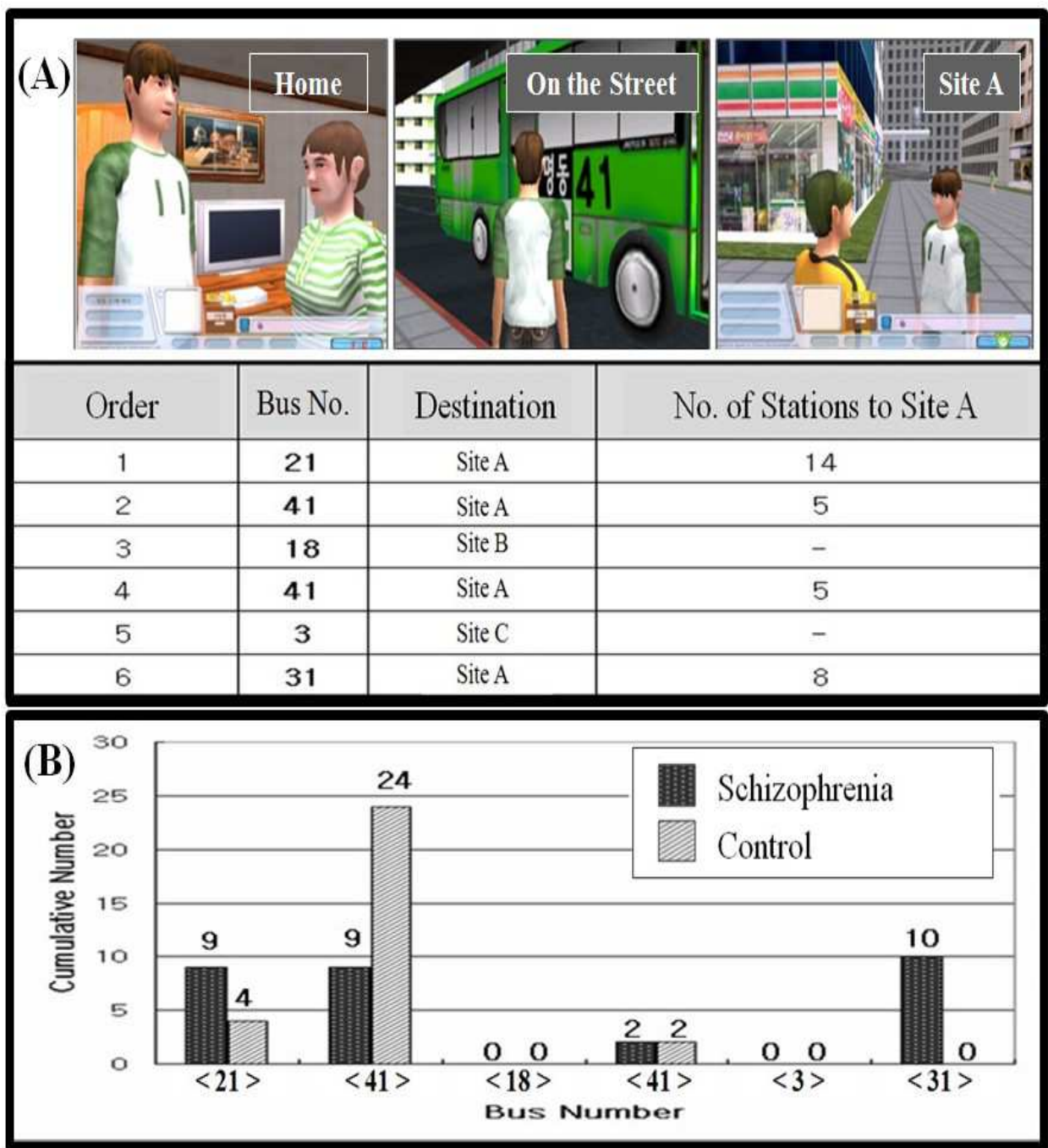| Order	Bus No.	Destination	No. of Stations to Site A
1	21	Site A	14
2	41	Site A	5
3	18	Site B	–
4	41	Site A	5
5	3	Site C	–
6	31	Site A	8

Fig. 6. An example of the virtual reality social problem-solving tasks and the experimental results. (A) In a task of getting on an appropriate bus, participants should get on a bus to site A. They had three options such as No. 21, 41 and 31. No. 21 bus was firstly arrived but had a lot of stations because it would use a detour. No. 41 bus was secondly and fourthly arrived and used the shortest way. No. 31 bus was finally arrived and had more stations to site A than No. 41 bus. However, participants could give priority to No. 31 bus because a virtual mother recommended them to get on No. 31 bus at the scene of home before the scene of getting on a bus. (B) Most normal controls tended to choose the first arrival of No. 41 bus, whereas most patients tended to choose the finally arrived No. 31 bus that a virtual mother proposed.

training. In addition, it is rather unrealistic to expect preparing a real world social interaction in order to help train social skills for a patient, so often time it is the responsibility of a clinician to help train social skills. Therefore, virtual reality based social skills training can also be a more cost-effective method in the long run compared to using clinician-based methods.

9. Integration of virtual reality and neuroimaging methods

One promising future direction in expanding the usage of virtual reality as a social skills assessment tool is to integrate the virtual reality system with neuroimaging methods such as functional magnetic resonance imaging (fMRI). Through the emergence of social neuroscience, there has been an explosion of neuroimaging research with much of its concentration on brain-mapping of various social cognition abilities. Based on an on-going accumulation of extensive neuroimaging research in social cognition and social skills, integration of neuroimaging methods and virtual reality promises to help form a synergistic relationship between the two fields whiling building on the past knowledge about the brain mechanisms involved in social skills.

Recent studies have shown promising trend of such integration. For example, an fMRI study investigated brain activity evoked by mutual and averted gaze in a compelling and commonly experienced social encounter (Pelphrey et al., 2004). In this study, subjects wearing virtual-reality goggles viewed a man who walked toward them and shifted their neutral gaze either toward (mutual gaze) or away (averted gaze), and the results showed that the superior temporal sulcus was involved in processing social information conveyed by shifts in gaze within an overtly social context. Another fMRI study using a virtual reality task during which subjects experienced themselves walking towards a complex scene composed of animate and/or inanimate objects also demonstrated strong activity in the superior temporal sulcus while the observer approached the social scene, but only when the virtual human was making gestures, suggesting the importance of biological motion in inferring the intentions of others (Morris et al., 2005).

Using our accumulated knowledge to assess individuals' condition relating to the neurocognitive basis of social skills germane to mental health problems provides new and exciting possibilities. For example, in order to evaluate attributional style which means how people typically infer the causes of emotional behaviors, a virtual reality attribution task was developed, and patients with schizophrenia and healthy controls underwent fMRI while performing three (happy, angry, and neutral) conditions of the task (Park et al., 2009b). The results showed that the patients may have functional deficits in mirror neuron system when attributing positive behaviors, which may be related to a lack of inner simulation and empathy and negative symptoms. In contrast, the patients may have increased activation in the precuneus/posterior cingulate cortex related to self-representations while attributing negative behaviors, which may be related to failures in self- and source-monitoring and positive symptoms.

Integration of neuroimaging methods and virtual reality systems offers benefits that are reciprocal in nature between the two methods. First of all, neuroimaging and human brain-mapping research can benefit from the improvement on the degree of realism depicted via presentation of social stimuli using virtual reality. On the other hand, behavioral research

previously using the virtual reality system could now benefit from an extra layer of measure that may inform more in-depth neurocognitive mechanisms relevant to mental health assessment and the evaluation of social skills among other things. This of course is based on a caveat that the progress on the social neuroscience end of the research provides enough certainty in order to execute dependable social skills assessment. We cautiously but at the same time optimistically approach such assertion since advances in neuroimaging research methods and accumulation of social neuroscience research via in vivo human neuroimaging research allows for a realistic expectation that in the near future, we may begin using integrated assessment set up using both virtual reality and neuroimaging methods. Positron emissions tomography (PET), as well as certain optical imaging methods may also be considered for integration with virtual reality systems. Such integrative uses will not only allow collection of more in-depth data. But also provide more extensive data on what neurological region is involved in the patients' social skills deficit or improvement.

In addition to neuroimaging methods, other bio-feedback tools can be integrated with virtual reality system for assessment and training of social skills. For example, galvanic skin response measures can readily be used in conjunction with virtual reality methods to provide real time feedback to participants. Such real-time biofeedback may be especially beneficial in social skills training setting. With the help of visible feedback on one's own physiological responses, patients may be able to regulate their own emotion and cognition, both crucial factors in engaging in orderly social interaction.

10. Conclusion

In summary, virtual reality systems can provide an opportunity for people to experience interpersonal and social situation. A virtual avatar can be perceived as a real human by the participants in the virtual environment, and can influence on their behavior, emotion and memory. Since a virtual reality task using the avatar can draw the participants' behavioral and emotional characteristics and assess those objectively, it provides a potential to be used for assessing a social ability of mentally ill patients who have deficits in social function. Because impairment of social skills is often a cardinal feature in most mental illnesses, virtual reality may play an important role in objectively evaluating symptoms of mental illnesses and measuring effectiveness of treatments designed to rehabilitate social skills in patients with mental illnesses. In addition, it can be used to train patients by eliciting various emotions close to reality as well as to find out the clinical characteristics related to patients' symptoms. It may be expected that the neural basis of various social functions and their deficits will be able to be elucidated by combined uses of virtual reality and function neuroimaging techniques.

11. Acknowledgement

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Virtual Reality

Edited by Prof. Jae-Jin Kim

Technological advancement in graphics and other human motion tracking hardware has promoted pushing "virtual reality" closer to "reality" and thus usage of virtual reality has been extended to various fields. The most typical fields for the application of virtual reality are medicine and engineering. The reviews in this book describe the latest virtual reality-related knowledge in these two fields such as: advanced human-computer interaction and virtual reality technologies, evaluation tools for cognition and behavior, medical and surgical treatment, neuroscience and neuro-rehabilitation, assistant tools for overcoming mental illnesses, educational and industrial uses In addition, the considerations for virtual worlds in human society are discussed. This book will serve as a state-of-the-art resource for researchers who are interested in developing a beneficial technology for human society.

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