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Increased personal space of patients with schizophrenia in a virtual social environment

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ABSTRACT

Virtual reality may be a good alternative method for measuring personal space and overcoming some limitations in previous studies on the social aspects of schizophrenia. Using this technology, we aimed to investigate the characteristics of personal space in patients with schizophrenia and evaluate the relationship between their social behaviors and schizophrenic symptoms. The distance from a virtual person and the angle of head orientation while talking to a virtual person in a virtual environment were measured in 30 patients with schizophrenia and 30 normal controls. It was found that patients with schizophrenia had longer distances and larger angles than did normal controls. The severity of the negative syndrome had significant inverse correlations with the distance from the angry and neutral virtual persons and with the angle of head orientation toward the happy and angry virtual persons, suggesting that negative symptoms may have a close relationship with personal space, including distancing and eye gaze. The larger personal space of 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.

1. Introduction

Personal space is a portable, invisible boundary surrounding an individual that others cannot intrude upon (Hayduk, 1983), and is an emotionally tinged zone around the human body (Sommer, 1959). A primary function of personal space is that it acts as a buffer that protects people from potential threats, overstimulation or overarousal (Horowitz et al., 1964; Dosey and Meisels, 1969; Scott, 1993). In addition, personal space reflects nonverbal communication such as intimacy between people (Hall, 1963, 1966). Personal space can be represented by nonverbal social behaviors, including interpersonal distance and eye gaze (Argyle and Dean, 1965; Cappella, 1981; Aiello, 1987; Bell et al., 2001).

Although personal space is an important nonverbal component of social skills (Bellack et al., 1997), how it is problematic in schizophrenia has not been thoroughly studied. Profiles of interpersonal distance in patients with schizophrenia have been reported in two previous studies. One study using photographs showed that patients with schizophrenia maintained longer distances (Srivastava and Mandal, 1990), and the other, using abstract word stimuli, showed that the negative syndrome had an inverse correlation with distance from neutral and threatening figures and a positive correlation with distances from family members and self-images (Nechamkin et al., 2003). An important methodological limitation of those studies might be that an actual interaction did not occur. It appears that a method involving an actual interaction would be better to measure the spatial behavior between people (Bell et al., 2001).

In order to overcome this limitation, virtual reality can be an alternative to study personal space in patients with schizophrenia. Virtual persons have been used to scientifically examine social interaction between people. 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 (Bailenson et al., 2003).

This study was designed to explore the nature of personal space in patients with schizophrenia in interactive situations within a virtual environment. We hypothesized that patients with schizophrenia would display unique patterns in personal space according to the virtual person's emotions, and that there would be a close relationship between personal space and schizophrenic symptoms.

2. Methods

2.1. Participants

Patients with schizophrenia ($n = 30$) were recruited at Severance Mental Health Hospital in South Korea, and diagnosed according to DSM-IV-TR criteria. They had no

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Table 1
Summary of demographic data.

Variable		Patients with schizophrenia	Normal controls	p
Gender [men/women]		16/14	16/14	NS
Age (years)		28.7 (5.5)	26.3 (4.3)	NS
Education (years)		12.6 (2.1)	15.6 (1.6)	<0.01
Raw score of RPM		41.7 (13.4)	55.6 (4.0)	<0.01
Employment status [employed/unemployed]		2/28	6/24	NS
Marital status [married/unmarried]		3/27	2/28	NS
Number of admissions [median, range]		3, 1–12		
Duration spent in hospital (months)		13.3 (21.0)		
Duration of illness (months)		69.7 (51.9)		
PANSS	Positive symptoms	19.1 (3.4)		
	Negative symptoms	20.6 (5.1)		
	General psychopathology	39.4 (6.6)		
Dosage of antipsychotics (mg) (chlorpromazine equivalent)		779.0 (589.6)		

Mean (S.D.).
NS, not significant; PANSS, Positive and Negative Syndrome Scale; RPM, Raven's Progressive Matrices.

other concurrent diagnoses on Axis I. Schizophrenic symptoms were assessed using the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987). Normal controls ($n=30$) were recruited from college and graduate schools and the local community. The volunteers were carefully interviewed by a trained psychiatrist to exclude any Axis I disorders. Participants' intellectual functions were measured using Raven's Progressive Matrices (Raven et al., 1988). This study was approved by the Institutional Review Board. After a complete description of the study, written informed consent was obtained from all subjects.

Table 1 summarizes the demographic and clinical data of the subjects. Between-group differences in gender, employment status and marital status (chi-square test), and between-group differences in mean age (Student *t*-test) were not significant. However, education level ($t=6.1$, $P<0.01$) and intellectual function ($t=4.7$, $P<0.01$) were significantly lower in the patient group compared with the normal controls. The patients had a mean duration of illness of 69.7 ± 51.9 months and a mean chlorpromazine-equivalent dosage of antipsychotics (Marangell et al., 2003; Woods, 2003) of 779.0 ± 589.6 mg.

2.2. Preparation of the virtual environment

In our preliminary experiment, we investigated human perception of a virtual person's facial expressions with five levels of intensity of happiness and anger using a linear morphing technique, and found that people experienced similar intensities of emotion in terms of valence and arousal at happy level 4 and angry level 3 (Ku et al., 2005). Based on previous findings, we generated six virtual persons: happy male, neutral male, angry male, happy female, neutral female, and angry female. The happy virtual persons were given dynamic facial expressions changing from happy level 3 to 5 (mean level 4) and a still facial expression of happy level 4 between animated expressions. The angry virtual persons were given dynamic facial expressions changing from angry level 2 to 4 (mean level 3) and a still facial expression of angry level 3 between animated expressions. The neutral virtual persons were given facial expression of level 0.

Six scripts were prepared according to the virtual persons' emotions and gender, and recorded as if the virtual persons were speaking to participants. As shown in Fig. 1B, six virtual environments were constructed by placing each virtual person in a virtual room. In order to increase the realism, all virtual persons were made to look at participants, blink their eyes naturally, open their mouths in accordance with the recorded voices, and make gestures that matched their facial expressions. In each task condition, the virtual persons were programmed to introduce themselves and ask participants to do the same. To make the introduction more natural, an experimenter controlled the timing of when the virtual persons would start introducing themselves. For visual stimuli, participants put on a head-mounted display (HMD) that included a display monitor over each eye. The receiver 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.

2.3. Task procedure and measurement

As shown in Fig. 1, the task was to have a conversation with a virtual person with the goal being for participants to introduce themselves to the virtual person. Participants were given instructions on how to approach the virtual person at the most comfortable distance, say ‘hello’, listen to the virtual person's introduction, and then introduce himself/herself. In order to become accustomed to the virtual environment, participants first explored an empty virtual environment. The task consisted of six trials, and each trial condition contained six different virtual persons. The order of the trials was counterbalanced across participants.

While participants performed the tasks, a computer system tracked participants' positions and head orientations. The starting point of the participant was placed 200 cm from the transmitter. The virtual person was placed 100 cm from the transmitter in the counter direction of the starting point in the virtual environment. At the starting point, the participant was asked to look the virtual person in the eyes and the degree of the angle of head orientation was calibrated to 0°. Based on the information from the receiver, the computer automatically calculated the distance and head orientation from the virtual person. The sampling rate was 10 times per second. As illustrated in Fig. 2, the data were serially measured; the figure demonstrated an example of the serial data from one of the normal controls toward the angry virtual female. We indexed the distance and angle of head orientation as the average distance and the average angle during the conversation with the virtual person in each of six task conditions. In terms of the angle of head orientation, we calculated an absolute value mean because a signed mean did not precisely reflect the change in eye gaze during a task. We used the angle of head orientation as an indirect measure of the eye gaze of the participant because recording eye gaze directly without being obtrusive was difficult using our virtual reality system. Although the data were obtained during the entire task time, only the data while listening to the virtual person's introduction were taken into account for the

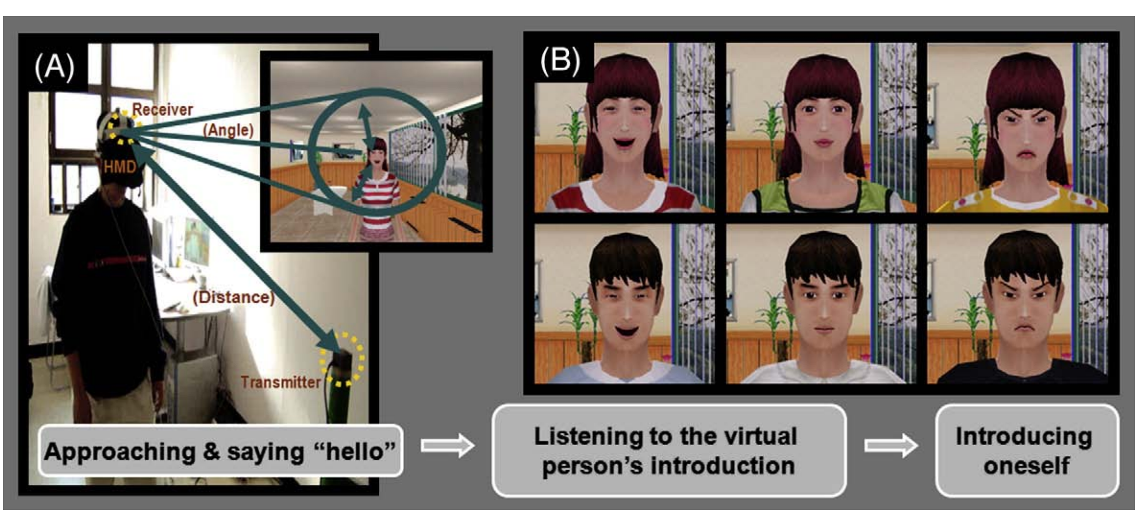

Fig. 1. Virtual reality system for measuring personal space. (A) The participant is wearing a head-mounted display and is in a virtual environment. The receiver on the vertex of the participant measures real distance and angle of head orientation from a transmitter. A computer calculates the distance and angle of head orientation from the virtual person based on the information from the receiver. (B) The participant experiences six virtual environments with six virtual persons who vary in gender and emotion (happy, neutral and angry). The participant is asked to approach the virtual person from the most comfortable distance and say “hello.” As programmed, the virtual person introduces himself or herself, talks about a topic, and asks the participant some questions. The participant should introduce himself or herself and answer the questions.