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Virtual Reality to Study Responses to Social Environmental Stressors in Individuals With and Without Psychosis

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Abstract. A virtual reality environment was created to study psychotic symptoms in patients and non-patients. Participants' task was to find five virtual characters that each had a small number label on his or her chest. The density and ethnic appearance of the virtual characters in the bar was controlled. For a non-patient group (N=24), results showed a significant main effect for density on participants' physiological responses, their behaviour, reported level of discomfort, and their ability to remember place and location of the numbered avatars. The avatar's ethnicity had a significant effect on non-patients' physiological responses. Comparison between two patients and non-patient group showed differences in physiological responses, behaviour and reported level of discomfort.

Keywords. Virtual reality, psychosis, social scene, psychotic, paranoia, exposure.

Introduction

Psychosis is a mental condition whereby people have delusions or prominent hallucinations. Core symptoms include paranoid delusions, ideas of reference and social anxiety. Psychotic individuals can experience fear because they believe that others intend to harm them. In subclinical severity, paranoia and social anxiety are also prevalent in the general population, which makes it useful to study these symptoms both in patient and in non-patient populations. One key variable in understanding psychosis is the social environment. Epidemiological studies have shown high rates of psychotic disorders in densely populated urban environments, and among immigrants who live in neighbourhoods with a low proportion of ethnic minorities, likely reflecting the causal influence of environmental risk factors [1]. Recreating the social environment in virtual reality (VR) has been put forward as a means to study psychotic symptoms [2]. Paranoid thoughts and anxiety are elicited by social and interpersonal stimuli such as eye contact, speaking, gestures, etc. In this study we manipulate two

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Figure 1. Bar world.

potential social environmental stressors: population density and ethnic appearance of an avatar group in a bar setting. The study focuses on the feasibility of this technology in this context and therefore falls into the Technology Element category of the Mental Health Computing Research Model [3].

1. Method

Individuals could freely navigate through the bar consisting of an indoor and outdoor setting (Figure 1). Potential stressors that could be set were: (1) the ethnic proportion of the avatar group, either mainly white-European or mainly North-African; and (2) the density of the avatars in the bar, either between 7 and 9 or between 34 and 38 avatars. To engage the people with these avatars the system randomly gave five of these avatars a number, visible on their clothing, which participants had to find. During this task the navigation behaviour with a Logitech Chillstream Gamepad was automatically recorded. Participants wore an Emagin Z800 3D Visor with a resolution of SVGA 800x600 24 bit, with 40 degrees diagonal Field of View, and built-in 3DOF tracker. Physiological data was collected with a Mobi8 from TMSi with Xpod Oximeter for heart rate (HR) measurement, and galvanic skin response (GSR) sensor with two finger electrodes. The study analysed the average distance kept to avatars, HR (variability), GSR as behavioural and physiological indicators of paranoia, anxiety and/or (social) stress. Participants were a white, Dutch, non-patient group consisting of university staff and students, including four females and 20 males, with an average age of 29 years (*SD* = 9.2); and two Dutch male patients, 36 and 25 years old, who completed technical and vocational training for 12-16 year-olds and for 16-18 year-olds. Both patients were white Dutch. Patient A had a DSM IV diagnosis of delusional disorder. Patient B was diagnosed with a schizoaffective disorder. They were eligible for this study because they both had paranoid delusions and delusions of reference at referral to the mental health clinic. At the time of the experiment, they had mild symptoms. The experiment was set up with a 2 by 2 within-subjects design for the two factors of the avatar group (ethnicity and density). Participants were informed in detail about the experiment. After they signed the informed consent form, as a baseline measurement for GSR, a three-minute neutral physiological measurement was taken, where participants sat in a chair. After this, participants had a training session in which they navigated through the VR world and looked for the numbered avatars. Once this was completed, participants were exposed to the four experimental conditions, with a maximum of three and a half minutes each for the non-patient group and four minutes for the patients. After each exposure participants were asked to write on a map the positions and the numbers of the five avatars. The experiment of the non-patient group was conducted in a university lab, while the two patients participated at the mental health clinic.

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2. Results

Table 1 shows the results of the non-patient group and patient A and B. To reduce variance caused by individual differences, the GSR in micro Siemens (μS) values (δ) were set against mean GSR value of the neutral (β) phase ((δ - β) / β), whereby an increase indicates an increase in moisture level. Participants' navigation behaviour was analysed by looking at the mean distance between their location in the VR world and a visible avatar within a 2 meter radius. To study the size of the area explored in the bar, the mean of the Euclidean Distance Matrix (EDM) was calculated, which was based on participant's position sampled every 5 seconds. The effects for ethnicity and density was analysed in a series of MANOVAs with repeated measures conducted on the data of the non-patient group. Compared to low density conditions, in the high density conditions: fewer locations ($F(1,23) = 7.07$, $p. = 0.014$) and numbers ($F(1,23) = 10.47$, $p. = 0.004$) were correctly remembered of the labelled avatars; self-reported subjective unit of discomfort (SUD) was higher ($F(1,23) = 5.24$, $p. = 0.032$); SD of the heart rate was larger ($F(1,23) = 10.09$, $p. = 0.004$); average distance towards an avatar was smaller ($F(1,23) = 4.86$, $p. = 0.038$) in a two meter radius of a visible avatar. Compared to white-European avatars, in the conditions with a majority of North-African avatars, the SD of heart rate was larger ($F(1,23) = 4.70$, $p. = 0.041$) and SD of galvanic skin response was larger ($F(1,22) = 4.54$, $p. = 0.044$). The beat-to-beat SD is often taken as

Table 1. Mean (SD) of non-patient group and results of patient A and B

	White-European (own ethnicity)		**North-African (other ethnicity)**	
Measure	**low density**	**high density**	**low density**	**high density**
Location correct				
M (*SD*)	3.6 (1.3)	2.8 (1.5)	3.7 (1.6)	3.1 (1.3)
Patient A / B	3* / 2**	3/ 4**	3* / 4	2** / 2**
Labels correct				
M (*SD*)	3.9 (1.3)	3.3 (1.5)	4.3 (0.9)	3.5 (1.4)
Patient A / B	4 / 3**	4* / 3	3** / 4	2** / 2**
SUD from 1 to 10				
M (*SD*)	1.75 (1.00)	2.04 (1.16)	1.92 (1.02)	2.21 (1.18)
Patient A / B	8** / 4**	7** / 4**	6** / 3**	8** / 5**
HR in bmp				
M (*SD*)	82 (11)	83 (11)	83 (11)	83 (11)
Patient A / B	101** / 113**	102** / 110**	99** / 110**	103** / 109**
SD HR in bmp				
M (*SD*)	3.39 (0.78)	4.08 (1.49)	3.93 (1.33)	4.21 (1.24)
Patient A / B	2.48** / 2.83**	5.09** / 2.97**	4.01 / 4.98**	3.42** / 2.83**
RMSSD HR in bmp				
M (*SD*)	1.31 (0.19)	1.33 (0.30)	1.29 (0.17)	1.32 (0.29)
Patient A / B	1.11** / 1.07**	1.35 / 1.18*	1.20* / 1.45**	1.10** / 1.11**
GSR in % to neutral				
M (*SD*)	0.68 (0.57)	0.69 (0.62)	0.64 (0.68)	0.65 (0.57)
Patient A / B	0.59 / 0.88	2.67** / 1.61**	0.84 / 2.29**	1.72** / 2.46**
SD GSR in μS				
M (*SD*)	0.24 (0.31)	0.24 (0.21)	0.26 (0.25)	0.34 (0.34)
Patient A / B	0.09* / 0.26	0.23 / 0.51**	0.22 / 0.30	0.20 / 0.23
Distance avatar in m				
M (*SD*)	1.29 (0.08)	1.28 (0.08)	1.32 (0.11)	1.26 (0.07)
Patient A / B	- / 1.20**	1.25 / 1.28	1.28 / 1.18**	1.16** / 1.18**
EDM in m				
M (*SD*)	6.35 (0.96)	6.89 (1.01)	6.49 (1.51)	6.96 (1.15)
Patient A / B	- / 5.22**	5.98** / 6.12**	5.19** / 5.65*	8.12** / 7.55*

** p. < 0.05; ** p. < 0.01*

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a measure of heart rate variability (HRV). A reduction in HRV indicates an increase cognitive or emotional strain [4]. SD, however, does not consider temporal distance between successive heartbeats as is calculated with the square root of mean squared difference of successive (RMSSD) HR measurement. A MANOVA with repeated measures on RMSSD HR however found no significant effects for ethnicity or density. Figure 2 shows HR and GSR of a participant in the non-patient group. For him, the VR worlds with a majority of North-African avatars resulted in more overall fluctuation in his HR and GSR compared to the VR worlds with a majority of white-European avatars. As an exploration, the data obtained from the two patients were compared with a series of one-sample *t*-tests with the means of the non-patient group. Compared to the mean of the non-patient group the overall trends across the conditions for these two patients was that they positioned themselves more closely to visible avatars in a two meter radius. Individual ANOVAs on the samples (0.1s) of the distance towards a visible avatar of the two patients in the high-density conditions showed, for patient A, significant main effects for avatar's gender ($F(1, 8283) = 23.85$, $p. < 0.001$) and for avatars' ethnicity ($F(1, 8283) = 69.08$, $p. < 0.001$), as well as a two-way interaction effect ($F(1, 8283) = 100.48$, $p. <0.001$). As Figure 3 shows, patient A kept a greater distance towards the North-African female avatars. A similar analysis for patient B only showed that this patient's distance was significantly ($F(1, 8151) = 6.04$, $p. = 0.014$) smaller towards the North-African avatars than towards the white-European

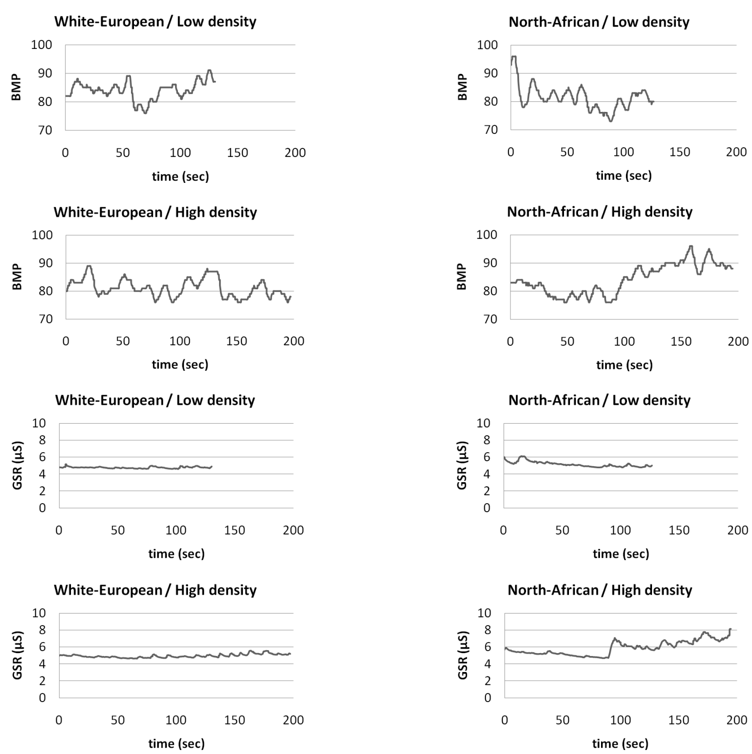

Figure 2. Heart rate and relative galvanic skin response of a non-patient.

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avatars. Furthermore, the EDM results (Table 1) seem to suggest that the two patients cover a smaller area than the non-patient group on average. The opposite, however, was the case in the high density / North-African condition where both patients cover a significantly larger area than the non-patients, on average. Table 1 also shows that the patients' heart rates were higher, they sweat more, and their SUD score was higher. Except for patient B in the low density / North-African condition, the RMSSD HR scores were smaller compared to the non-patient group suggesting an increased level of cognitive or emotional strain.

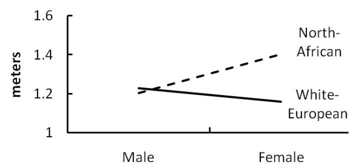

Figure 3. Distance between Dutch male patient (A) and visible avatars with different gender and ethnicity.

3. Conclusion and Discussion

Results of the non-patient group seem to indicate that an increased population density and an increased proportion of avatars with other ethnicity are associated with more fluctuation in physiological arousal, and more subjective distress when population density increased. The latter however seems likely to have coincided with an increase in the degree of task difficulty as well. The fluctuation in the physiological responses might be a reaction towards the various stimuli (i.e. avatars) non-patients engaged and disengaged with as they progressed through the VR world. This seems to validate the VR world, and confirm earlier reports on physiological responses towards ethnicity of an avatar [5]. The VR world seems to have had a larger effect on the two patients. Their physiological arousal and subjective distress level was higher. Furthermore, in three of the four conditions, they seem to cover a smaller area of the bar. Interestingly however, they approached the avatars more closely. More research is needed to see if these observations can be generalised across patients and to investigate in more detail if the observed behavioural and physiological patters indeed reflect paranoia and social anxiety. The result also shows the possibility for individual analyses of the behaviour towards various types of avatars, such as gender, and ethnic appearance of avatars.

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