A 3D virtual environment for empirical research on social pain: Enhancing fidelity and anthropomorphism in the study of feelings of ostracism inclusion and over-inclusion

Eva VENTURINI [a,,1] Paolo RIVA [b], Francesco SERPETTI [c], Leonor ROMERO LAURO [b], Federica PALLAVICINI [a], Fabrizia MANTOVANI [a], Renee CLOUTIER [d], Fred MCMAHAN [d], Kiefer STONECIPHER [d] *AND* Thomas D. PARSONS [d]

[a] CESCOM: Department of Human Sciences for Education, University of Milano-Bicocca, Milan, Italy.

[b] *Department of Psychology, University of Milano-Bicocca, Milan, Italy.*

[c] *INFN, Florence, Italy*

[d] *Computational Neuropsychology and Simulation Lab, Department of Psychology, University of North Texas*

Abstract. The traditional Cyberball paradigm is a 2D virtual ball-toss game that uses line drawn characters for research on ostracism. Using this paradigm, studies have reported increased level of distress during the exclusion condition. While the 2D Cyberball was developed purposefully to be minimal, it lacks the ecological validity that many virtual environments now offer. For this study, we developed a virtual reality-based Cyberball paradigm with highly anthropomorphic avatars, in line with other studies and with 3 conditions (Inclusion, Exclusion and Over-inclusion). In an effort to assess the impact of increased fidelity and anthropomorphism in the CyberballAvatar3D paradigm, the overall objective of this study is to compare the changes in mood between the 3 steps of original 2D low anthropomorphism Cyberball and our new high-anthropomorphism CyberballAvatar3D in a sample of undergraduate students.

Keywords. Cyberball, Virtual Reality, Social Pain, 3D, Avatar

1. Introduction

The traditional Cyberball paradigm [1] is a 2D virtual ball-toss game that uses line drawn characters for research on ostracism. Social scientists have started using the virtual gaming task called Cyberball to induce social exclusion in participants. A number of researchers have used the Cyberball game as an experimentally controlled social exclusion assessment that elicits affective [2], neurobiological [3], psychophysiological [4], and hormonal [5] responses. Results from neuroimaging studies have revealed that the experience of being excluded from ball-tossing evokes increased activation of the dorsal anterior cingulate cortex and anterior insula, which correlates with self-reports of physical and social pain [6], however, these results have

[1] Corresponding author, e.venturini3@campus.unimib.it

been put into question in recent publications [7]. A more recent study [8] found that the Cyberball task activated the dorsal anterior cingulate circuit less than other experimental social pain tasks. These findings are consistent with the suggestion that the social pain that follows from Cyberball is less intense than the social pain that follows from more personal forms of social rejection [9].
Given that the 2D Cyberball was developed purposefully to be minimal (i.e., devoid of

most social information), it lacks the ecological validity that many virtual environments now offer [10]. A recent advance in the Cyberball paradigm is an immersive virtual environment version, in which the participants wear a head-mounted display (HMD), through which the virtual environment was displayed [11]. Data from this study suggest that not only does ostracism in this environment have the same negative effects as in other environments, but these effects are powerful. Other virtual reality desktop versions [12] [13] allow for enhanced flexibility in manipulation of social information about the confederates' avatars, virtual humans, and/or their behaviors [14]. Given recent interest in the study of social pain [13], processing of social cues [15], and the need for novel approaches to assessment and treatment of autistic syndrome using virtual environments [16], we developed a non-immersive virtual reality-based Cyberball paradigm (with highly anthropomorphic avatars) that can be used to assess a sample of adults with high-functioning autism.

2. Cyberball

The *Cyberball game* [1] is a computer based 'ball tossing' game (Fig. 1). Before starting using the game it is possible to set the number of ball tosses and the time between tosses. Furthermore, other features can be adjusted, including the avatars' names, the players' pictures and the presence of a chat. In the inclusion condition, throws are distributed evenly to all players throughout the game. In the exclusion condition, participants receive 4 balls at the beginning of the game and are ignored thereafter (36 tosses). In the over-inclusion condition participants receive all tosses from the 2 other players.

In this study, on-line players were not provided with photos or their names to avoid giving participants any other reason for disliking another player apart from the fact that they were being ostracized by these players.

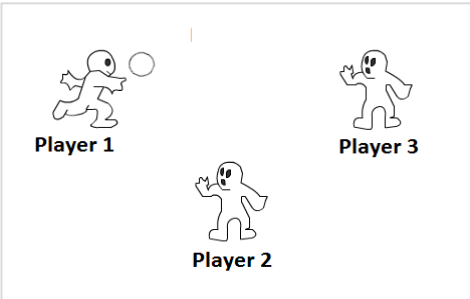

Figure 1. Cyberball (low level of anthropomorphism)

3. CyberballAvatar3D

The *CyberballAvatar3D* (Fig.2 and Fig.3) is a 3D version of the classic paradigm, developed by Unity 5.0. The avatars are rigged and generated by Autodesk Character Generator (free version). This version of the game features the same operations and the same setting at predetermined blocks. The only aspect that changes regards the

characteristics of the environment and the players. In the Avatar3D version, in fact, it has the image of an external environment, a grass in an open field, where 3 avatars (default: left player is a boy and right player is a girl; the participant player is either a boy or a girl) can play with a ball. The dimension of depth and anthropomorphic characteristics of the players make the scene more realistic and immersive.

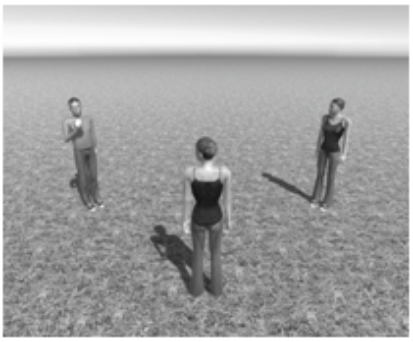

Figure 2. CyberballAvatar3D (male participant) **Figure 3.** CyberballAvatar3D (female participant)

In addition, to increase the sense of presence in participant, the corresponding avatar can be customized by choosing his gender (Fig. 3), the color of hair and clothes. Also in this version of the game the three steps of inclusion, exclusion and over-inclusion are programmed with 40 tosses for each one and with the same time between tosses.

4. Research protocol and preliminary results

In this paragraph we present the protocol of the ongoing research.

4.1. Participants and procedure

The study employed a 3 (Inclusionary status: Inclusion vs. Exclusion vs. Over-inclusion) X 2 (Cyberball Type: Cyberball vs CyberballAvatar3D) mixed factorial design, with the first factor (steps of the game) varying within subjects and the second factor varying between subjects

Participants. The experimental sample included 62 students, (males= 37) voluntary recruited from the University of North Texas. Participants were randomly assigned to the two conditions, while engaged in each of the Cyberball paradigms.

Aim of the study. The overall aim is to validate the functionality of our game, comparing changes in negative emotions and basic needs satisfaction between the 3

steps (inclusion, exclusion and over-inclusion) of original 2D low anthropomorphism Cyberball with our new high-anthropomorphism CyberballAvatar3D in a sample of undergraduate students. The second aim will be to use the 3D game with a sample of adult with autistic syndrome.

Procedure. Before starting the experiment each participant was provided with written information about the study and invited to give written consent for the inclusion. They are told that the researcher is interested in 'the effects of mental

visualization on task performance'. Participants are led to believe they are playing a game of virtual ball-toss with other individuals online, though all tosses are predetermined.

4.2. Psychological assessment

After each step (inclusion, exclusion and over-inclusion) we administered a battery of questionnaires. For each subscale, we reported the value of Cronbach's alpha (mean of the three steps). The *Rejected emotions scale* [17] assessed sense of rejection during the game (20 items on a 7-point Likert scale). The scale measured the intensity of five emotions: Anger (alpha=.855), Happiness (alpha=.899), Hurt feelings (alpha=.820), Anxiety (alpha=.762), Sadness (alpha=.746).
The *Need Threat scale* [18] measured satisfaction of four basic psychological needs: Belonging (alpha=.857), Self-esteem (alpha=.889), Control (alpha=.680), and Meaningful existence (alpha=.867). These were rated on a 7-point Likert scale from 'not at all' to 'very much'.

4.3. Preliminary results

Changes in psychometric measures were analyzed using mixed ANOVAs to compare the mean differences and interactions between conditions (between subjects factor) and mean differences in considered measures between steps (within subjects factor). The preliminary results showed that mixed ANOVAs did not present significant effects and/or interactions related with the between subject factor (all *ps*>.052). Only exception for the hurt feelings variable where we found a significant main effect of the Cyberball Type factor ($F_{1,60}$=5.040 p<.05, partial η2=.077). Specifically, participants who played with the classical version of Cyberball reported higher levels of hurt feelings compared with participants who played with the CyberballAvatar3D (*p*<.05). However, we found a significant effect of the within subject factor, on all dependent variables. Specifically, there was a main effect of the manipulation of Inclusionary status on anger ($F_{1.546,92.740}$=29.427 p=.000, partial η2=.320) (Tab.1), happiness ($F_{1.794,102.273}$=45.958 p=.000, partial η2=.446), hurt feelings ($F_{1.405,84.286}$=16.110 p=.000, partial η2=.212), anxiety ($F_{1.769,106.118}$=45.037 p=.000, partial η2=.429) and sadness ($F_{1.351,81.057}$=10.108 p=.000, partial η2=.242). In table 1 is reported mean and standard deviation for each measure in both condition.

Table.1 Mean and Standard Deviation of negative emotions (within subjects factor)

Condition/step		Anger		Anxiety		Happiness		Hurt feelings		Sadness	
		M	SD	M	SD	M	SD	M	SD	M	SD
2D	Inclusion	1.413	.979	2.135	1.281	3.440	1.495	1.288	.706	1.250	.538
	Exclusion	2.808	1.814	3.395	1.845	5.370	1.401	1.980	1.431	2.163	1.565
	Over-incl	1.433	.740	1.577	.639	3.260	1.889	1.173	.473	1.134	.362
3D	Inclusion	1.174	.597	1.722	1.088	4.051	1.691	1.097	.288	1.263	.569
	Exclusion	2.174	1.480	2.916	1.642	5.588	1.483	1.458	.664	1.923	1.333
	Over-incl	1.153	.561	1.625	.968	3.686	1.742	1.062	.201	1.298	.719

Moreover, we found the main effect of the manipulation of Inclusionary status also on the need to belong ($F_{1.709,102.562}$=142.864 p=.000, partial η2=.704) (Tab.2); control

($F_{1.868,112.103}$=174.406 p=.000, partial η2=.744); meaning existence ($F_{1.584, 95.051}$=101.811 p=.000, partial η2=.629) and self-esteem ($F_{1,779, 106.753}$=62.810 p=.000, partial η2=.511). Pairwise comparisons showed significant differences between the dependent variables in each step. Specifically, following the exclusion condition participants reported higher levels of negative emotions (considering the five separate emotions) compared to the inclusion and overinclusion conditions (all *ps*<.00l), but there were no differences between inclusion and over-inclusion conditions. Following the exclusion condition participants reported lower levels of basic needs satisfaction (considering the four separate needs) compared to the inclusion and overinclusion conditions (all *ps*<.00l). Then, following the inclusion condition participants reported lower levels of basic needs satisfaction (considering the four separate needs) compared to the overinclusion condition (*p*<.001). In table 2 is reported mean and standard deviation for each measure in both condition.

Table 2. Mean and Standard Deviation of psychological needs (within subjects factor)

Condition/step		Sense of Belonging		Control		Meaning existence		Self esteem	
		M	SD	M	SD	M	SD	M	SD
2D	Inclusion	6.038	1.269	2.936	1.292	6.410	.925	4.321	1.331
	Exclusion	2.987	1.792	1.244	.615	3.718	1.997	2.423	1.315
	Over-incl	6.756	.607	5.282	1.750	6.897	.374	5.269	1.840
3D	Inclusion	6.213	1.095	2.824	1.508	6.269	1.269	3.620	1.611
	Exclusion	3.519	1.942	1.167	.525	4.074	1.997	2.407	1.501
	Over-incl	6.824	.999	4.935	1.581	6.861	.727	5.120	1.860

In keeping with past research based on the classical version of Cyberball, our results show that the exclusion step increased negative emotions and threatened basic needs satisfaction compared with the inclusion and the over-inclusion conditions. Furthermore, our results showed that the over-inclusion also differs from the inclusion step. Specifically, when we compared the overinclusion condition with the inclusion condition, we found that participants felt greater sense of belonging, meaning existence, self-esteem and control. We found the same pattern of results using both versions of Cyberball, suggesting that considering self-reports measures and heathy participants, a virtual reality-based Cyberball paradigm with highly anthropomorphic avatars does induce similar effects of the classical version of Cyberball.

The next challenge of this project will concern the use of the CyberballAvatar3D

with a sample of adults with high-functioning autism; particularly we will test the over-inclusion step for the first time with this syndrome.

References

[1] K. D. Williams, C. K. Cheung, and W. Choi, Cyberostracism: effects of being ignored over the Internet., *Journal of Personality and Social Psychology*, **79 (**2000**)**,748–762
[2] C. H. J. Hartgerink, I. van Beest, J. M. Wicherts, and K. D. Williams, The ordinal effects of ostracism: a meta-analysis of 120 Cyberball studies *PLoS One*, **10** (2015), e0127002.
[3] N. I. Eisenberger and S. W. Cole, " Social neuroscience and health : neurophysiological mechanisms linking social ties with physical health, *Nature Neuroscience* **15** (2012) 1–6.
[4] B. Gunther Moor, E. A. Crone, and M. W. van der Molen, The heartbrake of social rejection: heart rate deceleration in response to unexpected peer rejection. *Psychological Science.*, **21** (2010), 1326–33.
[5] E. Andari, J. Duhamel, T. Zalla, E. Herbrecht, M. Leboyer, and A. Sirigu, Promoting social behavior with oxytocin in high- functioning autism spectrum disorders, *Proceedings of the National Academy of Sciences of the United States of America*. **107** (2010), 4389–4394, .
[6] N. I. Eisenberger, Broken Hearts and Broken Bones, A Neural Perspective on the Similarities Between Social and Physical Pain, *Current Directions in Psychological Science.* **21**(2012), 42–47.
[7] S. Cacioppo, C. Frum, E. Asp, R. M. Weiss, J. W. Lewis, and J. T. Cacioppo, A Quantitative Meta-Analysis of Functional Imaging Studies of Social Rejection*, Scientific Reports*, **3** (2013), Article Number 2027
[8] J.-Y. Rotge, C. Lemogne, S. Hinfray, P. Huguet, O. Grynszpan, E. Tartour, N. George, and P. Fossati, A meta-analysis of the anterior cingulate contribution to social pain., *Social Cognitive. And Affective Neuroscience*, 10 (2015), 19–27.
[9] N. I. Eisenberger, Social Pain and the Brain: Controversies, Questions, and Where to Go from Here, *Annual Review of Psychology*, **66** (2015), 601–629.
[10] T. D. Parsons, Virtual Reality for Enhanced Ecological Validity and Experimental Control in the Clinical, Affective and Social Neurosciences, *Frontiers in Human Neuroscience.*, **9** (2015), 1–19.
[11] M. P. Kassner, E. D. Wesselmann, A. T. Law, and K. D. Williams, Virtually Ostracized: Studying Ostracism in Immersive Virtual Environments, *Cyberpsychology, Behaviour and. Social.Networking*, **15** (2012), 399–403
[12] E. Mavromihelaki, J. Eccles, N. Harrison, T. Grice-Jackson, J. Ward, H. Critchley, and K. Mania, Cyberball3D+: A 3D serious game for fMRI investigating social exclusion and empathy, *2014 6th Int. Conf. Games Virtual Worlds Serious Appl. VS-GAMES 2014*, 2014.
[13] D. Z. Bolling, N. B. Pitskel, B. Deen, M. J. Crowley, J. C. McPartland, M. D. Kaiser, B. C. Vander Wyk, J. Wu, L. C. Mayes, and K. a Pelphrey, "Enhanced neural responses to rule violation in children with autism: a comparison to social exclusion.," *Devolopmental Cognitive Neuroscience* **1** (2011), 280–94.
[14] G. Riva, Virtual reality as assessment tool in psychology, *Studies Health Technologies Informatics*, **44** (1997), 71–79.
[15] American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders*. 2013.
[16] M. R. Kandalaft, N. Didehbani, D. C. Krawczyk, T. T. Allen, and S. B. Chapman, Virtual reality social cognition training for young adults with high-functioning autism.," *Journal of Autism and Devolepmental Disorders*, 43 (2013), 34–44
[17] K. E. Buckley, R. E. Winkel**,** and M. R. Leary, Reactions to acceptance and rejection: Effects of level and sequence of relational evaluation, *Journal of Experimental and Social Psychology.*, **40** (2004), 14–28
[18] I. van Beest and K. D. Williams, When inclusion costs and ostracism pays, ostracism still hurts. *Journal of Personality and Social Psychology*, **91** (2006) 918–928.