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An exploratory study on virtual reality and in-person effects on loneliness

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Abstract— Most studies investigated the effectiveness of virtual reality (VR) for healthcare and educational purposes, but little is known on the effectiveness of VR in social interaction. Our aim was to examine whether VR would be similar to in-person interaction in reducing loneliness. A total of 73 participants participated in this study. They were randomly assigned to in-person or VR condition and interacted for 15 minutes about a tourist landmark. Participants completed a set of questions that measured belonging – acceptance and exclusion, positive and negative affect, wellbeing, trust, and mood before and after the interaction. Results showed that in both conditions, loneliness was significantly lower, with higher wellbeing, higher positive and lower negative affect, feeling happier and had more fun post task. Trust was higher in the VR condition post task but not for in-person. Our regression analyses showed that having higher wellbeing was a significant predictor in reducing loneliness for in-person condition and that being older and higher belonging – acceptance were significant predictors on feeling lonelier for the VR condition. In sum, our results demonstrated some success in reducing loneliness in VR but may not be sufficient to develop lasting friendship.

Keywords— loneliness, virtual reality (VR), mood, wellbeing, trustworthiness, sense of belonging

I. INTRODUCTION

Research findings have shown that loneliness is a risk factor for developing dementia, increased mortality and physical and mental health decline across the lifespan [1]–[3]. The recent COVID-19 pandemic added to this problem in that people were forced to be isolated for long periods and had minimal opportunities to have frequent social interaction with others, which led to increased anxiety levels and feelings of loneliness [4]–[6]. Empirical evidence showed that young adults, people living alone, people with lower education or income, the economically inactive, women, ethnic minority groups and urban residents had a higher risk of being lonely both before and during the pandemic [7], [8], suggesting that loneliness interventions should be targeted to these groups.

Researchers have identified several risk factors in young adults' loneliness such as negative emotions, sense of belonging, and wellbeing. For negative emotions, evidence showed that loneliness had a moderately significant effect on depression [9] and negatively correlated with positive affect [10], in that people who reported feeling lonely had higher likelihood of experiencing negative emotions. Sense of belonging is an important psychological construct for mental health and well-being. Previous studies have shown that having low sense of belonging affects mental health and

wellbeing [11], [12] and could potentially harm future career prospects [13].

Beyond working from home and online classroom, the COVID-19 pandemic encouraged many individuals to go online to maintain some social interaction with others using video conferencing applications and programs [14]. Volker argued that online social networks work well with close friends but not ideal when the relationships are weak [15]. This was supported by another study that reported individuals feeling more stress and greater negative affect with weaker friendships although maintaining close interaction with stronger friendships helped them to feel more socially connected [16]. This suggests that virtual networks may not be a good start in forming new friendships. There is also an element of distrust that online friends may not be sincere and may have prevented individuals from going online [17]. During COVID-19 movement restriction, there has been an increase in using virtual reality (VR) application for communication e.g. VRChat or AltspaceVR [18] and that users went on these platforms to fulfil social needs [19]. Despite the mounting interest in VR technology for healthcare and educational needs [20], [21], very little is known about the possibility of using VR technology to address social needs. One study found that individuals reported enjoyment and relatedness when using social VR [22]. The authors suspected that the positive psychological outcomes are associated with the immersive ability from the VR application, specifically the ability to elicit sense of presence with others.

The aim of this study is to examine whether a VR environment would have similar effects compared to in-person in terms of reducing loneliness. As shown by previous studies, individuals might experience enjoyment or 'positive affect' when meeting new people. We hypothesized that participants would demonstrate lower loneliness, higher positive affect (PA) and lower negative affect (NA) after participating in the task and that this would be similar in both in-person and VR conditions [H1]. Additionally, we anticipated that the VR activity might promote higher sense of belonging and wellbeing similar to in-person because of the spatial relatedness and enjoyment of sharing an experience together [H2]. Previous studies have shown that trust can easily be developed in various contexts [23] although there is lower trust for online platforms [17]. Further, individuals showed higher trust in the human-like avatar due to the sense of relatedness compared to a robot in a VR environment [24]. We hypothesized that participants would have higher levels of trust for in-person but not VR environment [H3]. Finally, we

predicted that lower loneliness is predicted by higher sense of belonging – acceptance, wellbeing and trust [H4].

II. METHOD

A. Participants

We calculated a power analysis to determine sample size. Using a small effect size $f = 0.2$, $\alpha = 0.05$, power $(1-\beta) = 0.80$, two independent variables with two groups, we needed 50 participants. We initially recruited 76 participants but we removed 3 participants for failing to complete the study fully. A total of 73 participants (39 males, 32 females and 2 who chose not to disclose) with a mean age of 30.36 with a SD of 9.28 (range: 18 to 59) participated in the study. They were recruited from the University cafes and atrium. We had one inclusion criterion in that participants were at least novice VR user or had not used VR in the last 12 months. Participants did not receive any monetary compensation and provided informed consent prior to starting the study. This study was approved by [redacted for anonymity].

B. Materials

Participants completed a series of questions on an online platform twice; once before starting the study and another after completing the study. In each session, they completed the UCLA loneliness scale, General Belongingness Scale, Positive Mental Health, Positive Affect and Negative Affect, trust, and two items on mood. They also completed other tasks which are not reported here.

Loneliness (UCLA-8) [25]. This was an 8-item scale to which participants rated themselves on a scale of 1 (Never) to 4 (Often). An example of the item was “I lack companionship.”. Four items are reverse-coded and a higher overall sum indicate higher loneliness. The authors reported a reliability score of $\alpha = 0.84$. For this study, the reliability for pre-test is $\alpha = 0.819$ and $\alpha = 0.856$ for post-test.

General Belongingness Scale (GBS) [26]. This scale has 12 items and 6 items were to measure acceptance or inclusion while the remaining 6 items were to measure exclusion or rejected. An example of the inclusion item was “when I am with other people, I feel included” and “I feel like an outside” for exclusion. Participants had to rate each item on a 7-point Likert scale with 1 “strongly disagree” to 7 “strongly agree”. Total scores for inclusion and exclusion were calculated separately and a higher score indicated a higher inclusion or exclusion score. The authors for GBS reported a reliability score of 0.94. The reliability scores in this study was $\alpha = 0.938$ pre-test and $\alpha = 0.929$ for post-test.

Positive Mental Health (PMH) [27]. The PMH has 9 items to which participants had to rate on a scale of 1 (not true) to 4 (true). An example of the item is “I am often carefree and in good spirits”. The 9 items were totaled together to form an overall score and a higher score indicated higher PMH. The authors in the original reported $\alpha = 0.93$ and it was $\alpha = 0.919$ for pre-test and $\alpha = 0.929$ for post-test.

Positive and Negative Affect (PANAS) [28]. The PANAS has 20 words in which 10 words were for positive affect (PA) and the other 10 words were for negative affect (NA). Participants had to rate on a scale of 1 (very slightly or not at all) to 5 (extremely) for each word. An example of the item was “irritable” and “excited”. The PA was totaled from the 10 items and higher scores indicated higher positive affect. Same

formula was used for negative affect. The authors in the original study reported reliability scores ranged from 0.86 to 0.90 for PA and from 0.84 to 0.87 for NA. The pre-test reliability scores in this study were 0.658 for PA and 0.594 for NA. The post-test reliability scores were 0.594 for PA and 0.639 for NA.

Trust [29], [30]. This was a 3-item question that probes personal trust. Participants were given two options for each question. An example of an item was “Generally speaking, would you say that most people can be trusted or that you can’t be too careful in dealing with people?” and the two options were “Most people can be trusted” and “can’t be too careful”. Total sums were computed for the choices demonstrating trust in others.

Mood. We included two items (happy, fun) to get participants to respond on their immediate mood state using visual analogue scale from low to high. They were asked to slide along a ruler from 0 (low) to 100 (high). The higher the value, it meant that they were feeling happier or having more fun.

Participants in the VR condition was provided with a google VR cardboard and used “Sites in VR” to explore their environment. The “Sites in VR” was accessed through a mobile phone. As the Google VR cardboard does not have sound, we also used MS Teams to call each other.

C. Procedure

Participants were invited to the psychology lab in groups of three. We verified that they did not know each other and were meeting for the first time. Participants were randomly assigned to one condition: VR or in-person.

After providing informed consent, participants completed the survey questions. For the in-person condition, they sat around a round table with an image of Eiffel Tower in Paris on the table. For the VR condition, participants were brought into individual lab rooms (one participant per lab room) and connected to “Sites in VR” and the image of Eiffel Tower was shown here (see Figure 1a and 1b). Participants was provided with a headset to ensure clear sound. All participants were informed that the topic of conversation was about visiting Paris and they were left to decide on the conversation direction. The conversation in both conditions lasted 15 minutes and then all participants completed the survey questions before being debriefed and thanked for participation.



Fig 1a. Eiffel Tower image for in-person condition.

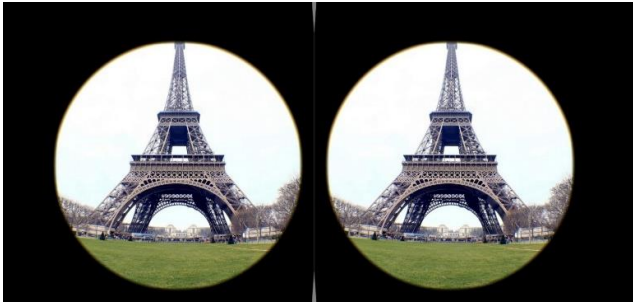


Fig 1b. Eiffel Tower image for VR condition.

III. RESULTS

Our data was normally distributed for all variables except NA ($p < .001$) as shown in Shapiro-Wilk, all $ps > 0.1$ and visual inspection of the histogram. We ran an independent t-test for all variables at pre-test to ensure that participants' characteristics were similar prior to starting the task. Results showed a non-significant finding for all variables, all $ps > 0.29$.

For H1, we ran a paired t-test on loneliness scores in both conditions and found that loneliness was lower in the post-test compared to pre-test in both conditions, both $ps < .004$. Participants also reported feeling more PA and lower NA in the post-test in both conditions, all $ps < 0.004$. We then conducted an independent between-subject t-test on loneliness, PA and NA for in-person and VR conditions. Results showed a non-significant finding on all three, all $ps > 0.37$ (Table 1).

TABLE I. DESCRIPTIVE AND T-TEST VALUES FOR IN-PERSON AND VR CONDITIONS

	In-person (n = 35)		VR (n = 38)		Between conditions	Within conditions
	Pre	Post	Pre	Post		
Loneliness	18.06 (4.78)	14.91 (4.80)	17.95 (4.63)	15.74 (5.05)	Pre, t (71) = 0.10 Post, t (71) = 0.71	In-person: t (34) = 7.34*** VR: t (37) = 3.08**
Belonging – acceptance	23.51 (3.01)	20.89 (4.56)	23.00 (2.79)	21.08 (3.91)	Pre, t (71) = 0.76 Post, t (71) = 0.20	In-person: t (34) = 3.17** VR: t (37) = 2.74
Belonging – exclusion	24.83 (3.31)	25.80 (3.44)	24.63 (3.10)	26.24 (4.04)	Pre, t (71) = 0.26 Post, t (71) = 0.50	In-person: t (34) = 1.18 VR: t (37) = 1.98
Wellbeing	26.80 (5.97)	29.17 (5.84)	26.03 (5.85)	28.47 (5.54)	Pre, t (71) = 0.56 Post, t (71) = 0.52	In-person: t (34) = 4.54*** VR: t (37) = 4.09***

PA	32.51 (7.39)	37.54 (8.00)	32.37 (9.14)	35.68 (9.32)	Pre, t (71) = 0.08 Post, t (71) = 0.91	In-person: t (34) = 4.68*** VR: t (37) = 3.05**
NA	18.74 (6.65)	14.71 (4.88)	20.47 (7.09)	15.63 (5.27)	Pre, t (71) = 1.07 Post, t (71) = 0.77	In-person: t (34) = 4.05*** VR: t (37) = 4.36***
Trust	1.49 (0.78)	1.71 (0.86)	1.32 (0.74)	1.71 (0.73)	Pre, t (71) = 0.96 Post, t (71) = 0.02	In-person: t (34) = 1.68 VR: t (37) = 3.58***
Mood - happy	58.06 (23.88)	74.94 (18.75)	59.29 (23.86)	71.66 (18.59)	Pre, t (71) = 0.22 Post, t (71) = 0.75	In-person: t (34) = 4.90*** VR: t (37) = 3.56***
Mood - fun	47.49 (23.85)	68.89 (23.00)	52.84 (24.20)	67.76 (18.88)	Pre, t (71) = 0.95 Post, t (71) = 0.23	In-person: t (34) = 5.22*** VR: t (37) = 3.63***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For H2, we did a similar test for sense of belonging and wellbeing for in-person and VR. At post-test, there was no significant difference for sense of belonging – acceptance and exclusion, both $ps > 0.62$. Wellbeing was also not significant between the two conditions, $t(71) = 0.52$, $p = 0.60$. However wellbeing scores were higher at post-test compared to pre-test in both conditions, both $ps < .001$. Participants also reported an increase in feeling happy and having more fun at post-test in both conditions, both $ps < .001$. See Fig 2 and Fig 3.

In terms of trust [H3], there was no significant difference between the two conditions at post-test, $t(71) = 0.02$, $p = 0.34$. Trust scores were significantly higher at post-test compared to pre-test in the VR condition, $t(37) = 3.58$, $p < 0.001$ but there was no significant difference for in-person, $t(34) = 1.68$, $p = 0.10$.

For H4, we first did a correlational analysis between all variables for each condition. For the in-person condition, lower loneliness was significantly correlated with higher belonging – exclusion, higher PA, higher wellbeing, higher mood – fun and lower belonging – acceptance, all $ps < 0.05$. Results showed similar trend for the VR condition compared to in-person, all $ps < 0.001$. Additionally, lower loneliness was significantly correlated to higher NA, $r = 0.40$, $p < 0.05$, and higher mood – happy, $r = 0.60$, $p < 0.001$ in the VR condition.

We then ran a hierarchical regression with loneliness as an outcome variable, and all other variables as predictors in Step

1. Although trust was not significantly correlated in the earlier analysis, previous evidence on trust and likeability [17], [24] suggests that this might be an important predictor on loneliness. We then added age and gender (categorical with 1 for female, 2 for males) into Step 2. Evidence showed that sociodemographic variables may have influenced loneliness [31], [32] although there appears to be differences in relation to coping during the COVID-19 pandemic. We performed hierarchical regression for each condition.

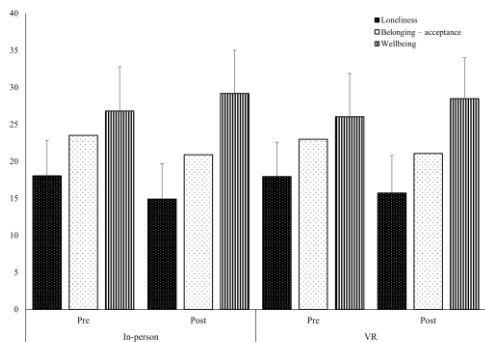


Fig 2. Means and SD for loneliness, belonging-acceptance and wellbeing for in-person and VR conditions in both pre- and post- interaction

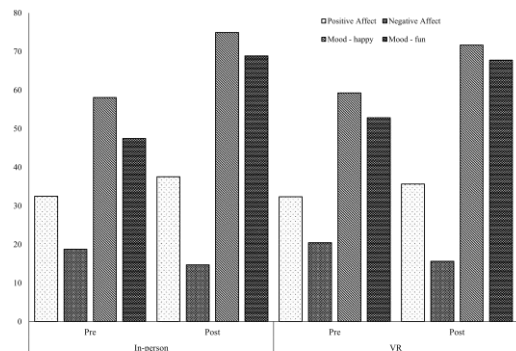


Fig 3. Means and SD for for positive and negative affect, mood – happy, and mood – fun in in-person and VR conditions in both pre- and post-

For in-person, the model was significant in Step 1, $F(8, 26) = 3.25, p = 0.011$ in that those who had higher wellbeing was a significant predictor in reducing loneliness, $t = 2.80, p = 0.009$. At Step 2, adding the age and gender contributed a 3.4% change in the model although the model was still significant, $F(10, 24) = 2.75, p = 0.02$. Results showed that higher wellbeing remained the only significant predictor to the overall model, $t = 2.26, p = 0.03$ and not for all other variables, all $ps > 0.11$.

For VR, the model was significant, $F(8, 29) = 7.77, p < 0.001$ in Step 1. There were two significant predictors in this model – higher belonging – acceptance, $t = 2.22, p = 0.03$, and lower mood – fun, $t = 2.07, p = 0.05$ for higher loneliness. The other variables were not significant, all $ps > 0.17$. At Step 2, age and gender contributed 5.2% R^2 change to the model. Results showed that belonging – acceptance was significant, $t = 2.70, p = 0.012$ and being older were significant for higher loneliness, $t = 2.29, p = 0.03$. See Table 2 for full regression details.

TABLE II. SUMMARY OF HIERARCHICAL REGRESSION ANALYSES FOR IN-PERSON AND VR CONDITIONS

Variable	R	R ²	ΔR^2	B	SE B	β	t
<i>In-person</i>							
Step 1	0.71	0.50	0.35				
Belonging – acceptance				0.26	0.18	0.25	1.46
Belonging – exclusion				-0.34	0.24	-0.25	-1.42
Wellbeing				-0.53	0.19	-0.65	-2.80**
PA				0.05	0.16	0.09	0.33
NA				-0.23	0.17	-0.24	-1.40
Trust				0.66	0.80	0.12	0.82
Mood - happy				0.07	0.07	0.28	1.11
Mood - fun				-0.04	0.07	-0.17	-0.56
Step 2	0.73	0.53	0.34				
Belonging – acceptance				0.30	0.18	0.29	1.66
Belonging – exclusion				-0.27	0.25	-0.20	-1.08
Wellbeing				-0.46	0.20	-0.56	-2.26*
PA				0.10	0.17	0.16	0.58
NA				-0.22	0.17	-0.23	-1.34
Trust				0.99	0.86	0.18	1.15
Mood - happy				0.04	0.07	0.16	0.59
Mood - fun				-0.05	0.07	-0.25	-0.79
Age				-0.02	0.09	-0.03	-0.18
Gender				-2.08	1.62	-0.24	-1.28
<i>VR</i>							
Step 1	0.83	0.68	0.59				
Belonging – acceptance				0.35	0.16	0.27	2.22*
Belonging – exclusion				-0.26	0.19	-0.21	-1.42
Wellbeing				-0.20	0.16	-0.22	-1.22
PA				-0.01	0.09	-0.03	-0.15
NA				0.18	0.12	0.19	1.55
Trust				1.01	0.83	0.15	1.22
Mood - happy				0.01	0.06	0.03	0.14
Mood - fun				-0.12	0.06	-0.44	-2.07*
Step 2	0.86	0.73	0.64				
Belonging – acceptance				0.43	0.16	0.33	2.70*
Belonging – exclusion				-0.22	0.18	-0.17	-1.20
Wellbeing				-0.32	0.17	-0.35	-1.90
PA				0.02	0.09	0.03	0.19
NA				0.16	0.12	0.17	1.37
Trust				1.11	0.79	0.16	1.41
Mood - happy				0.02	0.06	0.08	0.39
Mood - fun				-0.10	0.06	-0.37	-1.80
Age				0.13	0.06	0.27	2.29*
Gender				-0.09	1.04	-0.01	-0.08

* $p < .05$, ** $p < .01$

IV. DISCUSSION

The aim of this study was to examine whether a VR environment would have similar effects compared to in-person in terms of reducing loneliness. Our findings showed that both conditions had significantly reduced feelings of loneliness after completing a brief social interaction. Additionally, we also found that wellbeing improved together with increased PA, reduced NA and participants reported feeling happier and had more fun in both conditions, supporting H1 and partially for H2. This is because our findings showed that sense of belonging – acceptance was lower and sense of belonging – exclusion was higher after the task in both conditions. Further, we did not find support for H3 and showed the opposite of what we predicted in that there was a significant increase of trust for the VR condition but not for in-person. Lastly, our findings showed that having good wellbeing is a significant predictor in reducing feelings of loneliness for in-person condition, demonstrating partial support for H4. We did not find any support for trust and belonging though. Interestingly in the VR condition, we found that being older is a predictor on feeling lonelier and that higher acceptance is also a predictor to feeling lonelier.

Our findings is indicative that one can use VR social platforms for social interaction and is able to reduce feelings of loneliness even among strangers irrespective of strong or weak relationships thus giving further support from previous research [14], [15], [22]. This is particularly helpful as it may help other users to gain more benefits especially for those unable to meet people in-person due to mobility or health issues [33], [34]. VR is not as widely used compared to regular virtual platforms [35] as they are primarily marketed for entertainment purposes and also the high costs involved. In our study, we found that participants reported feeling more fun and happier using the cheap VR cardboard goggles and it is possible that the novelty of using VR may have prompted the positive feeling rather than the social interaction component. Our findings also showed that the sense of belonging – acceptance was lower and exclusion higher post-task in both conditions. This suggests that the 15-minute social interaction with strangers were not sufficient to develop the sense of belonging with other people and although they reported a higher sense of trust post-task, the general belonging sense has yet to be fully developed. Taken together with the higher fun and happier mood and lowered loneliness, these findings suggest that participants enjoyed the interaction exercise but not enough to form lasting relationship or impression. We are uncertain as to why individuals felt more excluded and less accepted in both conditions. However, these results were not significant for the VR condition but it was for the in-person condition. We suspect that in the VR condition, it is likely that participants did not see an avatar or human-like self in the environment so had no opportunity to develop the sense of belonging with others.

We did not find support for more trust in the in-person post-task but there was significant increase in the VR condition. It is possible that participants perceived others nonverbal cues during the in-person interaction which may hampered their trust levels towards others. Reading nonverbal cues from others may have also contributed to the less acceptance as others may have given some implied negative social cues. Likewise, seeing the nonverbal cues from others in the in-person condition may have contributed to the lowered sense of acceptance and increased exclusion. Unlike the in-person condition, participants in the VR condition only had

verbal communication with others and the conversation was clearly enjoyable as participants reported having higher trust post-task.

Our other finding was that older participants felt lonelier compared to younger adults in the VR condition. This is concordant with one study that reported this during the COVID-19 pandemic [32] but not in another global study [31]. The authors suspected that loneliness was partly attributed to the forced isolation and physical distancing regulations [32]. Although older adults do use technology, they often face many barriers that prevents them from using them effectively [36], [37]. It is possible that the VR environment was challenging for them or not as engaging as in-person and feeling left out compared to others. We did not find any support for gender differences. We suspect that loneliness for them is not as acute as those reported in other studies [31], [32], but we also did not ask them for any specific incidents that may have shed more light into this.

We acknowledge that we did not ask our participants on their cultural identity. Studies have shown that some cultures are more trusting than others [38] and having this question included might shed light about it further. Future studies should include head-mounted device (HMD) as the current google cardboard has limited movement. The 3D virtual environment in the Oculus Rift is more immersive and the Multi-User Virtual Environment (MUVE) has the ability for multiple users in the same virtual space. These environments might increase the feeling of relatedness and could possibly increase trust levels between participants. Additionally, trying out this paradigm in other VR platforms e.g. VRChat or AltSpaceVR could have been tested to determine whether social communication channels would work similarly to a group of strangers coming together in-person.

In sum, our study demonstrated the potential of VR in reducing loneliness as it had similar effects to in-person condition. Our VR participants also reported a more positive outcome (higher positive affect, lower negative affect, higher wellbeing) similar to in-person suggesting that VR technology could generate similar benefits. However VR acceptance needs further scrutiny particularly among older age groups as they reported feeling more lonely and less accepted by others, suggesting other psychological barriers may have an effect on loneliness.

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