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Research on Companion Experiments Based on Metaverse on the Psychological Well-Being of Senior Citizens Living Alone

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Abstract. With the continuous advancement of technology, the metaverse, as an extension of virtual reality, has permeated various aspects of society and found widespread applications. Elderly individuals living alone, as a group lacking companionship and care, may potentially benefit from the application of the metaverse, offering them a new social and life experience. This study aims to explore the impact of metaverse application on the psychological well-being of elderly individuals living alone.

Keywords. Senior citizen, living alone, metaverse

1. Introduction

Social isolation is a global public health issue, and living alone is a major component of social isolation, as well as a social and medical issue for the elderly. Elderly individuals living alone refer to those over the age of 60 who live by themselves without a spouse, children, or others. The population of elderly individuals living alone is expected to grow with the trends of an aging population and the increase of 'empty nests.' As a vulnerable group in society, elderly individuals living alone face numerous challenges. They are more likely to suffer from disabilities and have a higher mortality rate. Furthermore, due to loneliness, lack of cultural and spiritual life, and the absence of children, they are among the most susceptible to psychological issues.

Research indicates that psychological issues are significant factors affecting the physical function and mortality of elderly individuals living alone. Given the large population of elderly individuals living alone in China, their psychological health is an important medical and public health issue. However, current research in China mainly focuses on their living conditions, care needs, and social support, with less emphasis on psychological health.

There are already many studies on the benefits of games for elderly individuals living alone.Kenneth Lachlan argue that midlife empty-nest parents were lonelier,

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played more WeChat mini-games, and engaged in fewer learning activities than non-empty nesters. Loneliness increased WeChat gaming while reducing motivation to learn which, in turn, drove learning activities on WeChat. [1]Lange presents an approach for maximizing function and participation for those aging with and into a disability by combining task-specific training with advances in VR and gaming technologies to enable positive behavioral modifications for independence in the home and community.[2]Geun-Ho Leeargues that the use of virtual reality, specifically the Nintendo Wii, as an intervention for fall prevention among elderly people living alone.[3] Peixian Gong discusse that the development of a novel graph neural network, MMPoint-GNN, for human activity recognition, which can be applied in intelligent monitoring of the elderly living alone. The method is evaluated for its effectiveness in recognizing human activities, including those related to gaming.[4] Wang, Q revealed the predicting power of game narrative, the social interaction and physical condition of the elderly, and the moderating effects of age, gender and previous experience on older people's gameplay intention. Implications were derived for the design of novel digital games that could foster physical activity, social interaction and entertainment for older people, especially for those who live alone.[5]Li, Y. J.foucus on proceeding from “sense of loneliness of old people”, and takes “Nanjing Happy Valley Gerocomium” as an example to verify the positive role played by the games in improving the sense of loneliness, thus providing future design of the game for the old with an effective theoretical support and design ideas. [6]King, A. P. Y., discusse co-design experience of game sets through participatory research with living alone elderly with dementia, game sets for cognitive impairment should compose with different stages to become more flexible due to diverse cognitive abilities. Research finding will help improve the patient’s participation due to unfavourable design of existing play tools that may harm the result of training.[7]

Traditional games, particularly non-VR ones, often provide limited immersive experiences. The metaverse, with its use of VR and AR technologies, offers a more immersive, 3D virtual environment that can feel more realistic and engaging.While traditional online games do offer social interaction, the metaverse provides a more nuanced and dynamic form of social engagement, closely simulating real-world interactions. This is particularly advantageous for activities like networking, social gatherings, and collaborative work.

The metaverse is a new world derived from the internet. Supported by modern technologies such as virtual reality, the metaverse has transformed from a conceptual technological utopia into a complete internet-based virtual ecosystem, encompassing a series of virtual avatars, social interactions, and environments. It has penetrated various aspects of society and is widely used, merging the digital and real worlds and becoming a simulation of reality. As a virtual reality space, the metaverse can offer elderly individuals living alone a social and life experience that transcends traditional limitations, potentially positively impacting their psychological health.

This study aims to explore the impact of metaverse application on the psychological health of elderly individuals living alone. By utilizing metaverse technology platforms to create personalized metaverse spaces for them and collecting data through psychological scales and physiological indicators, the research analyzes the impact of metaverse application on their psychology, hoping to provide new ideas and methods for improving the mental health and spiritual life of elderly individuals living alone.

The design of these metaverse group activities takes into account the elderly's operational habits and physical conditions, ensuring a simple and intuitive interface that is easy to operate. By participating in these activities, elderly individuals can experience the joy of social interaction in the safety and comfort of their homes, thereby enhancing their quality of life and psychological health.

2. Background

2.1. The General Well-Being Schedule

The General Well-Being Schedule (Fazio, 1977) is a structured assessment tool developed for the United States National Center for Health Statistics. It is used to evaluate the respondent's statements about their well-being. The Overall Well-Being Scale is a psychological assessment tool designed to measure an individual's overall sense of well-being. This scale encompasses various dimensions of a person's life, including emotional, psychological, and sometimes physical aspects of health.

In psychological terminology, well-being refers to an individual's overall quality of life from their own perspective. It is a broad construct that includes subjective evaluations of positive emotions, life satisfaction, fulfillment, and purpose. The concept of well-being is central to the field of positive psychology, which focuses on what makes life worth living, rather than just the treatment of mental illness.

The Overall Well-Being Scale typically consists of a series of statements or questions. Respondents rate these items based on their personal experiences, often using a Likert-type scale ranging from strong disagreement to strong agreement. The total score is then calculated, reflecting the individual's overall level of well-being. Generally, higher scores indicate greater well-being.

This scale is a valuable tool in both clinical and research settings. In clinical practice, it helps psychologists and therapists understand a client's overall mental health status, guiding treatment plans and interventions. In research, it assists in examining the effectiveness of various psychological treatments and interventions in enhancing overall well-being.

This scale consists of 33 items, and in 1996, a domestic scholar Duan Jianhua revised the scale, adopting the first 18 items of the scale for testing subjects. In this study, the domestic revised version of the Overall Well-Being Scale was used to collect participants' self-assessment data before and after participating in the experiment.

2.2. Physiological Indicator Monitoring Design

This study primarily focuses on monitoring the following three dimensions of indicators in participants before and after the experiment:heart rate (HR), respiratory rate (RR), and blood pressure (BPR) are important physiological indicators that can reflect the following aspects:

Heart Rate (HR): Heart rate, the number of heartbeats per minute, is a key indicator of cardiac activity and overall physiological arousal level. In psychological research, changes in heart rate are often used to assess an individual's emotional responses, stress levels, or anxiety states.

Respiratory Rate (RR): Respiratory rate is the number of breaths taken per minute. This metric can be used to assess an individual's emotional state and stress response. During emotional tension or anxiety, breathing may become faster and shallower. Conversely, relaxation techniques like deep breathing or meditation usually reduce the respiratory rate, indicating a more relaxed state.

Blood Pressure (BPR): Blood pressure is the pressure exerted by the blood against the walls of blood vessels. Changes in blood pressure can reflect an individual's stress response and emotional state. Prolonged high blood pressure may be associated with stress, anxiety, or other psychological health issues. In certain situations, such as facing fear or stress, blood pressure may temporarily rise.

By monitoring these physiological indicators, researchers can better understand the relationship between psychological states and bodily responses, as well as how individuals physiologically react under different emotional and cognitive loads. This information is crucial for understanding aspects of psychological health, emotional regulation, and stress management.

3. Design of the Experiment

The 12 elderly individuals participating in this experiment were aged between 60 and 80 years, with an approximately equal ratio of men to women and a balance between those residing in urban and rural areas. Before the experiment began, we used psychological self-assessment scales and physiological indicators to collect routine data from the participants as control data. To minimize the influence of the experimenters on the overall results, one week before the start of the experiment, the experimenters assisted the participants in using the metaverse space to ensure they could independently use the relevant functions during the experiment. The official experiment lasted four weeks. During this time, participants used the metaverse space and its features as part of their daily life. Three experiments were designed.

3.1. Experiment One

The metaverse photo wall, designed specifically for elderly individuals living alone, is an interactive activity filled with emotional connections. In the metaverse, the elderly could see a virtual wall displaying photos with their children and other meaningful dynamic pictures. These photos were not just static but could dynamically showcase moments such as the growth of their children, happy times at family gatherings, or significant family celebrations. The elderly could interact with these photos using simple gestures or voice commands, such as zooming in, switching between them, or learning more about the background stories of the photos. Virtual reality or augmented reality technology was used to create this metaverse environment, ensuring a user interface that was simple to use, adapted to the operational habits of the elderly. This experiment aimed to explore the potential of virtual reality technology in enhancing the mental health and social wellbeing of elderly individuals living alone.

3.2. Experiment Two

Interactive Virtual Avatars in the Metaverse. This experiment aims to create an immersive experience in the metaverse space, specifically addressing the social needs of elderly individuals living alone. In this virtual environment, avatars of significant relatives of the elderly, such as children or deceased spouses, can be generated. These avatars not only provide a visual representation but are also capable of interaction through advanced artificial intelligence algorithms. They can respond to questions, engage in simple conversations, or accompany the elderly in virtual activities.

This interaction offers emotional support and stimulates the cognitive functions of the elderly by simulating real social interactions.

3.3. Experiment Three

Metaverse Group Activities are designed to provide a virtual social and entertainment platform for elderly individuals living alone. In the central hall of the metaverse, we can set up various cultural and entertainment modules, such as traditional opera appreciation, classic movie reviews, and chess competitions. These modules not only offer activities familiar and beloved by the elderly but also encourage them to engage in collective interaction and socialization online.

4. Results

In this study, we utilized the Overall Well-Being Scale and physiological indicator monitoring to assess the psychological changes of elderly individuals living alone before and after the metaverse experiment. Detailed data are provided in table 1.

Table 1. Results of Experiment 1

Item Number	Well-Being Scale Total Score		Heart Rate		Respiratory Rate		Blood Pressure	
	B	A	B	A	B	A	B	A
P1	63	73	58	65	14	16	135	143
P2	59	66	58	63	13	15	144	149
P3	68	73	64	70	14	15	139	147
P4	72	79	65	69	15	16	153	161
P5	69	72	68	72	16	18	132	138
P6	66	71	66	67	15	15	128	135
P7	71	73	67	71	15	15	113	118
P8	77	79	63	66	14	16	132	130
P9	66	69	59	63	14	15	125	126
P10	60	65	60	67	15	16	120	123

P11	58	64	63	65	16	16	138	135
P12	61	67	64	69	13	14	130	134
Mean	65.83	70.92	62.92	67.25	14.50	15.58	132.42	136.58

* B=before experiment, A=after experiment

In the study, the average total score of the Overall Well-Being Scale improved by 5.09 points, with a variance of 5.1, representing an average increase of 9.46% compared to before the experiment. The average heart rate increased by 4.33, with a variance of 3.06, marking an average increase of 6.88% compared to the pre-experiment measurements. Respiratory rate showed an average increase of 1.08, with a variance of 0.58, amounting to an average increase of 7.45% from the initial measurements. Blood pressure averages rose by 4.16, with a variance of 13.14, which translates to an average increase of 3.14% compared to the pre-experiment values.

Table 2. Results of Experiment 2

Item Number	Well-Being Scale Total Score		Heart Rate		Respiratory Rate		Blood Pressure	
	B	**A**	**B**	**A**	**B**	**A**	**B**	**A**
P1	63	66	58	60	14	15	135	138
P2	59	61	58	61	13	14	144	146
P3	68	72	64	66	14	14	139	142
P4	72	75	65	66	15	16	153	155
P5	69	73	68	71	16	16	132	136
P6	66	68	66	70	15	16	128	131
P7	71	75	67	68	15	16	113	119
P8	77	78	63	65	14	15	132	135
P9	66	73	59	61	14	15	125	127
P10	60	66	60	65	15	15	120	121
P11	58	59	63	66	16	17	138	139
P12	61	69	64	68	13	15	130	135
Mean	65.83	69.58	62.92	65.58	14.50	15.33	132.42	135.33

* B=before experiment, A=after experiment

The overall score on the Well-Being Scale improved by an average of 3.75 points, with a variance of 4.69, indicating an average increase of 5.7% compared to before the experiment. The average heart rate increased by 2.67, with a variance of 1.39, marking an average increase of 4.24% compared to the pre-experiment measurements. The average respiratory rate increased by 0.83, with a variance of 0.31, resulting in an average increase of 5.75% from the initial measurements. Blood pressure averages rose

by 2.92, with a variance of 2.08, translating to an average increase of 2.2% compared to the pre-experiment values.

Table 3. Results of Experiment 3

Item Number	Well-Being Scale Total Score		Heart Rate		Respiratory Rate		Blood Pressure	
	B	A	B	A	B	A	B	A
P1	63	69	58	58	14	15	135	132
P2	59	66	58	59	13	13	144	136
P3	68	73	64	65	14	14	139	135
P4	72	78	65	66	15	16	153	144
P5	69	73	68	69	16	16	132	130
P6	66	71	66	68	15	16	128	124
P7	71	78	67	68	15	15	113	110
P8	77	83	63	64	14	15	132	128
P9	66	71	59	60	14	14	125	122
P10	60	68	60	62	15	16	120	115
P11	58	65	63	64	16	16	138	132
P12	61	69	64	66	13	14	130	123
Mean	65.83	72.00	62.92	64.08	14.50	15.00	132.42	127.58

* B=before experiment, A=after experiment

The average total score on the Overall Well-Being Scale increased by 6.17 points, with a variance of 1.47, marking an average increase of 9.37% compared to before the experiment. The average heart rate rose by 1.17, with a variance of 0.31, reflecting an average increase of 1.85% compared to the pre-experiment measurements. The average respiratory rate increased by 0.5, with a variance of 0.25, indicating an average increase of 3.45% from the initial measurements. Blood pressure, on average, decreased by 4.83, with a variance of 4.47, representing an average reduction of 3.65% compared to before the experiment.

Compared to before the metaverse experiment, participants showed a significant improvement in their overall well-being, as evidenced by the increased total scores on the Overall Well-Being Scale, indicating a more positive and stable state. In terms of physiological indicators, there were relatively positive changes in various metrics both before and after the experiment. Notably, in Experiment Three involving metaverse activities, a decrease in blood pressure was observed among the elderly living alone, which will be further investigated in subsequent studies.

This improvement was not only reflected at the psychological level but also confirmed through monitoring physical health indicators. Particularly in Experiment Three, the collective activities in the metaverse environment not only enhanced social interactions among the elderly living alone but also positively impacted their physical

health. The most significant change was observed in blood pressure, where a certain level of reduction was noted. This finding suggests that social and interactive activities in the virtual world may have an important impact on the physical health of the elderly.

Given these preliminary findings, future research will further explore the specific mechanisms through which metaverse activities affect the physical health of the elderly. We will analyze how activities in the metaverse enhance psychological well-being and social interaction, thereby positively influencing physical health. Additionally, the research will focus on the effects of different types of metaverse activities on various physiological indicators in the elderly, as well as the long-term effects of these activities on improving the quality of life for the elderly. Through these studies, we aim to provide more effective strategies for supporting the psychological and physical health of elderly individuals living alone.

5. Reflection

The limitations of this experiment, which assesses the psychological changes in elderly individuals living alone before and after the experiment, might include several factors:

Sample Size and Diversity: The sample size may be relatively small, and the diversity among participants might be limited, affecting the generalizability of the findings to a broader population.

Short Duration of Experiment: The experiment's duration may be too short to observe long-term effects or changes in psychological and physiological well-being.

Technological Familiarity: Participants' varying levels of familiarity and comfort with metaverse technology and virtual environments could influence their experiences and the outcomes of the experiment.

Physical and Cognitive Constraints: The physical and cognitive constraints of elderly participants, such as vision or hearing impairments and cognitive decline, might affect their engagement with the metaverse environment and the accuracy of physiological monitoring.

These limitations should be considered when interpreting the results of the study and in planning future research.

6. Conclusion

By conducting a metaverse companionship experiment and related data analysis, this paper explores the impact of using metaverse spaces and their features on the psychological health of elderly individuals living alone. The results of the experiment demonstrate that after the application of the metaverse in the daily lives of these individuals, there was an improvement in both their overall well-being and physiological health indicators, showing a more positive and stable psychological state. These conclusions offer new perspectives under the realm of the metaverse for research on the psychological health of elderly individuals living alone and for developing psychological care strategies.

References

[1] Yang, Dongdong, Kenneth Lachlan, and Ye Chen. "WeChat Gaming, Learning, and Midlife Empty Nest." Mobile Communication in Asian Society and Culture, 2023, 7–23.
[2] Lange, B.S., P. Requejo, S.M. Flynn, A.A. Rizzo, F.J. Valero-Cuevas, L. Baker, and C. Winstein. "The Potential of Virtual Reality and Gaming to Assist Successful Aging with Disability." Physical Medicine and Rehabilitation Clinics of North America 21, no. 2 (2010): 339–56.
[3] Lee, Geun-Ho. "Effect of Virtual Reality-Based Training Program on Patients with Mild Cognitive Impairment." Asia-pacific Journal of Convergent Research Interchange 7, no. 1 (2021): 71–80.
[4] Gong, Peixian, Chunyu Wang, and Lihua Zhang. "MMPoint-GNN: Graph Neural Network with Dynamic Edges for Human Activity Recognition through a Millimeter-Wave Radar." 2021 International Joint Conference on Neural Networks (IJCNN), 2021.
[5] Wang, Qingfeng, and Xu Sun. "Investigating Gameplay Intention of the Elderly Using an Extended Technology Acceptance Model (ETAM)." Technological Forecasting and Social Change 107 (2016): 59–68.
[6] Li, Ya-jun, and Wei-qing Ren. "A Study of Game Design Based on Sense of Loneliness of the Elderly." HCI International 2018 – Posters' Extended Abstracts, 2018, 175–82.
[7] King, Alex Pui-yuk, and Kin Wai Siu. "Redeveloping Game Set for Living Alone Elderly with Dementia Using Participatory Action Research Approach in Hong Kong." Advances in Intelligent Systems and Computing, 2017, 129–38.