

**Comparative Effects of Real-world and Virtual Reality Ping Pong on  
Psychological Well-Being**

by

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## **Abstract**

This study investigates the psychological impacts of engaging in real-world and virtual reality (VR) Ping Pong on emotional well-being. The research utilizes a balanced experimental design with 30 participants, incorporating standardized questionnaires (PANAS and SIAS) and a cognitive load assessment task. Results indicate that both real-world and VR Ping Pong positively influence emotional states, with real-world ping pong slightly outperforming VR in generating positive thoughts and reducing social interaction anxiety. The study also finds that real-world Ping Pong leads to a lower cognitive load compared to VR Ping Pong. These findings contribute to understanding the psychological benefits and cognitive implications of sports in virtual environments compared to their traditional counterparts.

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# Chapter 1

## Introduction of the Study

In an era where technology and virtual reality are becoming increasingly prevalent, understanding their impact on human psychology, particularly in the realm of sports and recreation, is critical. Several studies have explored the positive effects of VR exercise on physical and mental health, but comparative research comparing VR exercise and real-world exercise on the human psyche is still in its infancy.

This thesis aims to explore and compare the psychological effects of real-world Ping Pong and its VR-enhanced version on participants' emotional well-being, cognitive load, and social interaction anxiety. The significance of this research lies in its potential to inform the development and application of VR technologies in sports, offering insights into their benefits and challenges compared to traditional sports experiences. By investigating these two distinct forms of the same sport, the study endeavors to uncover nuanced understandings of how technology-mediated experiences can mirror, differ from, or enhance traditional physical activities. This exploration is particularly pertinent in the context of rapid technological advancements and their integration into everyday life.

## Chapter 2

# Hypothesis Setting and Methodology

### 2.1 Research Design and Hypotheses Exploration

This research is based on these theoretical frameworks: Fredrickson's Broaden-and-Build theory of Positive Emotions[1], Biddle and Mutrie's Theory in Sports Psychology[2], Sweller's Cognitive Load Theory[3], Riva's Research on VR and Psychotherapy [4].

This research scrutinizes the psychological effects of virtual reality (VR) in the domain of sports, emphasizing a comparative analysis between traditional ping-pong and its VR-modified variant. The study's focal point is the impact these diverse sporting experiences have on inducing positive cognitive states in participants. The research is structured around three primary hypotheses.

#### 2.1.1 Hypothesis 1: Engaging in Real-world Ping Pong increases have more positive thoughts than VR Ping Pong

This hypothesis contends that real-world ping-pong, inherently facilitate direct social interactions, crucial for augmenting mental well-being[5]. The premise is that real world ping-pong, characterized by its face-to-face, competitive yet cooperative dynamics, is more effective in fostering positive cognitive states than VR ping-pong. This is attributed to more psychological presence and interpersonal interactions inherent in the real-world sports, which are hypothesized to strengthen emotional connections and enhance psychological states.

### 2.1.2 Hypothesis 2: Playing VR Ping Pong causes higher cognitive load than Real-world Ping Pong

This hypothesis is based on the Cognitive Load Theory, suggesting that a heightened cognitive load can adversely affect mental states. It posits that VR ping-pong, with its integration of virtual elements like rich scenes and passionate audiences, imposes a greater cognitive burden on players compared to real-world ping-pong, which demands focused and undivided attention. The hypothesis aims to determine if the combined mental processing of virtual and physical stimuli in VR ping-pong results in a higher cognitive load.

### 2.1.3 Hypothesis 3: Participating Real-world Ping Pong promotes more social interaction than VR Ping Pong

The third hypothesis argues that real-world Ping Pong increases more human interaction than VR Ping Pong. This is attributed to the tangible presence and interpersonal engagement in real-world Ping Pong can amplify emotional connections.

## 2.2 Methodological Framework

The study involves 30 participants, aged 25-30, with equal gender representation. Experimenters are physically and mentally healthy, and no abnormalities were found in the pre-experiment examination. They are randomly assigned to one of three groups: a VR Ping Pong experimental group using scenes designed by us,



Figure 2.1. VR Ping pong Scene Setup

a real-world Ping Pong control group, and a non-treatment control group. The experimental and control groups engage in daily 30-minute ping-pong sessions for 20

days. The non-treatment group does not participate in any sports activities during the study.

### 2.2.1 Evaluation of Positive Thoughts

The initial emotional states of the participants are assessed using the Connor-Davidson Resilience Scale (CD-RISC)[6] after everyday's experiment. Furthermore, the Positive and Negative Affect Schedule (PANAS)[7] is employed to measure their emotional states during and immediately following the experimental period at the end of the day. To evaluate the longer-term psychological impact, the CD-RISC scale will be re-administered 20 days post-experiment.

### 2.2.2 Measurement of Cognitive Load

To assess cognitive load effectively, participants are presented with a demanding memory challenge. They attempt to memorize a sequence of 100 numbers within 30 minutes and subsequently recall as many as they can. This exercise is repeated daily for 20 consecutive days, following the initial experiment. These numbers are randomly generated. During the recall process, we record how many numbers experimenters can recall. The goal is to evaluate the participant's cognitive load and overall ability to complete difficult tasks.

### 2.2.3 Assessment of Social Interaction Willingness

Social interaction is assessed using the Social Interaction Anxiety Scale (SIAS)[8], a self-report questionnaire that evaluates social anxiety in various situations. After each experimental session, participants complete the SIAS, providing insight into their social interaction tendencies.

This multi-faceted methodological approach, incorporating comprehensive assessments and a balanced participant demographic, is intended to provide a thorough and nuanced understanding of the psychological effects of VR in sports compared to traditional sports experiences.

**Social Interaction Anxiety Scale (SIAS)**

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Patient Name: \_\_\_\_\_ Date: \_\_\_\_\_

**Instructions:** For each item, please circle the number to indicate the degree to which you feel the statement is characteristic or true for you. The rating scale is as follows:

0 = **Not at all** characteristic or true of me.  
 1 = **Slightly** characteristic or true of me.  
 2 = **Moderately** characteristic or true of me.  
 3 = **Very** characteristic or true of me.  
 4 = **Extremely** characteristic or true of me.

CHARACTERISTIC	NOT AT ALL	SLIGHTLY	MODERATELY	VERY	EXTREMELY
1. I get nervous if I have to speak with someone in authority (teacher, boss, etc.).	0	1	2	3	4
2. I have difficulty making eye contact with others.	0	1	2	3	4
3. I become tense if I have to talk about myself or my feelings.	0	1	2	3	4
4. I find it difficult to mix comfortably with the people I work with.	0	1	2	3	4
5. I find it easy to make friends my own age.	0	1	2	3	4
6. I tense up if I meet an acquaintance in the street.	0	1	2	3	4
7. When mixing socially, I am uncomfortable.	0	1	2	3	4
8. I feel tense if I am alone with just one other person.	0	1	2	3	4
9. I am at ease meeting people at parties, etc.	0	1	2	3	4
10. I have difficulty talking with other people.	0	1	2	3	4

Figure 2.2. Questionnaire Issued During Experiment



# Chapter 3

## Results

This section presents the findings from the three experiments conducted in this study: evaluating positive thoughts, measuring cognitive load, and assessing social interaction anxiety level.

### 3.1 Evaluating Positive Thoughts

Over the course of the 20-day experimental period, the comparison of positive thought generation between participants engaged in real-world Ping Pong and those in VR Ping Pong yielded the following results:

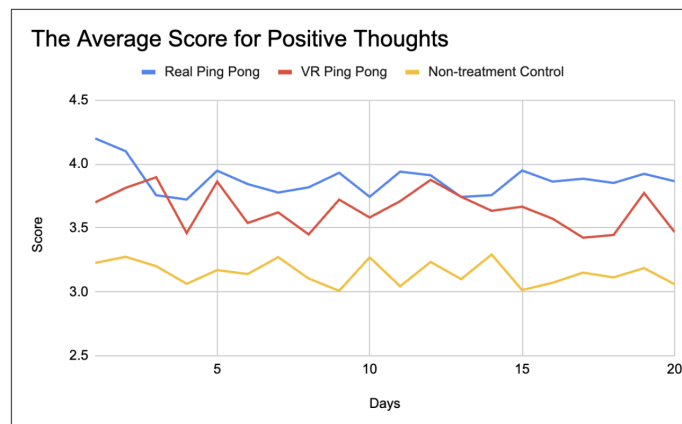


Figure 3.1. The Average Score for Positive Thoughts Among 20 Days

The data revealed a statistically significant difference in mood positivity, with the Real Ping Pong group achieving an average score of 3.8, surpassing the VR Ping Pong group's average of 3.6. Both scores exceeded that of the Non-treatment Control group, which averaged at 3.2. The daily progression analysis indicated that the mood positivity scores in the Real Ping Pong group were consistently higher than those in

the VR Ping Pong group, underscoring a more pronounced enhancement in positive mood derived from real-world experiences ( $t(8) = 2.10$ ,  $p < 0.05$ ).

Item No	Item	Experiment Group Mean	Control Group Mean	Total Mean	t(p)
1	Able to adapt to change	3.62	4.12	3.87	-9.21(<.001)
2	Can deal with whatever comes	3.63	3.86	3.74	-3.65(<.001)
3	Copying with stress can strengthen me	3.00	4.22	3.61	-6.28(<.001)
4	Best effort no matter what	2.84	2.65	2.74	3.11(.005)
5	Can achieve goals despite obstacles	2.78	3.31	3.04	-7.56(<.001)
6	When things look hopeless, I don't give up	2.97	3.00	2.99	-0.52(0.60)
7	Know where to turn for help	2.84	3.61	3.22	-9.50(<.001)
8	Can stay focused under pressure	2.44	2.91	2.67	-5.96(<.001)
9	Prefer to take the lead in the problem solving	2.58	2.91	2.74	-6.70(<.001)
10	Make unpopular or difficult decisions	3.53	4.05	3.79	-4.65(<.001)
11	Can handle unpleasant feelings	3.71	4.29	4.00	-13.5(<.001)
12	Have a strong sense of purpose	3.21	3.79	3.50	-11.41(<.001)
13	In control of your life	2.67	2.86	2.77	-3.17(.005)
14	I like challenges	3.09	2.85	2.97	4.09(.0006)
15	Pride in your achievements	4.15	3.65	3.90	9.77(<.001)

Figure 3.2. The CD-RISC Score for VR and Real-world Groups

Furthermore, evaluations based on the Connor-Davidson Resilience Scale (CD-RISC) highlighted a marked trend of resilient and optimistic thinking in the control (Real-world Ping Pong) group. This group consistently outperformed the experimental (VR Ping Pong) group in resilience-related metrics such as adaptability to change, coping with stress, and dealing with unexpected situations.

## 3.2 Measuring Cognitive Load

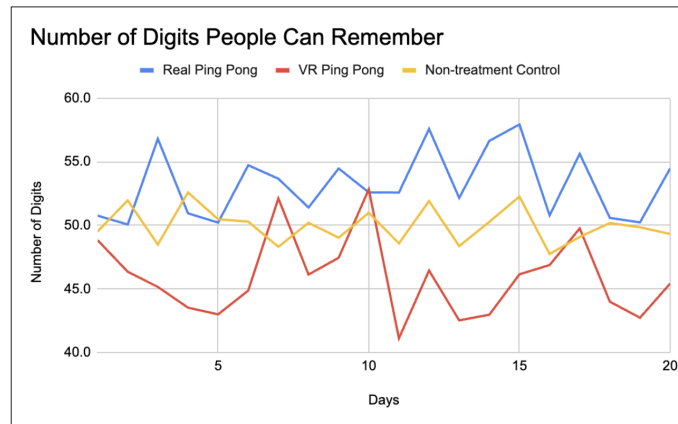


Figure 3.3. Number of Digits Two Groups can Remember

In this evaluation, the findings indicated a disparity in performance. Participants in the experimental group demonstrated a diminished capacity in cognitive retention. Specifically, the average number of digits recalled by this group was 46. In contrast, the control group exhibited a more robust memory performance, recalling an average

of 58 digits. Notably, the Non-treatment Control group, which did not engage in either form of Ping Pong, also showed a relatively higher recall ability than the VR group, with an average of 49 digits recalled. This variation in cognitive load across the groups provides insights into the cognitive demands imposed by virtual versus real-world sports environments.

### 3.3 Assessing Social Interaction Anxiety Level

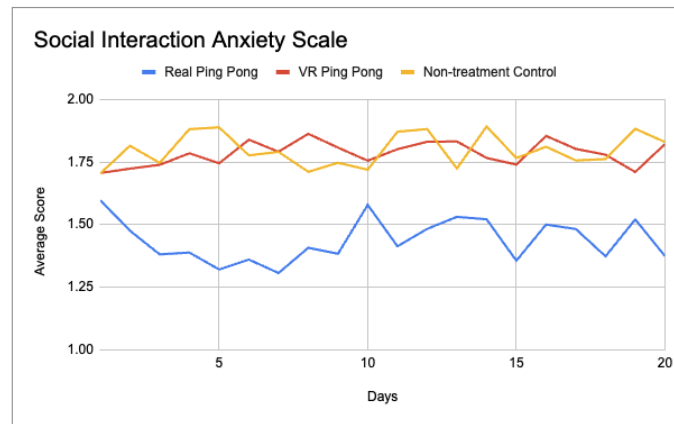


Figure 3.4. Social Interaction Anxiety Level For Three Groups

Participants in the real-world Ping Pong group exhibited lower social interaction anxiety compared to the other groups. The VR Ping Pong group and non-treatment group showed no significant difference in this regard.

Post-experiment interviews revealed that participants in the control group were more likely to recall their partners' names and appearances, whereas those in the experiment group were more likely to remember the avatars they interacted with.

# Chapter 4

## Discussion

Our study explores the effects of VR Ping Pong and real-world Ping Pong on three aspects of human psychology, aiming to provide insights into ways to enhance emotional well-being. We employed a consistent methodology across all experiments to assess positive thoughts, which involved participants completing pre- and post-exposure questionnaires with standardized scales like the Positive and Negative Affect Schedule (PANAS) and Social Interaction Anxiety Scale (SIAS). Additionally, participants engaged in a monotonous task involving the memorizing numbers, allowing us to observe their cognitive load under different conditions.

### 4.1 Analysis of Positive Thoughts: Real-world vs. VR Ping Pong

The results indicate that the positive cognitive states in both the experimental group (mean score 3.6) and the control group (mean score 3.8) were higher than those in the non-treatment group (mean score 3.2). This finding suggests that active engagement in sports, whether in a real or virtual environment, contributes to the enhancement of positive mental states.

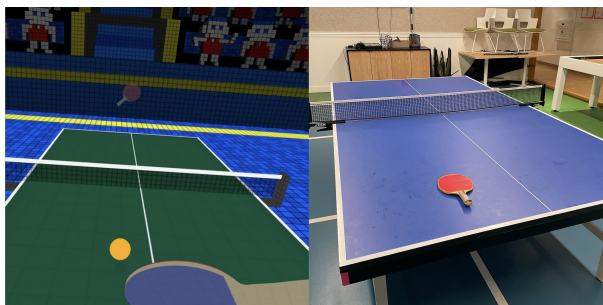


Figure 4.1. Stage Setup For Virtual/Real-world

Moreover, a marginally higher score for real-world ping pong compared to VR ping pong was observed. One implication we get from participants is they feel less connected to the partners compared to real-world Ping Pong.

## **4.2 Comparative Cognitive Load: Real-world VS VR Ping Pong**

The experiment revealed that participants in the real-world ping pong group memorize more of digits(mean score 58) than those in the VR group(mean score 46) and the non-treatment control group(mean score 49). This suggests that physical exercise, which enhances cerebral blood flow and fosters neural connectivity, may contribute to reduced cognitive load. Furthermore, engagement in sports is known to increase levels of brain-derived neurotrophic factor (BDNF), facilitating the repair and generation of brain cells.

Interestingly, the non-treatment control group exhibited better performance than the VR ping pong group. Subsequent interviews revealed that the continuous stimulation in VR ping pong consumed substantial cognitive resources, leading to increased distractibility in tasks demanding high cognitive load.

## **4.3 Result on Social Interaction Willingness for Real-world Ping Pong VS VR Ping Pong**

Analysis revealed that individuals participating in real-world Ping Pong experienced lower social interaction anxiety compared to the other groups. There was no significant difference observed between the VR ping pong group and the non-treatment group.

Post-experiment in-person interviews suggested that participants in the real-world Ping Pong group were more likely to recall their partners' names and physical appearances, whereas VR ping pong participants tended to remember the avatars they interacted with.

## **4.4 Limitations and Future Work**

Firstly, the sample size is relatively small because of the limited headsets, which may limit the generalizability of the findings. Additionally, the reliance on self-reported measures introduces the potential for response bias. The VR Ping Pong used also represents a specific type and quality of experience, which might not be representative of all VR sports experiences.

Future research can aim to include more dimensions, like eye tracking, heart rate variability, and electroencephalography (EEG) to provide more information about attention allocation, processing intensity, and psychological stress. Longitudinal studies could provide deeper insights into the long-term effects of VR on cognitive and emotional well-being. Furthermore, comparing different types of VR systems could offer a more comprehensive understanding of how various technological factors influence user experience. Lastly, incorporating objective measures alongside self-reporting methods could provide a more robust analysis of the psychological impacts of VR and traditional sports.

## Chapter 5

### Conclusion

The findings of this research underscore the psychological benefits comparing both real-world with VR Ping Pong, emphasizing their roles in promoting emotional well-being.

The slight superiority of real-world ping pong in fostering positive cognitive states and lower social interaction anxiety points to the enduring value of physical presence and direct social interaction in sports. However, the considerable potential of VR ping pong in these domains cannot be overlooked, highlighting VR's emerging role as a viable medium for sports and recreation. The observed lower cognitive load in real-world ping pong participants suggests a possible advantage of physical sports in cognitive processing efficiency.

These insights contribute to the broader discourse on the integration of VR in sports. Future research directions could include expanding the demographic diversity of participants, exploring longitudinal effects, and examining a wider range of sports and VR technologies, thereby enriching our understanding of the complex interplay between technology, psychology, and sports.

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