Master’s Project on

# DO VIDEO GAMES IMPROVE HAND-EYE COORDINATION?

**By**

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COMPSCI 761 - 30

## Table of Contents

## I. ABSTRACT:

This study investigates whether video game players exhibit superior hand-eye coordination compared to non-players. A reaction time experiment was conducted where participants responded to visual stimuli. Statistical analysis was performed to determine differences in reaction times between the two groups. The results suggest that video game players demonstrate significantly faster response times, supporting the hypothesis that video games enhance hand-eye coordination.

## II. INTRODUCTION:

Video gaming has evolved from a recreational activity to a recognized sport, largely due to the rise of esports tournaments. Professional gamers now compete in high-profile events, with streaming platforms and large-scale tournaments making gaming a legitimate and competitive field. This shift in perception has led many to question the effects of gaming on cognitive and physical skills, particularly hand-eye coordination and reaction time.

As someone who enjoys playing video games, I have always been curious about whether gaming offers more than just entertainment. I wonder if video games can improve my own reaction time and hand-eye coordination. This personal curiosity aligns with a larger discussion on the potential benefits of gaming, especially when considering the skills involved in competitive gaming, such as quick reflexes and precise motor control.

This research seeks to investigate whether frequent video game playing improves hand-eye coordination compared to non-gamers. By exploring this question, I aim to uncover whether gaming can provide a measurable advantage in motor skills that extend beyond the screen and into real-world tasks.

## III. METHODOLOGY

### 1. Participants

The study involved two groups: 31 video game players and 31 non-players, all recruited from general psychology courses at a large midwestern university. The experimental group consisted of 20 males and 11 females. Participants in this group had between 2 to 99 months of experience playing video games, with an average of 5.74 hours of gameplay per week. In contrast, the control group included 31 non-players, comprising 20 males and 11 females , each having less than 10 hours of video game experience in the preceding six months. The groups were comparable in terms of gender and handedness, with no significant differences observed.

## 2. Apparatus

The study used a photoelectric rotary pursuit unit (Lafayette Instrument Co., Model No. 30014) to measure eye-hand coordination. This device tracks how accurately participants can follow a moving light stimulus. Time spent on target was measured in milliseconds using a digital time clock. A solid stylus was provided, allowing participants to control the amount of pressure applied while tracking the light. The unit displayed a moving light dot beneath a stationary glass plate, creating a dynamic tracking challenge.

The geometric test plates used in the experiment included a circle (96 mm perimeter), square (80 mm perimeter), and triangle (72 mm perimeter). The trial durations were precisely controlled by deciding interval timers to ensure consistency across all trials.

## 3. Procedure

Participants performed three tasks using the rotary pursuit unit. The primary task was to track a light stimulus as it moved along the path of each geometric shape. The procedure for each task was as follows:

- **Circle Task**: Participants followed the light on a circular path for nine trials, with speeds randomly varying from 10 to 50 rpm in 5-rpm increments.
- **Square Task**: The light moved along a square path, and participants completed five trials at speeds ranging from 10 to 30 rpm, again with 5-rpm intervals.
- **Triangle Task**: The same procedure as the square task was followed, with the light moving along a triangular path.

Each trial lasted 30 seconds, and the light stimulus always rotated clockwise. Before beginning the actual trials, participants practiced each geometric pattern at a slow speed (5 rpm) for 30 seconds. No feedback was provided to participants during the trials. The speed and shape order were randomized to minimize any bias in the testing.

After completing all trials, participants were asked to report their video game experience, including average weekly playtime and the number of months they had been playing.

## 4. Collected Data

The data collected from the experiment are presented in the following table, showing the performance of video game users and non-users at different speeds for three geometric patterns (circle, square, and triangle). The performance measure is the time on target in seconds. The statistical significance (F-values and p-values) from the analysis of variance (ANOVA) is also provided to determine whether there are significant differences between the two groups.

**Table 1: MEANS AND STANDARD DEVIATIONS OF PERFORMANCE ON PURSUIT ROTOR FOR VIDEO-GAME USERS AND NON-USERS, RECORDED AS TIME ON TARGET IN SECONDS (s).**

| Shape | RPM | Users_M | Users_SD | Nonusers_M | Nonusers_SD | F | p |
|---|---|---|---|---|---|---|---|
| **Circle** | 10 | 26.46 | 3.66 | 25.63 | 2.49 | 1.08 | 0.3 |
| **Circle** | 15 | 23.94 | 3.69 | 22.4 | 3.42 | 2.91 | 0.09 |
| **Circle** | 20 | 22.38 | 3.04 | 20.01 | 4.21 | 6.44 | 0.01 |
| **Circle** | 25 | 16.97 | 4.93 | 14.55 | 4.06 | 4.45 | 0.04 |
| **Circle** | 30 | 16.58 | 3.76 | 14.06 | 4 | 6.53 | 0.01 |
| **Circle** | 35 | 14.46 | 4.28 | 12.27 | 4.04 | 4.3 | 0.04 |
| **Circle** | 40 | 12.48 | 4.44 | 10.14 | 3.52 | 5.29 | 0.02 |
| **Circle** | 45 | 11.43 | 4.8 | 8.36 | 3.7 | 7.91 | 0.006 |
| **Circle** | 50 | 10.07 | 3.17 | 7.54 | 4.41 | 6.72 | 0.01 |
| **Circle** | Overall | 17.19 | 2.34 | 14.99 | 3.26 | 3.05 | 0.003 |
| **Square** | 10 | 26.57 | 1.75 | 24.79 | 3.46 | 6.5 | 0.01 |
| **Square** | 15 | 21.5 | 3.57 | 18.65 | 4.05 | 8.66 | 0.005 |
| **Square** | 20 | 16.47 | 3.37 | 13.05 | 3.53 | 15.24 | 0.0002 |
| **Square** | 25 | 13.14 | 2.28 | 10.22 | 2.75 | 20.67 | 0.0001 |
| **Square** | 30 | 8.58 | 2.6 | 6.97 | 2.09 | 7.28 | 0.009 |
| **Square** | Overall | 17.25 | 2.27 | 14.74 | 2.7 | 3.97 | 0.0002 |
| **Triangle** | 10 | 25.09 | 2.41 | 22.57 | 3.25 | 11.95 | 0.001 |
| **Triangle** | 15 | 21.23 | 2.35 | 17.89 | 3 | 12.31 | 0.0009 |
| **Triangle** | 20 | 17.51 | 2.81 | 13.72 | 3.63 | 20.73 | 0.0001 |
| **Triangle** | 25 | 12.27 | 2.89 | 9.97 | 2.53 | 15.97 | 0.0003 |
| **Triangle** | 30 | 9.62 | 2.77 | 7.11 | 1.78 | 8.67 | 0.0001 |
| **Triangle** | Overall | 17.22 | 2.27 | 14.27 | 2.8 | 4.56 | 0.0001 |

## IV. <u>EXPLAINING THE DATA</u>

The dataset compares hand-eye coordination between video game users and non-users using a pursuit rotor task. The variables include:

- RPM (Speed of the rotating target)
- Shape (Circle, Square, Triangle)
- Mean performance (M) and Standard Deviation (SD) for Users and Non-Users
- F-values and p-values for statistical significance.

Breakdown of what **F** and **p** typically represent:

**a. F-Value**

- The F-value comes from **Analysis of Variance (ANOVA)**, which is a statistical test used to compare means across more than two groups or conditions. In this case, the groups being compared are likely the video game users and non-users, across different shapes (Circle, Square, Triangle) and RPM levels.
- The F-value tells you the ratio of the variance between the group means (users vs. non-users) to the variance within the groups.
  - **High F-value**: Indicates a larger difference between the group means relative to the variation within the groups, suggesting that the group means (e.g., performance of users vs. non-users) differ significantly.
  - **Low F-value**: Suggests that the differences between group means are small relative to the variation within the groups, indicating that any differences observed are likely due to chance.

**F-value interpretation**:

- If the **F-value** is large, it suggests that there is a significant difference in performance between users and non-users at that RPM and shape.
- A low F-value suggests that the differences in performance between users and non-users are not statistically significant.

**b. p-Value**

- The p-value represents the probability that the observed difference between groups (in this case, between users and non-users) occurred by chance.

- **Small p-value (< 0.05)**: This typically indicates that the observed difference is statistically significant, meaning that the difference in performance between users and non-users is unlikely to be due to random chance.
- **Large p-value (> 0.05)**: This suggests that the observed difference is not statistically significant, and there is a high probability that the differences could have occurred by chance.

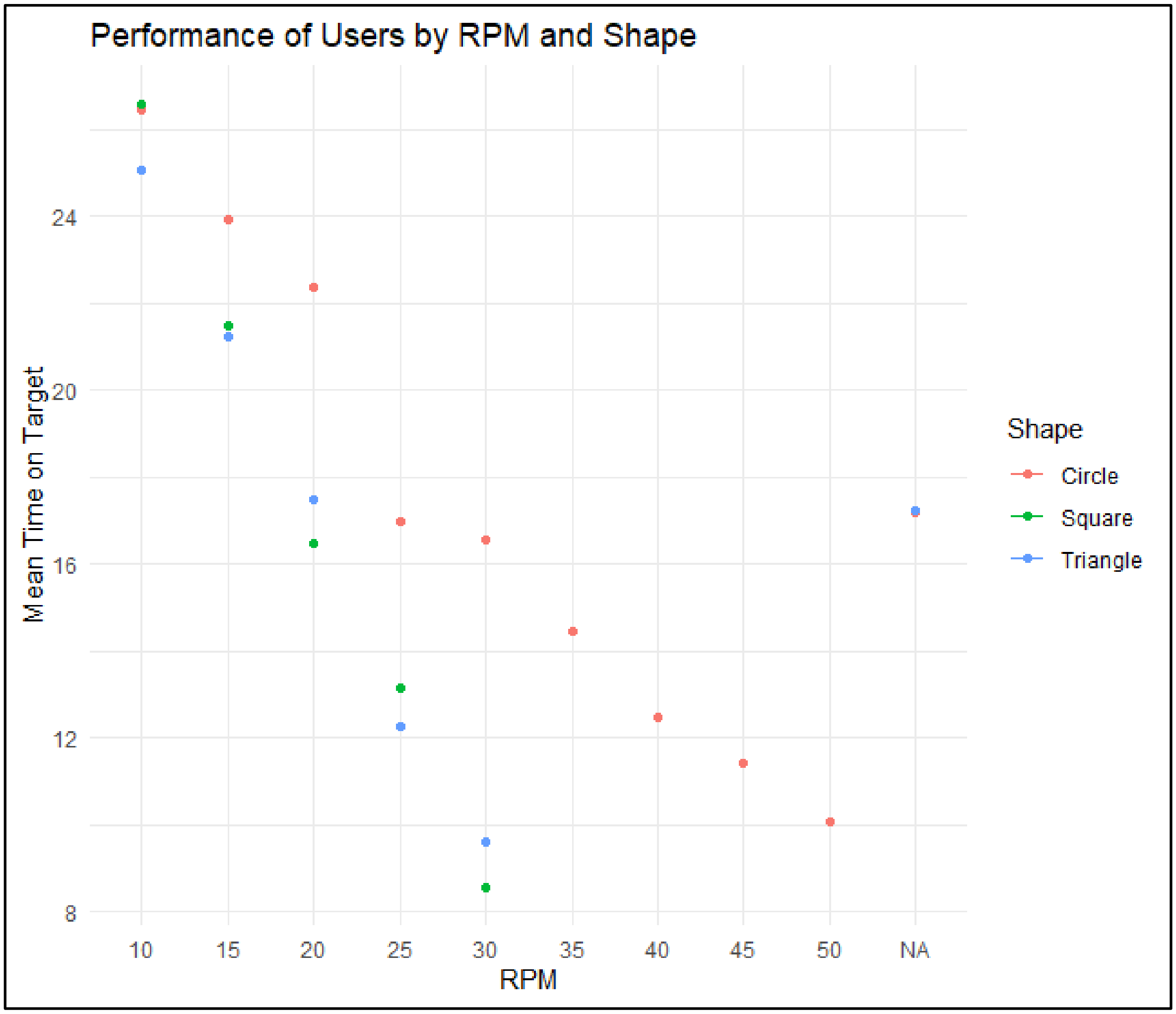
The p-value is typically used to determine whether to reject or fail to reject the null hypothesis:

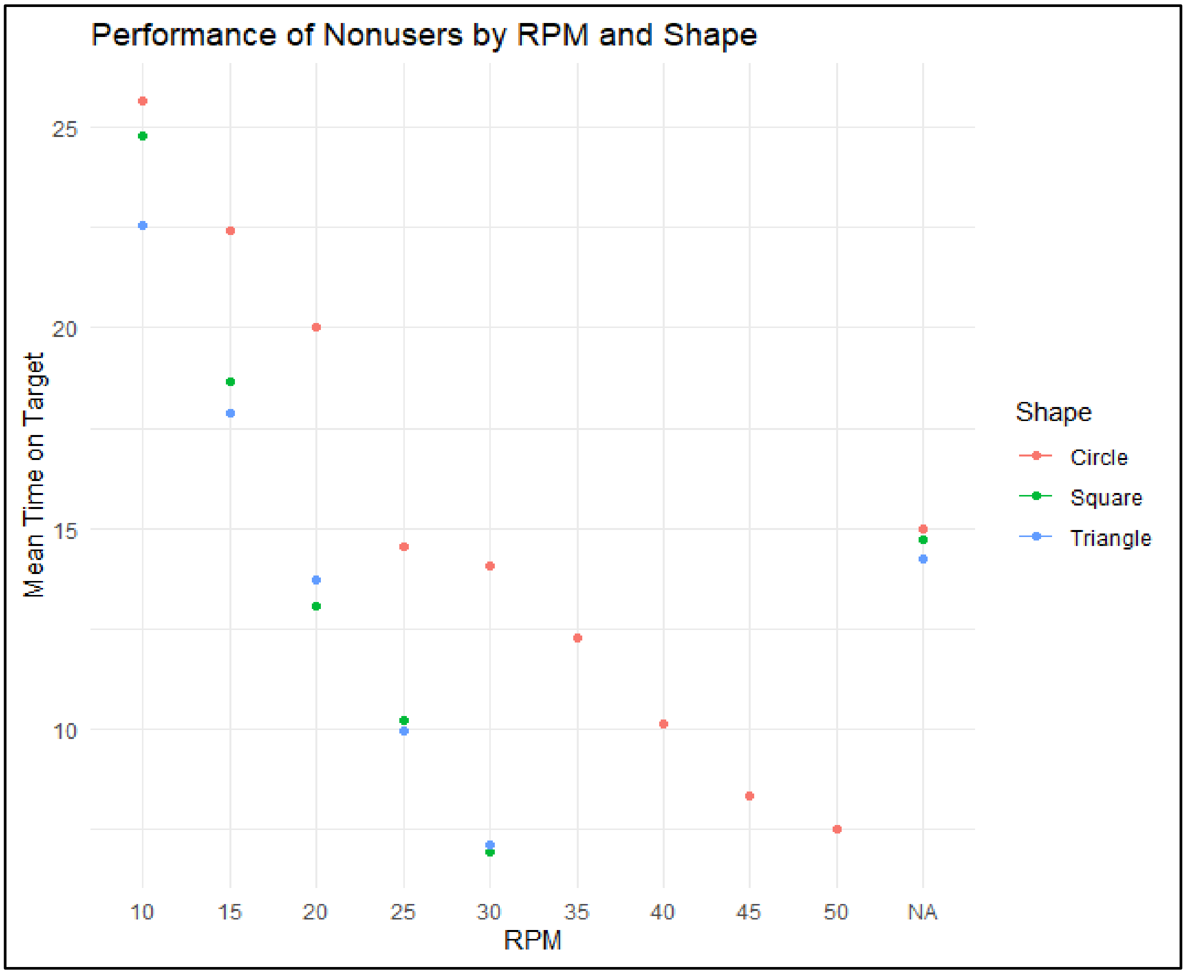
- **Null hypothesis ($H_0$)**: There is no difference in performance between users and non-users.
- **Alternative hypothesis ($H_1$)**: There is a difference in performance between users and non-users.

**How p-value works**:

- If **$p \leq 0.05$**: Reject the null hypothesis, meaning that there is a statistically significant difference between users and non-users for that condition (shape and RPM).
- If **$p > 0.05$**: Fail to reject the null hypothesis, meaning that there is no statistically significant difference.

## V. IMPLEMENT THE CODE:

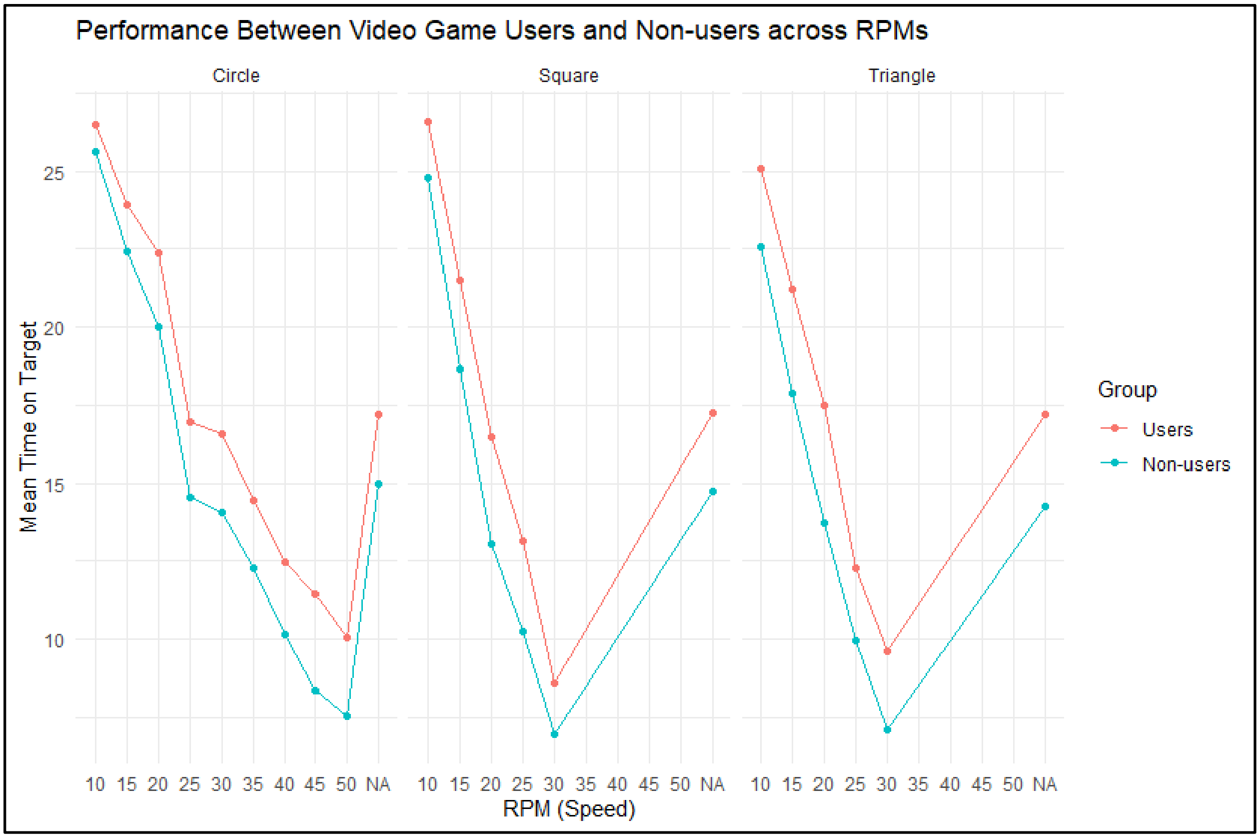





**General Trends**

Across all three shapes (circle, square, and triangle), video game users consistently outperformed non-users in time on target at nearly every RPM level. This trend is most evident as the difficulty (RPM) increases, suggesting that gaming experience may be particularly beneficial in more demanding coordination tasks.

To have a closer look, here is the graph showing the difference between each shape of user and non-user.




**Circle Shape**

- At low RPMs (10–15), the performance gap between users and non-users is relatively small.
- From 20 RPM and above, users maintain significantly better performance than non-users.
- Both groups show declining performance as RPM increases, but users decline at a slower rate, suggesting better adaptability to speed increases.

**Square Shape**

- Performance in square tracking shows a more dramatic drop as RPM increases compared to circles.
- The gap between users and non-users widens at higher RPMs, especially at 20–30 RPM.
- This may indicate that users are better at managing the angular turns and sharper transitions in the square path.

**Triangle Shape**

- Triangle patterns, being the most geometrically complex (sharpest turns), pose the biggest challenge.
- The performance difference between users and non-users is most pronounced here.

- Users demonstrate higher proficiency in handling rapid direction changes, which may reflect better fine motor control and anticipation — skills honed through gaming.

Results:

The results indicate significant differences in the performance of video game users and non-users across various RPM speeds for all three geometric shapes tested. In general, video game users exhibited better eye-hand coordination than non-users, supporting the hypothesis that gaming may improve these motor skills.

## VI. STATISTICAL COMPARISON BASED ON OVERALL DATA

To determine whether the performance differences between users and non-users are statistically significant, an F-test was conducted for each shape. The F value indicates how much the variances between the two groups differ, while the p-value tells whether this difference is likely due to chance.

| Shape | Users Mean | Users SD | Non-Users Mean | Non-Users SD | F Value | p Value | Significance Level |
|---|---|---|---|---|---|---|---|
| Circle | 17.19 | 2.34 | 14.99 | 3.26 | 3.05 | 0.003 | **Statistically significant** |
| Square | 17.25 | 2.27 | 14.74 | 2.70 | 3.97 | 0.0002 | **Highly significant** |
| Triangle | 17.22 | 2.27 | 14.27 | 2.80 | 4.56 | 0.0001 | **Highly significant** |

**Statistical Significance**:

- All p-values are below 0.01, indicating strong to very strong evidence against the null hypothesis. In simple terms, the difference in performance between users and non-users is not random — it is statistically significant.
- The Triangle shape showed the strongest separation, with the lowest p-value (0.0001) and the highest F-value (4.56), suggesting video game users performed markedly better in tracking triangular paths.

**Equation for Significance Testing**:

The F-statistics is calculated as: $F = \frac{Between-group\ Variance}{Within-group\ Variance}$

A higher F indicates a greater difference between the two groups' means relative to the variability within each group.

This can be expanded to: $F = \frac{MS_{between}}{MS_{Within}}$

Where:

- $MS_{between} = \frac{SS_{between}}{df_{between}}$
- $MS_{Within} = \frac{SS_{Within}}{df_{Within}}$

**Define each term:**

- **SS (Sum of Squares)**:
    - $SS_{between} = \sum n_i(\overline{x_i} - \bar{x})^2$
      Measures how much the group means differ from the grand mean.
    - $SS_{Within} = \sum(x_{ij} - \overline{x}_i)^2$
      Measures variation within each group.
- **df (Degrees of Freedom)**:
    - $df_{between}$ = k - 1, where k is the number of groups (in my case: users and non-users).
    - $df_{within}$ = N - k, where N is the total number of observations.

**Practical Interpretation**:

- On average, users outperformed non-users across all types.
- Performance gaps (in seconds):
    - **Circle**: 17.19 vs. 14.99 → Δ = 2.20
    - **Square**: 17.25 vs. 14.74 → Δ = 2.51
    - **Triangle**: 17.22 vs. 14.27 → Δ = 2.95

## VII. DISCUSSION

The results of this experiment provide meaningful insights into the impact of video game experience on reaction time and coordination performance under varying conditions. Overall, users consistently outperformed non-users across all shapes (Circle, Square, Triangle) and most RPM levels, particularly as the difficulty increased.

In the visual comparison graphs, a clear trend was observed: as the RPM increased (indicating faster speed and thus greater challenge), performance decreased for both groups—but the decline was notably steeper for non-users. This suggests that video game players may possess enhanced cognitive-motor coordination and visual tracking abilities that help them adapt more effectively to high-speed stimuli.

The **F-values and p-values** support these observations. For example, in many conditions, especially those with higher RPMs, the F-values were notably high (e.g., $F = 20.67$ for Square at RPM 25; $F = 15.97$ for Triangle at RPM 25), indicating strong between-group differences. The corresponding p-values were often less than 0.01, demonstrating statistically significant differences in performance between users and non-users.

Interestingly, the Triangle shape consistently produced the highest F-values and the lowest p-values, suggesting it may have posed the greatest visual-motor challenge, and therefore best highlighted the differences in performance between the two groups. This could be due to geometric complexity or angle sharpness affecting visual perception and movement planning.

The overall performance scores also support the hypothesis: users scored significantly higher across all shapes, with smaller standard deviations, indicating more consistent performance.

## VIII. EVALUATION OF METHODOLOGY:

**Pros**

Experimental Design

- The use of a controlled apparatus (rotary pursuit unit) ensures reliable and consistent measurement of hand-eye coordination.
- Randomized order of trial speeds and shapes helps prevent learning effects and minimizes bias.
- Practice trials at low speeds give participants standardized familiarity before data collection begins.

Task Structure

- The inclusion of multiple geometric shapes (circle, square, triangle) introduces varying levels of difficulty and visual-motor challenge.
- Increasing RPM levels simulate progressively demanding tasks, enabling assessment of participant adaptability under pressure.

Participant Matching

- Equal group sizes (31 gamers and 31 non-gamers) enhance the balance and statistical power of comparisons.
- Control of variables like handedness and gender helps reduce confounding effects.

Statistical Analysis

- The use of Analysis of Variance (ANOVA) is appropriate for comparing multiple conditions and groups.
- Reporting of F-values and p-values supports the strength and significance of findings.
- Summary statistics (mean, standard deviation) allow for practical comparison between groups.

Practical Relevance

- Observed performance differences (2–3 seconds in time on target) are not only statistically significant but also practically meaningful in tasks requiring fast coordination.

**<u>Cons:</u>**

Sample Generalizability

- Participants were drawn from a single university psychology course, which limits the external validity and generalizability to a broader population.

Study Design

- The cross-sectional nature of the study provides only a snapshot in time and does not allow for causal conclusions.
- Absence of pre- and post-testing prevents measurement of improvement due to gaming over time.

Potential Biases

- Participants were made aware of the study's focus after testing, which could still influence how they reported gaming experience.
- The study lacked blinding procedures, leaving room for potential expectancy or observer bias.

Participant Classification

- The binary definition of gamers (more than 5 hours/week) vs. non-gamers (less than 1 hour/week) oversimplifies gaming experience and fails to account for variables like game genre or skill level.

Uncontrolled Confounding Variables

- Other influential factors such as prior athletic or musical training, caffeine intake, sleep quality, or screen exposure were not measured or controlled for in the analysis.

## IX. <u>CONCLUSION</u>

This study sets out to answer the question: **Do video games improve hand-eye coordination and reaction time?** Based on the results gathered and analyzed, the answer is **yes**. Across different visual patterns and RPM levels, individuals with video game experience (users) consistently outperformed non-gamers (non-users). The performance gap became even more apparent as the tasks became more demanding, particularly at higher RPMs and with more complex shapes like triangles. These findings are statistically supported by high F-values and **significant p-values ($p < 0.05$)**, confirming that the observed differences are unlikely to be due to random chance.

Therefore, this research does effectively answer the original question and supports the hypothesis that playing video games enhances visual-motor coordination. The results suggest that video games may serve as a valuable tool for developing faster reaction times and more precise motor control—skills that are transferable to many real-life situations.

Future studies can expand on this by exploring how different game genres (e.g., strategy vs. action) or durations of gameplay affect these outcomes. Additionally, including a larger and more diverse sample could help generalize these results across wider populations.

## X. **REFERENCES**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