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The Influence of Age, Gender, and Gaming Experience on Robot Control Interface: An Exploratory Study

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Abstract This study investigated how three distinct control modes—dual-joystick, smartphone gyroscope, and PlayStation 5 (PS5) controller—affect user experience variables (challenge, competence, flow, tension) during interaction with a robotic car, considering demographic factors such as age, gender, and gaming experience. Using an experimental design with 30 participants, non-parametric analyses revealed significant differences in performance and perception across control modes. The PS5 controller demonstrated superior efficiency, with fewer path deviations ($p = 0.032$) and faster task completion ($p = 0.012$) compared to the smartphone gyroscope. Marginal tension differences ($p = 0.054$) favored the PS5 controller over the smartphone interface. Gender differences emerged in task completion time (Condition 1: $p = 0.038$) and perceived competence/positive affect (Condition 3: $p < 0.05$), with males reporting higher competence and satisfaction. Generational disparities were context-specific: Generation Z exhibited lower negative affect than Generation Y ($p = 0.009$) in the PS5 condition, likely due to greater console familiarity. Prior gaming experience enhanced adaptation, with advanced users showing higher competence ($p = 0.033$) and flow ($p = 0.023$) in smartphone control. These findings underscore the need for adaptive interface designs that account for gender-specific preferences, generational familiarity (e.g., gaming consoles for younger users), and prior gaming expertise. The study advocates for personalized Human-Robot Interaction solutions to improve inclusivity and efficiency across applications, from entertainment to industrial robotics.

Keywords: Control Interface, Human-Robot Interaction, Robotics, Generational Differences, User Experience

1 Introduction

Human-robot interaction (HRI) is a dynamic and rapidly evolving research area within the field of robotics [Sheridan, 2016]. With the increasing integration of robotics across various sectors of society, from manufacturing to entertainment, the need arises for control interfaces that are not only efficient but also intuitive and accessible to a wide range of users [Sheridan, 2020]. As robotics becomes more prevalent daily, understanding how different user groups interact with these technologies is essential for advancing the field.

A crucial aspect of successful HRI is the usability of teleoperation control interfaces. Interfaces that fail to meet user needs and expectations can create significant barriers to the adoption and effectiveness of robotic technologies, limiting their potential in practical applications [Porte and Trindade, 2021]. In robotics, especially in telerobotics, the control interface serves as the primary bridge between the human and the robotic agent, and it is responsible for translating the user's intentions into concrete actions for the robot. Therefore, the usability of these interfaces is not merely a matter of convenience but a determining factor in the effectiveness and efficiency of the interaction. In environments where precise and direct operation of the robot is essential—such as in industrial, educational, or healthcare settings—the choice of control interface can directly impact the user experience and the outcomes achieved [Buchner *et al.*, 2012; Tsagaris and Chatzikyrkou, 2023; Riek, 2017].

Given the central role of control interfaces in HRI, this study investigates how different interface configurations—from traditional physical controls to motion-sensor-based interfaces—affect usability and user experience. The relationship between control interface characteristics and perceived usability is fundamental to developing robotic solutions that are both accessible and effective for a diverse range of users.

In this context, our research examines how various demographic and social groups, including different age groups and genders, adapt to three distinct types of control interfaces for mobile robots: (1) a dual-joystick control, where each joystick independently controls a wheel of the robot; (2) a smartphone-based interface using the device's gyroscope, combined with on-screen controls; and (3) a PlayStation 5 controller, using commands based on console racing games. This approach allows us to explore not only the differences in ease of use among different age groups and gender but also how prior experience with technology, such as video games, may influence the interaction with new technological tools.

It is important to note that the system evaluated in this study is a teleoperated - a form of control also known as telerobotics

[Niemeyer *et al*., 2016] - robotic agent equipped with sensors, actuators, embedded computing and potential for some level of autonomy. Therefore can be classified as a robot [Ben-Ari and Mondada, 2017]. Although the primary interaction occurs via remote control, the system still fits within the definition of a robot as discussed in the HRI literature. For instance, systems like the Curiosity and Perseverance rovers, which are operated remotely by NASA, are still classified as robots due to their capabilities and the nature of their operation [Farley *et al*., 2020]. Similarly, teleoperated surgical robots and industrial robotic arms with manual control also fall under the category of robotic systems [Dupont *et al*., 2021]. This broader definition aligns with the principles of HRI, which encompass both autonomous and teleoperated systems, highlighting the importance of user interaction in the effective deployment of robotic technologies.

Thus, we formulated the following hypotheses for this study:

- H1: Different mobile robotic agent control modes result in significant differences in the user gameplay experience.
- H2: Users from different age groups will have distinct preferences for control modes, with younger users favouring more complex or sensor-based interfaces.
- H3: Prior experience with digital games facilitates adaptation and enhances user satisfaction with more advanced control modes.
- H4: Gender differences significantly influence user performance and experience across different control modes in the robotic agent scenario, with males and females showing variations in task completion time and gameplay experience.

By testing these hypotheses, we aim to deepen the understanding of how user characteristics, including age, gender, and prior experience, influence interactions with robotic agents through different control interfaces. The results of this investigation are intended to guide the design of more accessible and efficient interfaces, promoting a more inclusive and user-centred approach to robotics. By considering the differences in usability perception among various user profiles, including gender-specific variations, this study seeks to create solutions that can be easily adopted across a variety of contexts, thereby expanding the positive impact of robotics on society.

2 Related Works

The usability of control interfaces in robotics has been extensively explored in HRI literature, with numerous studies investigating how various factors—ranging from users' demographic characteristics to interface design—affect human-robot interaction. This work builds upon a well-established foundation of research that examines these aspects from different perspectives, with a particular emphasis on how user characteristics, such as gender and age, influence the interaction.

[Hancock *et al*., 2011] conducted a comprehensive meta-analysis on usability in HRI, focusing on how factors such as trust, acceptance, and adaptation to robotic technologies vary among different user profiles. The authors identified that trust in the control interface and perceived efficiency are significantly influenced by variables such as age and prior familiarity with similar technologies, suggesting that inclusive design should consider these individual differences. These findings provide an important foundation for the present study, which explores variability in usability perception across different demographic groups.

In a more recent study, [Saren *et al*., 2024] performed a comparative analysis of multimodal interfaces in human-robot interaction. They investigated how different forms of communication, including voice, gestures, and touch, affect task performance and user experience compared to traditional single-channel interfaces, such as touchscreens. The results indicated that multimodal interfaces can offer significant advantages in terms of performance and user satisfaction. However, the choice of the ideal modality depends on the type of task and user characteristics. This work provided valuable insights for developing more efficient and enjoyable interaction systems, highlighting the importance of considering a combination of different communication channels.

Another relevant work is Donald Norman's book, *"The Design of Everyday Things"* [Norman, 2013]. Norman explores human-object interaction, emphasizing the importance of intuitive and accessible design. He argues that objects should be designed to be easily understood by users without the need for complex instructions. Norman addresses fundamental concepts such as visibility, feedback, mapping, and affordances, all essential for good interface design. Norman's user-centred approach is particularly relevant to robotics as it provides principles that can be applied to the design of control interfaces to ensure they are intuitive and effective.

Gender differences in human-technology interaction have also been explored, notably in the study by Lukosch *et al*. [2017], which examines how gender and cultural context influence game-based learning experiences. Through an experiment involving 60 participants from various cultural backgrounds, the researchers identified significant differences in preferences and behaviors between men and women. For instance, women preferred more collaborative approaches, while men tended to be more competitive. These findings are particularly relevant to our study as they suggest that gender differences can significantly influence user experience and performance in technology-mediated environments, including HRI. Gender differences in human-technology interaction have also been explored in Brazilian studies. For example, Fortim *et al*. [2016] conducted a study on the typology of female gamers in Brazil, highlighting the diverse profiles and preferences within this demographic. Similarly, de Araújo Kohler *et al*. [2021] examined female representativity in digital games, discussing the challenges and progress in achieving gender inclusivity in gaming. These studies emphasize the importance of considering gender-specific preferences and interaction patterns, which are relevant to our investigation of control interfaces in robotics.

Teleoperation and the use of advanced interfaces, such as augmented reality (AR) and virtual reality (VR), have been shown to enhance HRI by providing intuitive and immersive control experiences. Wang *et al*. [2024] introduced a robotic teleoperation system enhanced by AR, which combines visual feedback with robotic arm operations, achieving a level of control that surpasses natural interfaces. This approach facilitates remote operations, making it highly relevant for our study's context of teleoperated robotic systems. Similarly, Udekwe and Seyyedhasani [2025] explored the use of VR for teleoperating robotic systems in agricultural settings, demonstrating that VR interfaces can improve task performance and user satisfaction. Although our study does not utilize AR or VR technologies, these works highlight the potential of using advanced interfaces to improve teleoperation experiences. Our focus is on more conventional control interfaces inspired by video games, such as dual joysticks, smartphone-based controls, and console controllers, which are also designed to be intuitive and effective for users.

These studies collectively provide a solid foundation for understanding the implications of control interface usability in robotics. They offer important context for our research, which investigates the interaction between different user characteristics—such as gender, age, and technological familiarity—and the effectiveness of various types of robotic control interfaces.

3 Development

The research was developed based on the OpenBot project, an initiative aimed at creating low-cost robots using accessible and easy-to-implement technologies. The goal of OpenBot is to keep the project cost under $50 while ensuring performance comparable to higher-investment robots [Müller and Koltun, 2021]. The project utilizes a smartphone as the central component, leveraging its advanced features such as camera, GPS, Wi-Fi, Bluetooth, and 4G.

Our work contributes in four main ways:

1. **Robot Design**: We designed a small electric vehicle based on inexpensive and readily available components, with a total hardware cost of only $50. This vehicle serves as the basis for a low-cost wheeled robot.
2. **Software Development**: We created a software stack that allows smartphones to use the vehicle as a chassis, enabling mobile navigation with real-time onboard detection and computation.
3. **Advanced Capability**: We demonstrated that the system can support advanced robotics workloads, such as people tracking and autonomous navigation.
4. **System Robustness**: We conducted extensive experiments showing that the approach is robust to variability between different smartphones and robot chassis.

Table 1 illustrates the costs associated with building the robot model. The table shows the components used, their quantities, unit prices, and bulk purchase prices.

For the physical construction of the robot, we used an acrylic base with a cover made of plywood. The vehicle is driven by two 3 to 6V DC motors at the front and a swivelling wheel at the rear. Power is supplied by a 9-volt adapter connected to the mains during use. Wheel control is managed by an Arduino Nano, which connects to a smartphone via cable. The smartphone, in turn, uses an Android application to communicate with other devices and control the vehicle. The

Component	Quantity	Unit Price	Bulk Price
3D-printed Body	1	$5.00	$5.00
Arduino Nano	1	$8.00	$3.00
Motor + Tire	2	$3.50	$2.00
Motor Driver	1	$3.00	$2.00
Battery (18650)	3	$5.00	$3.00
Speed Sensor	2	$1.50	$1.00
Sonar Sensor	1	$2.00	$1.00
Miscellaneous*	1	$5.00	$3.00
Total		**$48**	**$29**

Table 1. Costs associated with building the robot model.

robot is equipped with some sensors, including speed sensors and a sonar sensor, which enable it to perform tasks such as obstacle detection and navigation. These capabilities allow the robot to operate autonomously to some extent, further aligning it with the definition of a robotic system. In Figure 1, it is possible to see the main components used in the robotic car built for the study.

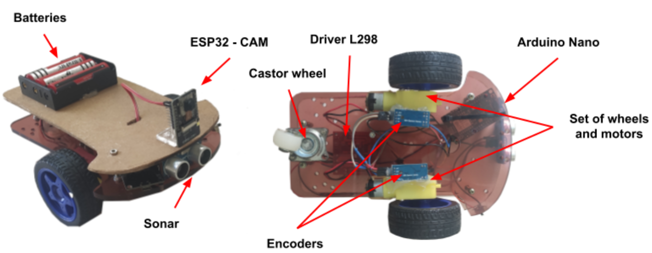

Figure 1. Components of the robotic car

The assembled robot can be remotely controlled in three different ways:

1. **Smartphone Control**: Two methods using Bluetooth or Wi-Fi to communicate between the user's smartphone and the smartphone on the robot.
2. **Bluetooth Control**: A Bluetooth controller is used to interact with the robot.

The Figure 2 shows the control methods explored in this investigation and the software layers used for communication, configuration and movement of the robot, according to the commands sent.

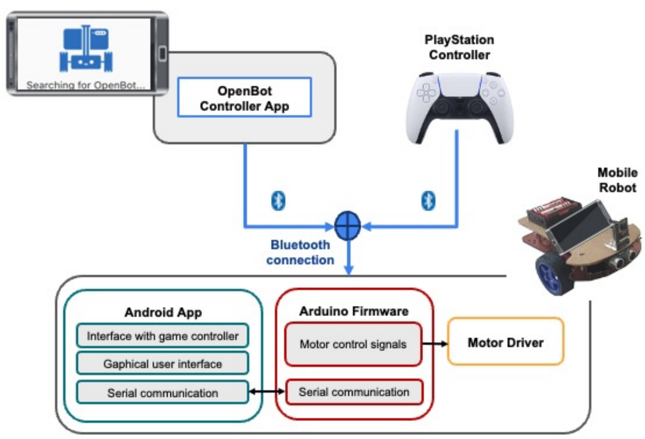

Figure 2. Software architecture and communication.

These control methods were evaluated in a study on intuitiveness with the public, exploring how different interaction methods impact user experience.

Figure 3 shows the assembled robot ready for the study.

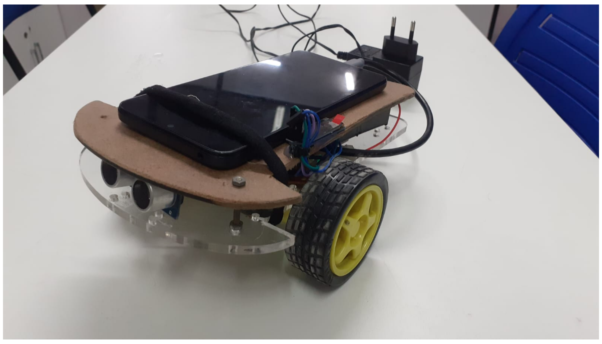

Figure 3. Assembled robot

4 Research Methods

4.1 Participants

The study involved volunteers who were randomly recruited on a university campus. Participants were approached verbally and invited to participate in the research as they passed by the study area. The selection was made to ensure a balanced distribution across different age groups and genders to explore how these variables influence interaction with robotic interfaces. Each participant was informed about the study's objectives and signed an informed consent form before beginning the research.

The informed consent form provided detailed information about the study, including its purpose, procedures, potential risks and benefits, and the voluntary nature of participation. Participants were assured of their right to withdraw from the study at any time without any negative consequences. The form also ensured the anonymity and confidentiality of the participants' data.

4.2 Materials

For the study, in addition to constructing the robotic cart, three distinct types of controls were used to operate the robot: (1) a controller with two bidirectional joysticks (Figure 4), allowing independent control of each wheel of the robot; (2) control based on the gyroscope of a smartphone (Figure 5), which used the device's tilt to move the robot; and (3) a PlayStation 5 controller (Figure 6), connected via Bluetooth, with commands set to typical racing game patterns. Each controller was used in one study condition, details in Section 4.4. Additionally, a circuit was set up on the floor of a robotics laboratory, marked by adhesive tape, for the robot to navigate during the tests (Figure 7).

In Figure 4, it can be seen that there are two control bars located on each side of the screen. Each of these bars is responsible for controlling one of the wheels of the robotic car independently. The bar on the left side controls the left wheel, while the bar on the right side controls the right wheel.

The operation of these bars is simple but crucial for the robot's movement. When the user slides the left bar up, only the left wheel of the robot moves forward, causing the robot to start turning to the right. This movement occurs because the right wheel remains stationary, creating a difference in wheel speeds, which results in the robot's rotation.

Similarly, if the user slides the right bar up, the right wheel of the robot moves forward while the left wheel remains stationary, causing the robot to turn to the left. This type of control allows the user to manoeuvre the robot precisely, controlling direction based on the rotation of individual wheels.

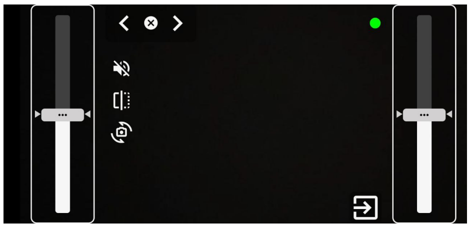

Figure 4. Control interface used in the first study condition

In Figure 5, it is possible to see symbols on each side of the screen. The symbol with some dots indicates that the cart should accelerate with both wheels simultaneously, while the symbol on the left makes the cart move backward.

Figure 5. Control interface used in the second study condition

In Figure 6, the controller used in the study is shown, where the R2 and L2 triggers are configured for acceleration and braking, respectively, and the directional buttons control the cart's movement.

Figure 6. PlayStation 5 controller used in the third study condition

4.3 Procedures

The study was conducted in a closed research laboratory, where participants carried out the activities individually. During each session, only the participant and two researchers were present in the laboratory. One researcher was responsible for recording the time taken to complete the task and

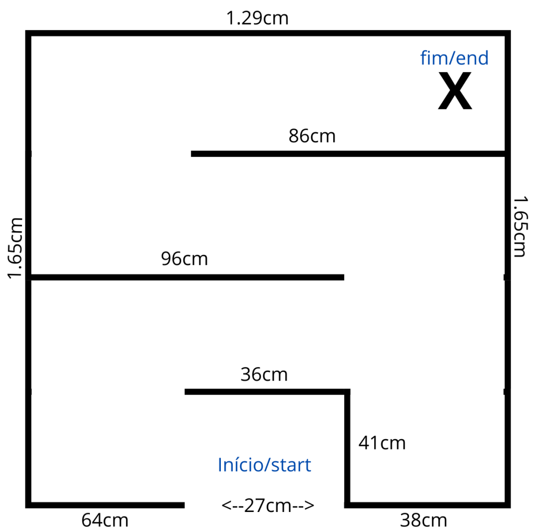

Figure 7. Circuit used for the experiment

the number of times the participant went off track. Another researcher was in charge of the technical aspects, addressing any issues with the robotic car or the controller.

Each participant used a different type of control and would request assistance from the researchers present in the room if necessary. The study was divided into two main stages: the practical test and the application of a questionnaire.

In the first stage, each participant was asked to use the designated control to operate the robot on a circuit drawn on the floor with tape. Controls were assigned randomly, and participants did not receive prior instructions on how to operate the control. The total time to complete the circuit was timed, and the number of times the robot went off the track was recorded.

Participants were invited individually to the laboratory. Upon accepting the invitation, they were escorted to the laboratory where they were alone with the two researchers. This ensured that each participant's experience and responses were not influenced by the presence of other participants.

In the second stage, after completing the interaction, participants answered a structured questionnaire divided into three sections (details in Section 4.5). The questionnaire was administered immediately after the practical test to capture the participants' experiences and perceptions accurately.

4.4 Manipulation

The experimental manipulation involved comparing the different control interfaces concerning the participants' demographic and experience variables. Efforts were made to balance the number of male and female participants across each study condition, as well as their ages and gaming experience. Additionally, the order of control use was randomized to minimize learning or fatigue effects.

In this study, three distinct conditions were used, each corresponding to a specific type of control for operating the robot cart. The conditions were structured as follows:

- **Condition 1: Bidirectional Joystick Control** (Figure 4) - In this condition, participants used a control based on two bidirectional joysticks. Each joystick independently controls one wheel of the robot. Moving both joysticks forward simultaneously makes the robot move straight; moving them backwards makes the robot reverse. If the user moves only the left joystick forward, the robot will turn right, and vice versa. This setup requires the user to coordinate the joystick movements to navigate the circuit.
- **Condition 2: Smartphone Gyroscope Control** (Figure 5) - In the second condition, the robot was controlled using the gyroscope embedded in the smartphone. The robot moves in response to the device's tilt: tilting the smartphone sideways causes the robot to turn, while acceleration and deceleration are controlled by virtual pedals on the screen, with the right pedal advancing and the left pedal reversing. This control is inspired by smartphone racing games, offering an intuitive interface based on the physical movement of the device. Other buttons were envisioned for the cart to have LEDs representing arrows, but these features were not implemented.
- **Condition 3: Console Gamepad Control** (Figure 6) - In the third and final condition, participants operated the robot using a PlayStation 5 controller connected via Bluetooth. The commands were mapped to replicate typical console racing game controls: the R2 trigger was used to advance, the L2 trigger to reverse, and the left joystick controlled the directions, allowing the robot to turn left or right. This control was chosen for its familiarity among players accustomed to consoles, offering a conventional game interface.

4.5 Questionnaires

The administered questionnaire consisted of three main sections: (1) Demographic Data, which collected information on participants' age, gender, and educational background; (2) Gaming Skill, which investigated participants' history with video game controls and remotely controlled devices; and (3) Interaction with the Robot, using the "*The Game Experience Questionnaire (GEQ)*" [IJsselsteijn *et al.*, 2013] to capture participants' perceptions and experiences during the experiment.

Despite the availability of various questionnaires designed for human-robot interaction, we identified a gap in instruments specifically suited to assess the interface experience of robotic systems, particularly concerning the controls used. Our study focuses on evaluating how different control interfaces impact user experience, with a specific emphasis on the interaction dynamics related to game-like controls.

The GEQ is structured into several modules to assess different dimensions of user experience comprehensively. It includes the Core Questionnaire, the In-Game GEQ, the Social Presence Module, and the Post-Game Module. For our study, we specifically utilized the In-Game GEQ, which consisted of fourteen questions and was selected for its relevance in capturing user experiences and emotional responses immediately following the interaction.

The In-Game GEQ assesses various dimensions of the gaming experience through seven components:

- **Competence:** Measures the participants' sense of skill and success in the task. Related questions include: "I felt successful" and "I felt skillful".

- **Sensory and Imaginative Immersion:** Assesses the extent to which participants feel immersed in the task, to the point of forgetting their surroundings. Related questions include: "I was deeply concentrated in the game" and "I lost track of time".
- **Flow:** Evaluates the state of being fully absorbed and focused on the task. Related questions include: "I was fully absorbed in the game" and "I felt content".
- **Tension:** Measures feelings of frustration, fatigue, and irritation. Related questions include: "I felt frustrated" and "I felt irritable".
- **Challenge:** Assesses the perceived difficulty and effort required for the task. Related questions include: "I felt challenged" and "I had to put in a lot of effort".
- **Negative Affect:** Evaluates negative emotional responses such as boredom and irritation. Related questions include: "I felt bored" and "I felt annoyed".
- **Positive Affect:** Measures positive emotional responses and overall well-being. Related questions include: "I felt happy" and "I felt good".

These components provided a thorough evaluation of user engagement with the different control interfaces.

The questions within this module used a Likert scale from 1 to 5, where 1 represents 'Not at all' and 5 represents 'Extremely'. They addressed the level of interest in the game's storyline, feelings of success, boredom, overall impression, immersion to the point of forgetting the surrounding environment, frustration, fatigue, irritation, sense of skill, total absorption, contentment, challenge, perceived effort, and overall well-being.

The choice of the GEQ was particularly relevant for this study because the control interfaces were inspired by video game controls, which are designed to be engaging and intuitive. The GEQ allowed us to capture detailed information about the user experience, including emotional responses and engagement levels, which are critical for understanding how users interact with game-like control interfaces in a robotic context. Additionally, the task of navigating the robot through the circuit presented a challenge similar to a game, where participants aimed to complete the course as quickly and accurately as possible. This game-like challenge further justifies the use of the In-Game GEQ to assess user experience.

4.6 Statistical Analysis

The collected data were analyzed using non-parametric statistical methods with IBM SPSS software. Since the Shapiro-Wilk test indicated that most of the data did not follow a normal distribution ($p < .05$), non-parametric tests were utilized.

To compare the control conditions (bidirectional joysticks, smartphone gyroscope, and console gamepad), we applied the Kruskal-Wallis test, a non-parametric alternative to ANOVA, suitable for comparing more than two independent groups. When the Kruskal-Wallis test revealed marginal or statistically significant differences, we applied the Mann-Whitney test with Bonferroni correction to perform pairwise comparisons between the conditions.

4.7 *Generative Pre-trained Transformer*

To support the writing and revision of this article, we utilized a natural language processing technology known as GPT. GPT assisted in various ways during the development of this article:

- Text Review: GPT was used to review sections of the article, helping to structure the texts clearly and concisely, and improving the fluency and cohesion of the content.
- Presentation of Results: The model contributed suggestions on how to present and interpret the data, based on standard practices in academic literature.
- Editing and Style Improvement: The technology was employed to review and enhance the writing, adjusting the style to conform to academic publishing standards and ensuring that the text was formal and precise.

The use of GPT was guided by ethical and methodological guidelines, ensuring that the technology was employed to support, rather than replace, critical thinking and originality in the writing of the article.

5 Results

Demographic Data

The study was conducted over 5 days in a university laboratory with 30 volunteers, evenly divided between genders (50% female and 50% male). The overall mean age of the participants was 27.43 years (SD = 10.72). Among them, 3 belong to Generation X (born between 1965 and 1980), 6 to Generation Y (born between 1981 and 1996), and 21 to Generation Z (born between 1997 and 2010). The mean age of female participants was 31.27 years (SD = 11.57), with 2 from Generation X, 5 from Generation Y, and 8 from Generation Z. For male participants, the mean age was 23.60 years (SD = 8.53), with 1 from Generation X, 1 from Generation Y, and 13 from Generation Z. In study condition 1, there were six female participants and four male participants. In condition 2, there were four female participants and six male participants. In condition 3, there were five female participants and five male participants.

In terms of general gaming experience, 30% (9) of the participants consider themselves advanced, 16.7% (5) experts, 10% (3) inexperienced, 26.7% (8) beginners, and 16.7% (5) intermediate. Regarding the frequency of digital gaming, 30% (9) play daily, 3.3% (1) less frequently, 6.7% (2) monthly, 16.7% (5) never, 16.7% (5) rarely, 13.3% (4) weekly, and 13.3% (4) several times a week.

When analyzed by gender, female participants showed that 20% (3) consider themselves advanced, 20% (3) inexperienced, 46.7% (7) beginners, and 13.3% (2) intermediate. Regarding the frequency of digital gaming, 6.7% (1) play daily, 13.3% (2) monthly, 26.7% (4) never, 33.3% (5) rarely, 6.7% (1) weekly, and 13.3% (2) several times a week. Male participants showed that 40% (6) consider themselves advanced, 33.3% (5) experts, 6.7% (1) beginners, and 20% (3) intermediate. The frequency of digital gaming among males reveals that 53.3% (8) play daily, 6.7% (1) less frequently, 6.7% (1) never, 20% (3) weekly, and 13.3% (2) several times a week.

H1: Control Modes

Component scores of the GEQ are calculated as the average value of their respective items. This modular approach allowed us to focus on key factors of user experience, including Competence, Flow, Tension, Challenge, and both Negative and Positive Affect, providing a comprehensive evaluation of how users engage with different control interfaces in our study. After calculating the mean scores for each factor, a statistical analysis was conducted to compare the three experimental conditions.

The Kruskal-Wallis test was applied to determine if there were significant differences between the three conditions regarding the evaluated factors. The results showed no statistically significant differences in most factors: Competence ($H(2) = 0.974, p = 0.614$); Sensory and Imaginative Immersion ($H(2) = 0.461, p = 0.794$); Flow ($H(2) = 1.909, p = 0.385$); Challenge ($H(2) = 2.413, p = 0.299$); Negative Affect ($H(2) = 0.801, p = 0.670$); Positive Affect ($H(2) = 1.473, p = 0.479$).

However, the factor Tension showed a marginally significant result ($H(2) = 5.821, p = 0.054$), suggesting a potential trend of difference between conditions. To investigate further, post-hoc comparisons were made using the Bonferroni-corrected multiple comparisons test. The results of the pairwise comparisons for the Tension factor were: C3-C1 = $H(2) = 2.300, p = 1.00$; C3-C2 = $H(2) = 8.950, p = 0.061$; C1-C2 = $H(2) = -6.650, p = 0.253$.

Figure 8 shows the boxplots for the variables Competence, Sensory, Flow, Tension, Challenge, Negative Affect, and Positive Affect across the three conditions (C1, C2, C3). These visualizations help to highlight any significant differences or trends in the data.

Although none of the comparisons reached conventional significance levels after Bonferroni correction ($p < 0.05$), the comparison between Conditions 3 and 2 showed a marginally significant result ($p = 0.061$), suggesting a trend in the experience of tension between these two conditions. Condition 2 (smartphone gyroscope control) presented higher tension metrics compared to Condition 3 (PlayStation 5 controller), indicating that users experienced more tension using the smartphone gyroscope control.

Additionally, when analyzing the number of times the car went off the course and the time taken to complete the route, the Kruskal-Wallis test indicated significant differences with $p = 0.014$ and $p = 0.013$, respectively. Pairwise comparisons revealed that for the number of times the cart went off the course, Condition 3 differed significantly from Condition 2 ($p = 0.032$), and Condition 1 also differed from Condition 2 ($p = 0.038$). For the time taken to complete the route, a significant difference was observed between Conditions 3 and 2 ($p = 0.012$). This indicates that the PlayStation 5 controller (Condition 3) allowed for better performance in terms of fewer deviations and faster completion times compared to the smartphone gyroscope control (Condition 2).

H2: Generational Perceptions

To validate the hypothesis regarding different age groups' perceptions of control modes, the Mann-Whitney U Test was used to compare generations in each study condition. In the first two conditions, no statistically significant differences were found between generations for the evaluated factors. In the third condition, the Challenge factor showed a marginal difference ($p = 0.071$). A more detailed analysis revealed a statistically significant difference ($p = 0.022$) between Generations Z and Y for this factor. Additionally, the Negative Affect factor showed a significant difference ($p = 0.025$), with a clear distinction between Generations Z and Y ($p = 0.009$).

The detailed results of the Kruskal-Wallis tests and pairwise comparisons for each condition are provided in Appendix A.

H3: Digital Gaming Experience

The study participants were classified according to their general gaming experience as follows: 30% (9) consider themselves advanced, playing regularly; 16.7% (5) are experts, with high frequency or competitive play; 10% (3) are inexperienced, never having played; 26.7% (8) are beginners, having played a few times; and 16.7% (5) are intermediate, playing occasionally.

To validate the hypothesis, the Mann-Whitney U Test was applied to compare the experience levels in each study condition. In the first condition, a marginal statistical difference was observed in the Challenge factor between beginners and intermediates ($p = 0.074$) and between advanced and intermediates ($p = 0.057$).

In the second condition, significant statistical differences were found for the Competence factor, with differences between beginners and experts ($p = 0.033$) and beginners and intermediates ($p = 0.020$). For the Flow factor, differences were identified between inexperienced and beginners ($p = 0.036$) and between advanced and beginners ($p = 0.023$). For the Tension factor, a significant difference was observed between advanced and beginners ($p = 0.010$). Marginal statistical differences were observed for the Challenge factor between inexperienced and advanced ($p = 0.054$), inexperienced and intermediates ($p = 0.056$), and experts and intermediates ($p = 0.064$), as well as a difference between experts and advanced ($p = 0.049$).

In the third condition, significant statistical differences were found in the Time to complete the route between experts and inexperienced ($p = 0.031$) and experts and beginners ($p = 0.013$). For the number of times the car went off the course, differences were observed between advanced and beginners ($p = 0.026$) and intermediates and beginners ($p = 0.026$). For the Flow factor, the difference was found between experts and intermediates ($p = 0.049$). For Positive Affect, the difference was between inexperienced and intermediates ($p = 0.027$).

The detailed results of the Kruskal-Wallis tests and pairwise comparisons for each condition are provided in Appendix B.

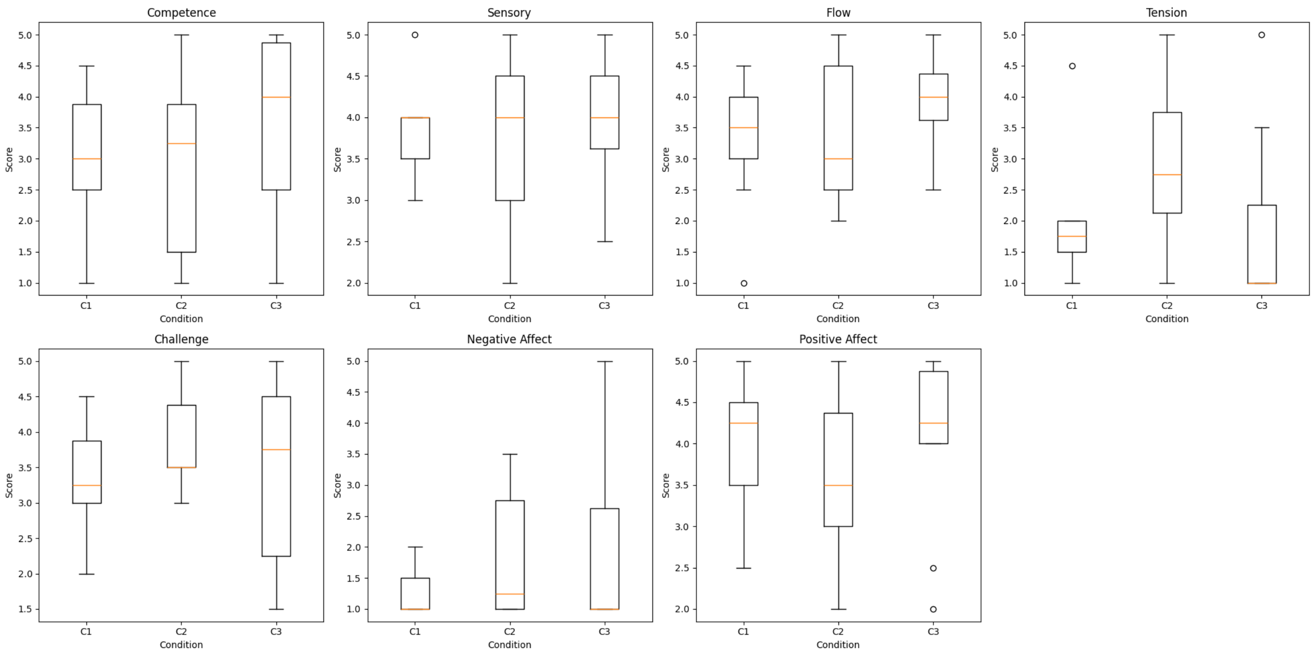

Figure 8. Boxplots showing the distribution of scores for each variable (Competence, Sensory, Flow, Tension, Challenge, Negative Affect, Positive Affect) across the three conditions (C1, C2, C3). The boxplots illustrate the median, interquartile range, and potential outliers for each condition.

H4: Gender Experience

The analysis of gender differences across the study conditions yielded varying results. In the analysis comparing participants' gender in the first study condition, only the time taken to complete the route showed a significant difference ($p = 0.038$), indicating gender-based variation. No significant differences were found for other factors, including the number of times the car went off course ($p = 0.352$), competence ($p = 0.914$), sensory experience ($p = 0.114$), flow ($p = 0.067$), tension ($p = 0.610$), challenge ($p = 0.257$), negative affect ($p = 0.476$), and positive affect ($p = 0.476$), suggesting that these factors are similar across genders.

In the analysis of the second study condition, none of the factors showed significant differences based on gender. The time taken to complete the route ($p = 0.476$), the number of times the car went off course ($p = 0.762$), and all dimensions of the GEQ—competence ($p = 0.476$), sensory experience ($p = 0.476$), flow ($p = 1.000$), tension ($p = 0.257$), challenge ($p = 0.914$), negative affect ($p = 0.257$), and positive affect ($p = 0.476$)—were similar across genders.

In the analysis of the third study condition, significant differences based on gender were observed in two factors. Specifically, competence ($p = 0.016$) and positive affect ($p = 0.032$) showed variations between genders, leading to the rejection of the null hypothesis for these factors. Conversely, the time taken to complete the route ($p = 0.056$), the number of times the car went off course ($p = 0.222$), and all other dimensions of the Game Experience Questionnaire—sensory experience ($p = 0.548$), flow ($p = 0.421$), tension ($p = 0.548$), challenge ($p = 0.222$), and negative affect ($p = 0.421$)—did not reveal significant differences by gender.

6 Discussion

The demographic data of this study reveal a heterogeneous distribution among generations, with a predominance of Generation Z (70% of participants). This distribution reflects the current reality of digital technology use, where younger generations tend to be more represented in studies on digital interfaces [Vogels, 2019]. The unequal gender distribution across generations in our study (more women in Generations X and Y, and more men in Generation Z) adds a layer of complexity to the interpretation of the results. Previous studies, such as those by Cruea and Park [2012], suggest that there may be gender differences in the adoption and use of new technologies, which could interact with the generational effects observed. Furthermore, the predominance of Generation Z in our sample (70%) may have influenced the overall results, especially considering that this generation tends to be more adaptable to new technologies [Turner, 2015]. This highlights the need for future studies with more balanced generational samples to validate and expand our findings.

H1: Control Modes

The results obtained for different control modes showed marginal differences in the Tension factor and significant differences in performance measures. Specifically, Condition 2 (smartphone gyroscope control) presented higher tension metrics compared to Condition 3 (PlayStation 5 controller), suggesting that the smartphone gyroscope control induced more stress or discomfort. This finding aligns with Sukaridhoto *et al*. [2023], who identified variations in users' tension levels when interacting with different control interfaces in virtual environments.

In terms of performance measures, Condition 3 had significantly fewer path deviations and faster completion times compared to Condition 2. This indicates that the PlayStation 5 controller provided better performance and efficiency. These results are consistent with Wickens *et al*. [2021], who noted that user performance can be significantly affected by the specific characteristics of the control interface.

Additionally, the significant differences in performance measures (path deviations and completion time) between conditions reinforce the importance of considering multiple factors when designing control interfaces. Notably, the type of control used may have influenced these results. The first control, which operates each robot wheel independently, may offer a different interaction experience compared to the second, mobile-game-style control or the third, console game controller. As noted by Wickens *et al*. [2021], user performance can be significantly affected by the specific characteristics of the control interface, even when differences in subjective experience are subtle. Thus, understanding how different control types impact both performance and user experience is crucial for effective interface design.

H2: Generational Perceptions

The differences observed between generations, particularly in the third study condition, align with previous research on generational differences in technology use. Generation Z reported significantly lower Negative Affect scores compared to Generation Y in Condition 3 ($p = 0.009$). This suggests that younger users had a more positive experience with the PlayStation 5 controller, potentially due to their greater familiarity and comfort with gaming consoles, as discussed by Dimock [2019].

These results reinforce the importance of considering generational differences in interface design, as argued by Shneiderman *et al*. [2017]. The authors emphasize that different generations may have distinct mental models of how interfaces should function, which can affect their experience and performance.

H3: Digital Gaming Experience

The variation in results based on prior experience with digital games is consistent with studies demonstrating the influence of user experience on interaction with new interfaces. Advanced and expert users reported higher competence and flow, and lower tension in Condition 2 (smartphone gyroscope control), indicating that prior gaming experience facilitates adaptation to more complex control modes. These findings corroborate Csikszentmihalyi *et al*. [2014], who noted that prior experience can affect the flow state and perceived competence in challenging tasks.

In Condition 3 (PlayStation 5 controller), significant differences in performance metrics (time and path deviations) were observed across experience levels. Experts and advanced users completed the route faster and with greater accuracy, reinforcing the notion that familiarity with similar technologies facilitates adaptation to new interfaces [of Sciences *et al*., 2018]. Moreover, the significant variations in Competence, Flow, and Tension among different experience levels align with findings by Csikszentmihalyi *et al*. [2014], highlighting how prior expertise influences the flow state and perceived competence in challenging tasks. These disparities in both objective performance and subjective experience further support the idea that previous exposure to comparable technologies enhances interaction with novel systems [of Sciences *et al*., 2018].

H4: Gender Experience

The analysis of gender differences across the study conditions revealed intriguing patterns that both align with and diverge from previous research in HRI and game-based learning. In Condition 1, the significant difference in time taken to complete the route ($p = 0.038$) suggests that gender may influence task performance with certain control interfaces. This aligns with Türkay *et al*. [2021], who found that video game experience and gender could predict performance in a surgical robotic arm. However, the lack of significant differences in other factors indicates that the overall experience may be similar across genders, despite differences in task completion time.

In Condition 2, the absence of significant gender differences suggests that this interface may be more gender-neutral in terms of usability and user experience. This supports Lukosch *et al*. [2017], who emphasized the need for personalized approaches in game-based learning experiences to accommodate gender differences.

In Condition 3, significant differences in competence ($p = 0.016$) and positive affect ($p = 0.032$) were observed based on gender. Men reported higher competence and positive affect, indicating that they might be more comfortable and satisfied with the PlayStation 5 controller. This difference could be attributed to greater familiarity and experience with gaming consoles among male participants, as suggested by Yang and Chen [2020].

The difference in positive affect between genders in the third condition could be related to Kaye *et al*. [2018] findings on the effects of avatar gender and explicit priming on stereotype threat in gaming environments. Their work suggests that gender-related factors can influence emotional responses and engagement in gaming contexts, which may extend to HRI scenarios.

It's important to note that while some significant differences were observed, many factors showed no significant variation across genders. This suggests that while gender is an important consideration in HRI and interface design, its impact may be nuanced and context-dependent. As Shen *et al*. [2016] demonstrated in their study debunking gender performance gaps in online games, it's crucial to consider multiple factors and avoid overgeneralization when examining gender differences in technological contexts.

7 Conclusion

This study demonstrates that the effectiveness and user experience with different control modes are influenced by a complex combination of factors, including the specific design of the interface, generational differences, levels of prior experience, and gender. Our results align with existing literature on interface design, generational differences in technology use, and gender-based variations in human-robot interaction, while also providing new insights into how these factors interact in specific interface control contexts.

The findings related to control modes reveal that the PlayStation 5 controller provided better performance and user experience, with significantly fewer path deviations and faster completion times compared to the smartphone gyroscope control. This indicates that traditional gaming controllers may offer advantages such as efficiency and ease of use.

Generational differences were also significant, with Generation Z reporting lower Negative Affect scores compared to Generation Y when using the PlayStation 5 controller. This suggests that younger users may have a more positive experience with gaming controllers, potentially due to their greater familiarity with such devices.

In terms of digital gaming experience, advanced and expert users reported higher competence and flow, and lower tension when using the smartphone gyroscope control. This indicates that prior gaming experience facilitates adaptation to more complex control modes, enhancing user satisfaction and performance.

Gender differences across the study conditions reveal that gender can play a significant role in certain aspects of user performance and experience, particularly in task completion time and perceived competence. However, the impact of gender appears to be context-dependent and varies across different control interfaces. This underscores the importance of considering gender as a relevant factor in interface design and evaluation, while also recognizing that its influence may be nuanced and interact with other variables such as prior gaming experience and the specific nature of the control interface.

These findings have significant implications for user interface design, highlighting the need for more personalized and adaptive approaches that take into account not only generational differences but also gender-specific preferences and performance patterns. As suggested by Norman [2013], user-centred design should consider not only the characteristics of the interface but also the diverse characteristics of users, including age, prior experience, gender, and cultural context.

It is important to acknowledge the limitations of this study, which may have influenced the obtained results:

- Robot Power Supply: Due to time constraints, the robot was powered by a plug-in source instead of batteries. This may have affected participants' performance, potentially influencing task completion times.
- Sample Size: The study involved a total of 30 participants (10 per condition). This limitation in sample size may have reduced the statistical power of the analyses and the ability to detect more subtle differences between conditions, groups, and genders.

These limitations should be considered in interpreting the results and highlight the need for more comprehensive and longer-term future studies.

It is important to acknowledge that this study focused on the performance and user experience with different control modes, rather than the participants' preferences. Each participant interacted with only one type of interface, which limited our ability to assess their preferences across multiple interfaces. Future research could address this limitation by allowing participants to interact with multiple control interfaces and providing comparative feedback.

Based on the obtained results and identified limitations, we suggest the following directions for future work:

- Replication and Expansion of the Study: Repeat the experiment with a larger and more diverse sample of participants, including a broader range of control types, and ensuring balanced gender representation. This would allow for a more robust analysis of differences between generations, levels of experience, and genders, potentially revealing patterns that may not have been detected in the present study due to sample limitations.
- Development of Adaptive Interfaces: Based on the results regarding which model was most pleasant for users, develop more easily adaptable controls that can accommodate gender-specific preferences and performance patterns. This could involve creating interfaces that automatically adjust to user preferences, skills, and gender-related interaction styles, possibly incorporating machine learning techniques to optimize user experience over time.
- Applications in Industry: Investigate the applicability of the studied controls in Industry 3.0 and production/maintenance machinery, considering potential gender differences in industrial settings. This could involve case studies in real industrial environments, evaluating how different control interfaces affect efficiency, safety, and operator satisfaction across genders in industrial contexts.
- Longitudinal Studies: Conduct long-term research to understand how adaptation to new control modes evolves over time for different user groups, including gender-specific adaptation patterns. This could provide valuable insights into learning and adaptation processes, as well as the durability of preferences for certain types of interfaces across genders and generations.
- Gender-Specific User Experience Research: Conduct in-depth qualitative studies to better understand the reasons behind gender differences in competence perception and positive affect observed in certain control conditions. This could inform the development of more inclusive and engaging user interfaces.

These directions for future research would not only address the limitations of the present study but also significantly expand our understanding of how to optimize control interfaces for a wide range of users and contexts, taking into account the important dimension of gender. By doing so, we could advance the development of more inclusive, efficient, and adaptable technologies to meet the diverse needs of users across different generations, experience levels, and genders.

Declarations

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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A Detailed Results of Generational Perceptions

This appendix contains the detailed results of the Kruskal-Wallis tests and pairwise comparisons for each study condition using the generational perceptions.

A.1 Condition 1

For Condition 1, the Kruskal-Wallis test was performed, but multiple comparisons were not conducted because there were less than three test fields for each variable. The results are summarized in Table 2.

Table 2. Results of Kruskal-Wallis tests for each variable in Condition 1

Variable	N	Test Statistic	DF	Sig. (2-sided)
Time taken to complete the track	10	1.091	1	0.296
Number of times the car went off the track	10	0.164	1	0.685
Competence	10	1.433	1	0.231
Sensory	10	0.080	1	0.778
Flow	10	0.017	1	0.895
Tension	10	3.169	1	0.075
Challenge	10	0.074	1	0.786
Negative Affect	10	4.375	1	0.036
Positive Affect	10	2.989	1	0.084

A.2 Condition 2

The results of the Kruskal-Wallis tests and pairwise comparisons for each variable in Condition 2 are summarized in Table 3. This table provides a comprehensive overview of the test statistics, degrees of freedom, and p-values for each comparison between generations.

A.3 Condition 3

The results of the Kruskal-Wallis tests and pairwise comparisons for each variable in Condition 3 are summarized in Table 4. This table provides a comprehensive overview of the test statistics, degrees of freedom, and p-values for each comparison between generations.

Table 3. Results of Kruskal-Wallis tests and pairwise comparisons for each variable between generations in Condition 2

Variable	N	Test Statistic	DF	Sig. (2-sided)	Comparison	Sig.
Number of times the car went off the track	10	1.609	2	0.447	Z-X Z-Y X-Y	0.734 0.207 0.379
Time taken to complete the track	10	1.488	2	0.475	X-Z X-Y Z-Y	0.953 0.281 0.233
Competence	10	3.568	2	0.168	Y-X Y-Z X-Z	0.731 0.144 0.155
Sensory	10	5.266	2	0.072	Y-X Y-Z X-Z	0.579 0.063 0.102
Flow	10	0.873	2	0.646	Z-X Z-Y X-Y	0.775 0.355 0.535
Tension	10	2.717	2	0.257	Z-X Z-Y X-Y	0.208 0.208 0.784
Challenge	10	1.361	2	0.506	X-Y X-Z Y-Z	0.945 0.300 0.484
Negative Affect	10	1.821	2	0.402	Z-X Z-Y X-Y	0.450 0.219 0.564
Positive Affect	10	5.398	2	0.067	Y-X Y-Z X-Z	0.785 0.090 0.065

Table 4. Results of Kruskal-Wallis tests and pairwise comparisons for each variable between generations in Condition 3

Variable	N	Test Statistic	DF	Sig. (2-sided)	Comparison	Sig.
					Z-Y	0.105
Number of times the car went off the track	10	4.517	2	0.104	Z-X	0.090
					Y-X	0.555
					Z-Y	0.086
Time taken to complete the track	10	3.713	2	0.156	Z-X	0.220
					Y-X	0.924
					X-Y	0.733
Competence	10	1.078	2	0.583	X-Z	0.390
					Y-Z	0.450
					Z-Y	0.423
Sensory	10	1.442	2	0.486	Z-X	0.295
					Y-X	0.624
					Z-Y	0.936
Flow	10	0.818	2	0.664	Z-X	0.370
					Y-X	0.430
					Z-Y	0.174
Tension	10	3.733	2	0.155	Z-X	0.102
					Y-X	0.485
					Z-X	0.501
Challenge	10	5.288	2	0.071	Z-Y	0.022
					X-Y	0.439
					X-Z	0.840
Negative Affect	10	7.366	2	0.025	X-Y	0.075
					Z-Y	0.009
					Y-Z	0.779
Positive Affect	10	0.207	2	0.902	Y-X	0.659
					Z-X	0.773

B Detailed Results of Digital Gaming Experience

This appendix contains the detailed results of the Kruskal-Wallis tests and pairwise comparisons for each study condition using participant's digital gaming experience.

B.1 Condition 1

The table 5 presents the results of the Independent-Samples Kruskal-Wallis Test for various measures across different levels of digital gaming experience in the first condition.

Table 5. Results of Kruskal-Wallis tests and pairwise comparisons for each variable in Condition 1 based on digital gaming experience

Measure	Comparison	Test Statistic	Std. Error	Sig.
Time to Complete Route	Intermediate - Advanced	0.100	2.533	0.969
	Intermediate - Beginner	3.167	2.764	0.252
	Advanced - Beginner	-3.067	2.211	0.165
Number of Times Car Went Off Course	Advanced - Beginner	-1.500	2.136	0.483
	Advanced - Intermediate	-2.750	2.447	0.261
	Beginner - Intermediate	-1.250	2.670	0.640
Competence	Intermediate - Beginner	1.250	2.713	0.645
	Intermediate - Advanced	1.750	2.487	0.482
	Beginner - Advanced	0.500	2.171	0.818
Sensory	Advanced - Beginner	-2.467	2.044	0.228
	Advanced - Intermediate	-2.800	2.342	0.232
	Beginner - Intermediate	-0.333	2.555	0.896
Flow	Advanced - Intermediate	-0.900	2.502	0.719
	Advanced - Beginner	-2.400	2.184	0.272
	Intermediate - Beginner	1.500	2.730	0.583
Tension	Advanced - Intermediate	-0.850	2.415	0.725
	Advanced - Beginner	-1.433	2.108	0.497
	Intermediate - Beginner	0.583	2.635	0.825
Challenge	Beginner - Advanced	0.100	2.129	0.963
	Beginner - Intermediate	-4.750	2.661	0.074
	Advanced - Intermediate	-4.650	2.439	0.057
Negative Affect	Intermediate - Advanced	1.800	2.214	0.416
	Intermediate - Beginner	3.667	2.415	0.129
	Advanced - Beginner	-1.867	1.932	0.334
Positive Affect	Beginner - Advanced	1.967	2.171	0.365
	Beginner - Intermediate	-3.417	2.713	0.208
	Advanced - Intermediate	-1.450	2.487	0.560

B.2 Condition 2

The table 6 presents the results of the Independent-Samples Kruskal-Wallis Test for various measures across different levels of digital gaming experience in the second condition.

Table 6. Results of Kruskal-Wallis tests and pairwise comparisons for each variable in Condition 2 based on digital gaming experience

Measure	Comparison	Test Statistic	Std. Error	Sig.
Time to Complete Route	Inexperienced - Intermediate	-1.000	4.282	0.815
	Inexperienced - Expert	2.667	3.496	0.446
	Inexperienced - Beginner	-5.000	3.496	0.153
	Inexperienced - Advanced	5.500	3.708	0.138

Continued on next page

Measure	Comparison	Test Statistic	Std. Error	Sig.
	Intermediate - Expert	1.667	3.496	0.634
	Intermediate - Beginner	4.000	3.496	0.253
	Intermediate - Advanced	4.500	3.708	0.225
	Expert - Beginner	-2.333	2.472	0.345
	Expert - Advanced	2.833	2.764	0.305
	Beginner - Advanced	0.500	2.764	0.856
Number of Times Car Went Off Course	Intermediate - Expert	3.333	3.485	0.339
	Intermediate - Inexperienced	3.500	4.269	0.412
	Intermediate - Advanced	6.250	3.697	0.091
	Intermediate - Beginner	6.333	3.485	0.069
	Expert - Inexperienced	-0.167	3.485	0.962
	Expert - Advanced	2.917	2.755	0.290
	Expert - Beginner	-3.000	2.465	0.224
	Inexperienced - Advanced	2.750	3.697	0.457
	Inexperienced - Beginner	-2.833	3.485	0.416
	Advanced - Beginner	-0.083	2.755	0.976
Competence	Beginner - Inexperienced	2.500	3.432	0.466
	Beginner - Advanced	4.500	2.713	0.097
	Beginner - Expert	5.167	2.427	0.033
	Beginner - Intermediate	-8.000	3.432	0.020
	Inexperienced - Advanced	2.000	3.640	0.583
	Inexperienced - Expert	2.667	3.432	0.437
	Inexperienced - Intermediate	-5.500	4.203	0.191
	Advanced - Expert	-0.667	2.713	0.806
	Advanced - Intermediate	-3.500	3.640	0.336
	Expert - Intermediate	-2.833	3.432	0.409
Sensory	Inexperienced - Beginner	-0.667	3.399	0.845
	Inexperienced - Advanced	3.000	3.606	0.405
	Inexperienced - Intermediate	-4.000	4.163	0.337
	Inexperienced - Expert	4.333	3.399	0.202
	Beginner - Advanced	2.333	2.687	0.385
	Beginner - Intermediate	-3.333	3.399	0.327
	Beginner - Expert	3.667	2.404	0.127
	Advanced - Intermediate	-1.000	3.606	0.782
	Advanced - Expert	-1.333	2.687	0.620
	Intermediate - Expert	0.333	3.399	0.922
Flow	Inexperienced - Advanced	1.000	3.629	0.783
	Inexperienced - Intermediate	-2.000	4.190	0.633
	Inexperienced - Expert	4.833	3.421	0.158
	Inexperienced - Beginner	-7.167	3.421	0.036
	Advanced - Intermediate	-1.000	3.629	0.783
	Advanced - Expert	-3.833	2.705	0.156
	Advanced - Beginner	-6.167	2.705	0.023
	Intermediate - Expert	2.833	3.421	0.408
	Intermediate - Beginner	5.167	3.421	0.131
	Expert - Beginner	-2.333	2.419	0.335
Tension	Advanced - Intermediate	-1.000	3.640	0.784
	Advanced - Expert	-2.833	2.713	0.296

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Measure	Comparison	Test Statistic	Std. Error	Sig.
	Advanced - Inexperienced	-4.500	3.640	0.216
	Advanced - Beginner	-7.000	2.713	0.010
	Intermediate - Expert	1.833	3.432	0.593
	Intermediate - Inexperienced	3.500	4.203	0.405
	Intermediate - Beginner	6.000	3.432	0.080
	Expert - Inexperienced	-1.667	3.432	0.627
	Expert - Beginner	-4.167	2.427	0.086
	Inexperienced - Beginner	-2.500	3.432	0.466
Challenge	Inexperienced - Expert	1.667	3.421	0.626
	Inexperienced - Beginner	-4.333	3.421	0.205
	Inexperienced - Advanced	7.000	3.629	0.054
	Inexperienced - Intermediate	-8.000	4.190	0.056
	Expert - Beginner	-2.667	2.419	0.270
	Expert - Advanced	5.333	2.705	0.049
	Expert - Intermediate	-6.333	3.421	0.064
	Beginner - Advanced	2.667	2.705	0.324
	Beginner - Intermediate	-3.667	3.421	0.284
	Advanced - Intermediate	-1.000	3.629	0.783
Negative Affect	Expert - Advanced	0.167	2.582	0.949
	Beginner - Advanced	0.167	2.582	0.949
	Expert - Beginner	0.000	2.309	1.000
	Expert - Intermediate	-1.167	3.266	0.721
	Expert - Inexperienced	-5.167	3.266	0.114
	Beginner - Intermediate	-1.167	3.266	0.721
	Beginner - Inexperienced	5.167	3.266	0.114
	Advanced - Intermediate	-1.000	3.464	0.773
	Advanced - Inexperienced	-5.000	3.464	0.149
	Intermediate - Inexperienced	4.000	4.000	0.317
Positive Affect	Beginner - Inexperienced	0.667	3.453	0.847
	Beginner - Advanced	3.417	2.730	0.211
	Beginner - Expert	4.667	2.442	0.056
	Beginner - Intermediate	-5.167	3.453	0.135
	Inexperienced - Advanced	2.750	3.663	0.453
	Inexperienced - Expert	4.000	3.453	0.247
	Inexperienced - Intermediate	-4.500	4.230	0.287
	Advanced - Expert	-1.250	2.730	0.647
	Advanced - Intermediate	-1.750	3.663	0.633
	Expert - Intermediate	-0.500	3.453	0.885

B.3 Condition 3

The table 7 presents the results of the Independent-Samples Kruskal-Wallis Test for various measures across different levels of digital gaming experience in the third condition.

Table 7. Results of Kruskal-Wallis tests and pairwise comparisons for each variable in Condition 3 based on digital gaming experience

Measure	Comparison	Test Statistic	Std. Error	Sig.
	Expert - Advanced	2.250	3.018	0.456
	Expert - Intermediate	-3.750	3.018	0.214

Continued on next page

Time to Complete Route

Measure	Comparison	Test Statistic	Std. Error	Sig.
	Expert - Inexperienced	-6.500	3.018	0.031
	Expert - Beginner	-7.500	3.018	0.013
	Advanced - Intermediate	-1.500	3.018	0.619
	Advanced - Inexperienced	-4.250	3.018	0.159
	Advanced - Beginner	-5.250	3.018	0.082
	Intermediate - Inexperienced	2.750	3.018	0.362
	Intermediate - Beginner	3.750	3.018	0.214
	Inexperienced - Beginner	-1.000	3.018	0.740
Number of Times Car Went Off Course	Advanced - Intermediate	0.000	2.687	1.000
	Advanced - Expert	-1.750	2.687	0.515
	Advanced - Inexperienced	-2.250	2.687	0.402
	Advanced - Beginner	-6.000	2.687	0.026
	Intermediate - Expert	1.750	2.687	0.515
	Intermediate - Inexperienced	2.250	2.687	0.402
	Intermediate - Beginner	6.000	2.687	0.026
	Expert - Inexperienced	-0.500	2.687	0.852
	Expert - Beginner	-4.250	2.687	0.114
	Inexperienced - Beginner	-3.750	2.687	0.163
Competence	Inexperienced - Advanced	5.250	2.963	0.076
	Beginner - Advanced	5.250	2.963	0.076
	Inexperienced - Expert	4.500	2.963	0.129
	Beginner - Expert	4.500	2.963	0.129
	Inexperienced - Beginner	0.000	2.963	1.000
	Inexperienced - Intermediate	-5.250	2.963	0.076
	Beginner - Intermediate	-5.250	2.963	0.076
	Expert - Advanced	0.750	2.963	0.800
	Expert - Intermediate	-0.750	2.963	0.800
	Advanced - Intermediate	0.000	2.963	1.000
Sensory	Advanced - Beginner	-0.750	2.944	0.799
	Advanced - Expert	-1.500	2.944	0.610
	Advanced - Inexperienced	-2.750	2.944	0.350
	Advanced - Intermediate	-3.750	2.944	0.203
	Beginner - Expert	0.750	2.944	0.799
	Beginner - Inexperienced	2.000	2.944	0.497
	Beginner - Intermediate	-3.000	2.944	0.308
	Expert - Inexperienced	-1.250	2.944	0.671
	Expert - Intermediate	-2.250	2.944	0.445
	Inexperienced - Intermediate	-1.000	2.944	0.734
Flow	Expert - Inexperienced	-0.500	2.925	0.864
	Expert - Beginner	-0.750	2.925	0.798
	Expert - Advanced	1.750	2.925	0.550
	Expert - Intermediate	-5.750	2.925	0.049
	Inexperienced - Beginner	-0.250	2.925	0.932
	Inexperienced - Advanced	1.250	2.925	0.669
	Inexperienced - Intermediate	-5.250	2.925	0.073
	Beginner - Advanced	1.000	2.925	0.732
	Beginner - Intermediate	-5.000	2.925	0.087

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Measure	Comparison	Test Statistic	Std. Error	Sig.
	Advanced - Intermediate	-4.000	2.925	0.171
Tension	Advanced - Expert	0.000	2.687	1.000
	Advanced - Inexperienced	-2.250	2.687	0.402
	Advanced - Intermediate	-3.250	2.687	0.227
	Advanced - Beginner	-4.500	2.687	0.094
	Expert - Inexperienced	-2.250	2.687	0.402
	Expert - Intermediate	-3.250	2.687	0.227
	Expert - Beginner	-4.500	2.687	0.094
	Inexperienced - Intermediate	-1.000	2.687	0.710
	Inexperienced - Beginner	-2.250	2.687	0.402
	Intermediate - Beginner	1.250	2.687	0.642
Challenge	Expert - Advanced	0.500	2.981	0.867
	Expert - Beginner	-4.750	2.981	0.111
	Expert - Intermediate	-5.250	2.981	0.078
	Expert - Inexperienced	-5.750	2.981	0.054
	Advanced - Beginner	-4.250	2.981	0.154
	Advanced - Intermediate	-4.750	2.981	0.111
	Advanced - Inexperienced	-5.250	2.981	0.078
	Beginner - Intermediate	-0.500	2.981	0.867
	Beginner - Inexperienced	1.000	2.981	0.737
	Intermediate - Inexperienced	0.500	2.981	0.867
Negative Affect	Advanced - Expert	0.000	2.677	1.000
	Advanced - Beginner	-3.000	2.677	0.262
	Advanced - Intermediate	-3.000	2.677	0.262
	Advanced - Inexperienced	-4.000	2.677	0.135
	Expert - Beginner	-3.000	2.677	0.262
	Expert - Intermediate	-3.000	2.677	0.262
	Expert - Inexperienced	-4.000	2.677	0.135
	Beginner - Inexperienced	1.000	2.677	0.709
	Intermediate - Inexperienced	1.000	2.677	0.709
	Beginner - Intermediate	0.000	2.677	1.000
Positive Affect	Inexperienced - Beginner	-1.750	2.944	0.552
	Inexperienced - Advanced	2.750	2.944	0.350
	Inexperienced - Expert	4.000	2.944	0.174
	Inexperienced - Intermediate	-6.500	2.944	0.027
	Beginner - Advanced	1.000	2.944	0.734
	Beginner - Expert	2.250	2.944	0.445
	Beginner - Intermediate	-4.750	2.944	0.107
	Advanced - Expert	-1.250	2.944	0.671
	Advanced - Intermediate	-3.750	2.944	0.203
	Expert - Intermediate	-2.500	2.944	0.396