Touch gestures and screen orientation in mobile endless runner games

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Abstract

This study investigates the impact of button and slider touch gestures on player performance and user experience in mobile endless runner games, across portrait and landscape screen orientations. Mobile gaming, an important player in the gaming industry, depends heavily on user experience for its success. This research aims to identify optimal touch gestures for different screen orientations to improve game design. A mobile endless runner game was developed and tested with 15 participants. They played the game in portrait and landscape orientation using either button or slider controls. Performance was measured by in-game scores and user experience. Quantitative analyses showed that buttons improved performance over sliders, but both buttons and sliders had no effect on experience. Qualitative findings indicate that orientation has no effect on either performance or experience.

These findings contribute to optimizing mobile game interfaces, particularly in the popular endless runner genre.

Keywords

Mobile gaming, Human computer interaction (HCI), touch gestures, screen orientation

Introduction

Mobile games have become a global form of entertainment, attracting millions of players worldwide. With over 2.7 billion mobile gamers globally [1], the mobile gaming industry is a multi-billion-dollar market primarily driven by smartphones and tablets [2]. They have thereby taken over the gaming industry, capturing 50% of the worldwide market, surpassing console and PC gaming [9].

Their success heavily relies on user experience and satisfaction. Well-designed user interfaces and intuitive controls are crucial for retaining players and fostering engagement [4], as games that fail to meet user

Pre-Study

When developing a game, obtaining user feedback during the development process can be rather beneficial [29]. With that objective, a straightforward, preliminary study was conducted to gain early user feedback. The participants, sampled within social circles, were introduced to the game and asked to test it in a think-out-loud format. Afterwards, follow-up questions about the game's concept, implementation, and design were asked.

The feedback obtained from the pre-study led our research team to an enhanced understanding of how the final evaluation should be conducted. It was determined that a brief introduction to the game was necessary to give new users an idea of the game's purpose, gameplay principles, and controls. It also led to adjustment of the difficulty level of the game, as it was initially perceived as too challenging. Additionally, design ideas were gathered, considering the preliminary version used placeholder graphics. While this was not an extensive pre-study, it supported the ongoing development process and helped us clarify the direction of the game.

expectations often see a decline in popularity and revenue [5].

Endless runner games, such as "Subway Surfers," represent a popular genre characterized by gameplay that requires players to make quick decisions and perform accurate touch gestures to navigate through continuously changing environments [6]. They exist in both landscape and portrait orientations, posing different implications to the design of user interfaces and controls [7]. Also, the choice of control schemes, such as buttons and sliders and their effectiveness can vary significantly depending on the screen orientation [8].

The current study explores how button and slider touch gestures affect player performance and satisfaction in mobile endless runner games across portrait and landscape screen orientations. The goal is to identify optimal touch gestures for these games on different screen orientations, to help enhance player experience and satisfaction in future mobile game development.

Background

One of the biggest challenges of mobile game development lies in the implementation of intuitive, touch gestures, which otherwise are a common source of player confusion [10]. Since user interfaces transitioned to mobile devices, it is common to virtually re-implement physical buttons from gaming consoles [11]. Current mobile game research has underscored the importance of mobile devices and input modes [12], concluding that touch-controlled games are more immersive for players [13]. While progress is made in understanding the impact of mobile game interfaces, there has been minimal success in determining the best placement of input zones, such as gestures or buttons, based on screen orientation [14] which was shown to have an impact on player performance [15].

Player Experience and Performance in Mobile Games

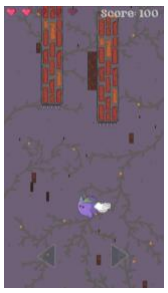
Player satisfaction, often referred to as player experience (PX) [16] and gaming experience (GX) [15], is a player's engagement level [20] concerning emotional and psychological states such as immersion and flow [19][18]. This relationship considers the game's interface components [15] and usability. Flow, often observed in competitive gaming [18], is an optimal psychological state where a player reaches a peak enjoyment based on a game's level of challenge, skills, and progress [19][13][21]. Immersion is the sense of being absorbed in a game while experiencing a loss of perception of real-world activity [22]. Immersion is commonly reported by players, game reviewers, and game designers [22]. The field of gaming has focused on measuring player satisfaction and experience through the lens of flow and other attributes [23]. Both notions play a critical role in player satisfaction [19].

IJsselsteijn et al. developed a framework, the game experience questionnaire (GEQ), to measure players' experience in the form of attributes such as immersion, flow, challenge, and affect (positive and negative) [24]. John Hallora et al. [23] leveraged the GEQ to compare a player's experience based on ease of controls and task completion within three gaming devices: mobile phone, PC, and console and concluded that player satisfaction depends on how the player controls the game [23].

Endless Runner Games

Endless runner games are a subtype of mobile games, often characterized by their continuous forward movement and simplicity in play style [25], relying

Game design



Orientation: Portrait
Controller: Button

Orientation: Landscape
Controller: Slider

Note: both variants of the controller (button and slider) are used for each orientation, but only one variant is shown here for each orientation.

highly on a player's touch gestures and speed; these gestures are commonly swiping or tapping [26].

Although endless runner games have become one of the most popular game types, ranking among the top 10 most downloaded games worldwide for the past decade [27][28], there is minimal research on understanding the relationship between touch gestures and screen orientation and their impact on player satisfaction and performance. This study aims to expand research and apply fundamental player satisfaction and experience notions on an endless runner game, most importantly, to understand how button and slider touch gestures influence gameplay performance and player satisfaction across different screen orientations. This leads to the following research question, with corresponding hypotheses:

***RQ**: "How do button and slider touch gestures affect player performance and experience in mobile games, across portrait and landscape screen orientations?"*

Hypothesis 1a: There will be a significant difference in player performance and experience between the buttons and sliders control methods.
Hypothesis 1b: There will be a significant difference in player performance and satisfaction between the portrait and landscape screen orientations.
Hypothesis 1c: The effect of control methods on performance and experience will differ depending on the screen orientation.

Experiment

Participants. The experiment involved 16 participants, 12 male and 4 female, between the ages of 22 and 27. The participants were mainly masters students recruited through convenience sampling. No exclusion criteria were made, though participants had prior experience with mobile endless runner games.

*Material*s. The experiment utilized a proprietary mobile endless runner game that supported both portrait and landscape orientations and both buttons and slider inputs. The experiment was conducted on an Android smartphone. Additionally, a questionnaire was employed to evaluate user experience and preference post gameplay. User experience was measured using the shortened Game Experience Questionnaire (GEQ) was used [24]. immediately after playing, the GEQ assesses aspects like immersion, flow, competence, tension, challenge, and negative and positive affect on a scale from 0 to 4. The current study opted for the shorter in-game version focusing on the most essential aspects of the gaming experience [24]. Additionally, another brief questionnaire was prompted to gain insight into control preference and overall feedback.

Procedure. First, verbal consent was obtained from participants. Next, participants were randomly assigned to play either button or slider controls. Additionally, the order of orientation was randomized to control for order effects. After instruction, each participant played 5 rounds (until game over) in each orientation. Performance was measured by tracking game score for each round. After the experiment, participants filled out the GEQ for both orientations and were asked open-ended questions on their preference and feedback.

Data Analysis. The independent variables were input method and screen orientation, both discrete with 2 levels. The dependent variables were game score, and user experience, both continuous. Given the study

Results game scores

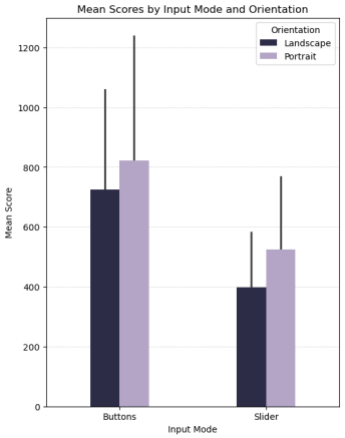


Figure 1: Mean scores by input mode and orientation

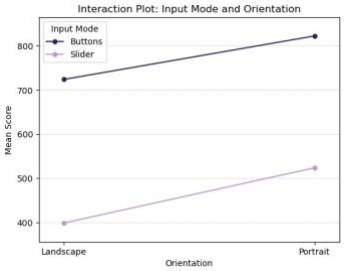


Figure 2: Interaction between input mode and orientation on average game scores.

involves both a within-subjects factor (screen orientation) and a between-subjects factor (input method), a mixed-design ANOVA is most appropriate [31]. This analysis was conducted using the *statsmodels* library in Python 3.10.10. Lastly, user feedback and preferences were analyzed qualitatively using descriptive analysis. This entailed summarization of key points and identifying general patterns [32].

Results

Game Score. Participants using the slider input mode scored significantly lower, by an average of 325.42 points, compared to those using the button input mode. (β = -325.417, P = 0.034). Additionally, participants who used the portrait orientation scored on average, 98.33 points higher than those using the landscape orientation, though this effect was not statistically significant (β = 98.333, P = 0.351). This suggests that orientation alone may not have a substantial impact on game scores. The interaction between input mode and orientation showed that the combined effect of using slider input mode and portrait orientation did not significantly alter the scores either (β = 26.667, P = 0.858). In figure 1, a grouped bar plot is shown, highlighting that mean scores are higher for buttons compared to sliders. Overall scores increase in portrait mode compared to landscape. In figure 2, an interaction plot shows the absence of interaction effect between screen orientation and input method on game scores.

Game Experience Score (GEQ). Participants who used slider input mode had a slightly improved experience score compared to participants who used the button input mode. However, this effect was not statistically significant (β =0.227, P = 0.791). Additionally, participants who used the portrait orientation had a slightly higher satisfaction score compared to using the landscape orientation. Again, this effect was not found to be statistically significant (β = 0.339, P = 0.594). Lastly, the interaction of input mode and screen orientation did not significantly influence user experience (β = -0.258, P = 0.776). Figure 3 the differences in user experience between input methods and screen orientations are displayed. Figure 4 displays the effect of screen orientation on game score differs depending on the usage of buttons or sliders.

Participant Preferences. In the button condition, portrait mode was well-received with most participants, and was found to be more intuitive. In landscape mode, controlling using buttons was found less intuitive. Multiple participants suggested alternatives like sliders, invisible buttons, and tap-to-jump mechanics. One participant in the button condition noted that they could imagine the slider control to be harder, contributing to the enjoyment of the game. Other suggestions included swiping instead of buttons. The slider input was found acceptable in portrait mode, while others noted it was hard to use. In landscape mode, though some participants found it more intuitive, others faced challenges with screen occlusion, likely due to device grip. Suggestions for improvement included tapping/swiping and repositioning the slider to prevent obstructing the view. Additionally, participants desired a longer visible distance ahead of the character for better gameplay.

Results User Experience (GEQ)

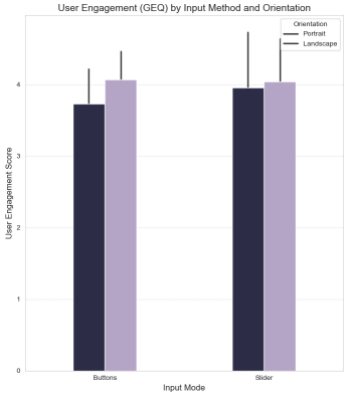


Figure 3: Grouped bar plot. suggesting no significant difference in user experience between input methods and screen orientations.

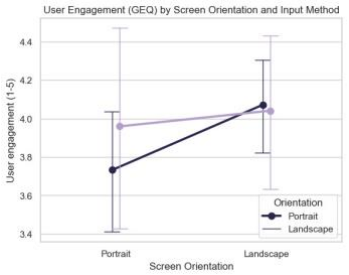


Figure 4: Interaction between input method and orientation on user experience, though non-significant.

Discussion

Our results indicate that the choice of input mode significantly affects player performance in mobile endless runner games, which is consistent with previous research on the usability of controls in mobile games [17]. In our study, the slider input mode was associated with a significant decrease in game performance compared to the button mode, suggesting that buttons are easier to control or more intuitive for endless runner games. Contrary to our hypothesis, screen orientation did not significantly affect player performance or satisfaction, which differs from studies suggesting that orientation affects performance [15]. The effect of orientation is likely highly dependent on the type of game being played, and it is possible that by making the game as similar as possible in both orientations, we may have mitigated the effect of orientation on performance and satisfaction. Player satisfaction remained high across all conditions, indicating a high overall enjoyment of the game. Neither input mode nor screen orientation significantly affected user experience, suggesting that gameplay and design may be more important for overall satisfaction than input mechanics, consistent with IJsselsteijn et al.'s findings on flow and immersion [24].

Limitations and Further Research

The first limitation perhaps explaining the non-significance of the results is the fact that our sample only consisted of 16 participants. More participants would allow for stronger conclusions and improved generalization. Next, one limitation is that our research was not focused on the ergonomic influences on orientation and input preferences. How one holds the device may greatly influence such preferences, which were not considered in the current scope.

Lastly, the current study was predominantly quantitative, possibly overlooking richer insights into user preferences and experiences. For example, one participant noted that more challenging input controls may contribute to enjoyment, a well-established phenomenon in game design. However, this observation was not confirmed by the quantitative results. For this reason, conducting in-depth interviews could provide a better understanding of player experience.

Finally, future research should explore how allowing players to customize their control layouts affects their performance and satisfaction. Also, investigating the impact of different device types (smartphones/tablets) and exploring device-specific features like screen size or touch sensitivity could provide valuable insights into the effectiveness of various control methods. Additionally, exploring other input controls such as swiping or tilt may be interesting avenues.

Conclusion

Our research findings cannot fully support our H1a hypothesis, as results indicate that input modes influence performance but not satisfaction. Thus, H1a is only supported from the performance perspective. However, our results further demonstrated the importance of input method placement [14], as participants perceived portrait mode as more intuitive due to occlusion issues caused by the input mode method in landscape mode.

Our H1b hypothesis is unsupported, as screen orientation does not significantly influence player performance and satisfaction. However, our research highlights the importance of orientation regarding the visibility of gaming assets, as participants emphasized longer visibility for endless runner games. Lastly, the

H1c hypothesis is not supported as the interactions between input mode and orientation did not significantly impact performance or satisfaction.

This study provides insightful data which developers can leverage when creating endless runner games, specifically when choosing input mode methods for respective screen orientations. Possibly our findings can be extended to other contexts where decisions are required on screen orientation or input method, for example scrolling through a document. Our qualitative data suggests that occlusion, visible input modes, and slow response times may be challenges developers should tackle to increase performance and engagement. Furthermore, we recommend developers consider player feedback when creating endless runner games.

References

[1] Number of gamers worldwide by region 2021. Statista. Retrieved June 7, 2024 from https://www.statista.com/statistics/293304/number-video-gamers/

[2] Soh, J. O., & Tan, B. C. (2008). Mobile gaming. Communications of the ACM, 51(3), 35-39.

[3] Kim, J., Lee, S., & Lee, W. (2015). Effects of screen orientation and hand posture on mobile phone usability. International Journal of Human-Computer Studies, 73, 37-47. DOI: 10.1016/j.ijhcs.2014.09.003.

[4] Johnson, D., Gardner, J., & Perry, R. (2013). Validation of two game experience scales: The player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). International Journal of Human-Computer Studies, 71(12), 933-941. DOI: 10.1016/j.ijhcs.2013.04.003.

[5] Amalfitano, D., Riccio, V., Paiva, A. C. R., & Fasolino, A. R. (2018). Why does the orientation change mess up my Android application? From GUI failures to code faults. Software Testing, Verification & Reliability, 28(1), e1654. DOI: 10.1002/stvr.1654.

[6] Bernhaupt, R., Boldt, A., & Mirlacher, T. (2015). Using contextual design to optimize user experience in mobile games. Human-Computer Interaction, 30(6), 491-521. DOI: 10.1080/07370024.2015.1042833.

[7] Seipp, K., & Devlin, K. (2013). Landscape vs portrait mode: which is faster to use on your smartphone? In Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services, 534-539. DOI: 10.1145/2493190.2494422.

[8] dos Santos Nunes, E. P., da Conceição Júnior, V. A., & Lima de Faria Borges, L. C. (2018). Interaction techniques to promote accessibility in games for touchscreen mobile devices: A systematic review. Universal Access in Human-Computer Interaction, 178-191. DOI: 10.1007/978-3-319-92049-8_13.

[9] Tom Wijman. 2023. Newzoo's video games market size estimates and forecasts for 2022. Newzoo. Retrieved June 3, 2024 from https://newzoo.com/resources/blog/the-latest-games-market-size-estimates-and-forecasts

[10] Kevin Browne and Christopher Anand. 2012. An empirical evaluation of user interfaces for a mobile video game. Entertainment Computing 3, 1 (January 2012), 1–10. https://doi.org/10.1016/j.entcom.2011.06.001

[11] Kathrin M. Gerling, Matthias Klauser, and Joerg Niesenhaus. 2011. Measuring the impact of game controllers on player experience in FPS games. In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, September 28, 2011. ACM, Tampere Finland, 83–86. https://doi.org/10.1145/2181037.2181052

[12] John Halloran and Anna Minaeva. 2019. Touch and play? Investigating the value of touchscreens for gamer experience. Entertainment Computing 32, (December 2019), 100312. https://doi.org/10.1016/j.entcom.2019.100312

[13] Matt Thompson, A. Imran Nordin, and Paul Cairns. 2012. Effect of Touch–Screen Size on Game Immersion. 2012. https://doi.org/10.14236/ewic/HCI2012.38

[14] Karsten Seipp and Kate Devlin. 2013. Landscape vs portrait mode: which is faster to use on your smart phone? In Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services, August 27, 2013. ACM, Munich Germany, 534–539. https://doi.org/10.1145/2493190.2494422

[15] Calvillo-Gámez, P. Cairns, A.L. Cox, Assessing the core elements of the gaming experience, in: Regina Bernhaupt, ed. 2015. Game User Experience Evaluation. Springer International Publishing, Cham. pp. 47–71.

[16] Aanders Drachen, L. Nacke, Towards a framework of player experience research, Proceedings of the 2011 Foundations of Digital Games Conference, EPEX 11 Workshop. 2011.

[17] Lawrence Barnett, Carlo Harvey, and Christos Gatzidis. 2018. First Time User Experiences in mobile games: An evaluation of usability. Entertainment Computing 27, (August 2018), 82–88. https://doi.org/10.1016/j.entcom.2018.04.004

[18] Graham McAllister, Gareth R. White, Video Game Development and User Experience, in: Regina Bernhaupt, ed. 2015. Game User Experience Evaluation. Springer International Publishing, Cham. pp. 11–34.

[19] Anna Cox, Paul Cairns, Pari Shah, and Michael Carroll. 2012. Not doing but thinking: the role of challenge in the gaming experience. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, May 05, 2012. ACM, Austin Texas USA, 79–88. https://doi.org/10.1145/2207676.2207689

[20] Jeanne H. Brockmyer, Christine M. Fox, Kathleen A. Curtiss, Evan McBroom, Kimberly M. Burkhart, and Jacquelyn N. Pidruzny. 2009. The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. Journal of Experimental Social Psychology 45, 4 (July 2009), 624–634. https://doi.org/10.1016/j.jesp.2009.02.016

[21] Mihaly Csikszentmihalyi. 2000. FLOW: The Psychology of Optimal Experience. (2000).

[22] Emily Brown and Paul Cairns. 2004. A grounded investigation of game immersion. In CHI '04 Extended Abstracts on Human Factors in Computing Systems, April 24, 2004. ACM, Vienna Austria, 1297–1300. https://doi.org/10.1145/985921.986048

[23] John Halloran and Anna Minaeva. 2019. Touch and play? Investigating the value of touchscreens for gamer experience. Entertainment Computing 32, (December 2019), 100312. https://doi.org/10.1016/j.entcom.2019.100312

[24] IJsselsteijn WA, de Kort YAW, Poels K. The Game Experience Questionnaire. Eindhoven: Technische Universiteit Eindhoven, 2013. 9 p.

[25] Rubem Jose Vasconcelos De Medeiros and Tacio Filipe Vasconcelos De Medeiros. 2014. Procedural Level Balancing in Runner Games. In 2014 Brazilian Symposium on Computer Games and Digital Entertainment, November 2014. IEEE, Porto Alegre, 109–114. https://doi.org/10.1109/SBGAMES.2014.30

[26] Harits Ar Rosyid, Hidayatul Hasanah, M. Iqbal Fathurrozi, and Muhammad Iqbal Akbar. 2019. Block-based Approach to Observe Game Content Space in Endless-runner Game. In 2019 International Conference on Electrical, Electronics and Information Engineering (ICEEIE), October 2019. IEEE, Denpasar, Bali, Indonesia, 273–278. https://doi.org/10.1109/ICEEIE47180.2019.8981422

[27] Mary Meisenzahl. "Subway Surfers" was the most downloaded mobile game of the decade. See the top 10 here. Business Insider. Retrieved June 4, 2024 from

[28] https://www.businessinsider.com/most-downloaded-games-of-decade-subway-surfers-to-fruit-ninja-2019-12

[29] Top Android games by global downloads 2024. Statista. Retrieved June 4, 2024 from https://www.statista.com/statistics/688372/leading-mobile-games-google-play-worldwide-downloads/

[30] Kruachottikul, P., Dumrongvute, P., Teamakorn, P. et al. New product development process and case studies for deep-tech academic research to commercialization. J Innov Entrep 12, 48 (2023). https://doi.org/10.1186/s13731-023-00311-1

[31] McKim, C. A. (2017). The value of mixed methods research: A mixed methods study. *Journal of mixed methods research*, *11*(2), 202-222.

[32] Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & health sciences*, *15*(3), 398-405.

Appendix

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	Score
No. Observations:	32	Method:	REML
No. Groups:	16	Scale:	44396.2034
Min. group size:	2	Log-Likelihood:	-201.9319
Max. group size:	2	Converged:	Yes
Mean group size:	2.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	724.167	108.473	6.676	0.000	511.564	936.769
Input_Mode[T.Slider]	-325.417	153.404	-2.121	0.034	-626.082	-24.751
Orientation[T.Portrait]	98.333	105.352	0.933	0.351	-108.153	304.820
Input_Mode[T.Slider]:Orientation[T.Portrait]	26.667	148.990	0.179	0.858	-265.349	318.682
Group Var	49734.457	182.481				

A: Overview - Results game performance

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	satisfaction
No. Observations:	30	Method:	REML
No. Groups:	2	Scale:	0.3248
Min. group size:	14	Log-Likelihood:	-26.2967
Max. group size:	16	Converged:	Yes
Mean group size:	15.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3.732	0.604	6.175	0.000	2.547	4.917
orientation[T.portrait_satis]	0.339	0.637	0.533	0.594	-0.909	1.588
input[T.Slider]	0.227	0.858	0.265	0.791	-1.455	1.909
orientation[T.portrait_satis]:input[T.Slider]	-0.258	0.907	-0.284	0.776	-2.036	1.521
Group Var	0.325					
Group x orientation[T.portrait_satis] Cov	0.000					
orientation[T.portrait_satis] Var	0.325					

B: Overview - Results User Engagement Ratings