Investigating Osu!: Exploring a Community who Exhibit Extreme Input Performance

by

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AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

STATEMENT OF CONTRIBUTIONS

Thomas Driscoll is the primary author of all chapters which were written under the supervision of Daniel Vogel. Thomas Driscoll was responsible for the study design, data collection, analysis, and write-up. Brandon Lit contributed as a second qualitative coder during the analysis phase of the results presented in Chapter 5.

ABSTRACT

We study "Osu!", a popular fast-paced rhythm game that is developed and organized by a large community. Of particular interest is how it requires very precise movements that push the limits of spatial and temporal precision and that players use a variety of input devices. Interviews were conducted with 20 members of the Osu! community, including top-ranked players, recreational players, as well as game-level designers and event organizers. Additionally, the creator and lead developer was interviewed, providing authoritative insights into the game and community. The results reveal findings about players, mapping practices, adopted strategies, personalized input setups, and community engagement. These provide insights into an under-explored game and players that demonstrate extreme dexterous ability, offering a foundation for future research on input devices and the development of input performance.

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STATEMENT OF POSITIONALITY

This research was conducted by three HCI researchers and an Osu! player and content creator. Most participants were recruited through connections of the Osu! content creator; this facilitated access to and trust with top ranked players as well as the lead developer. All interviews were conducted by the primary author, an HCI researcher with basic knowledge and experience with Osu!. The analysis was conducted by the primary author and another HCI researcher with minimal prior Osu! knowledge.

1

INTRODUCTION

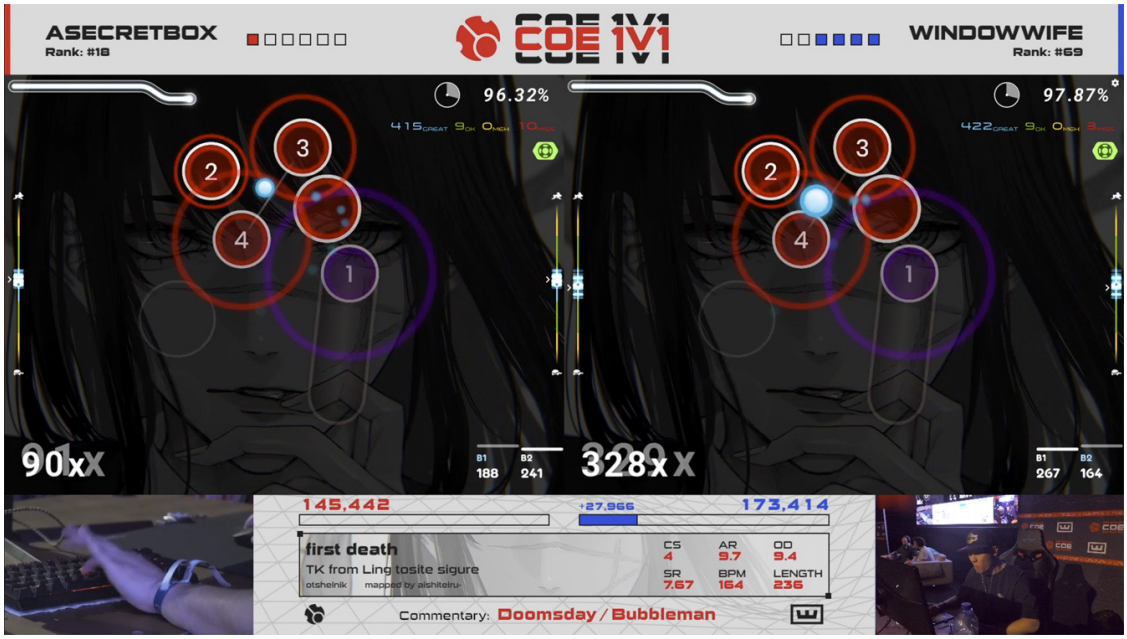


Figure 1.1: Frame from Cavoe's Osu! Event (COE) 2025 tournament stream [7]: two top-ranked players compete head-to-head to click and drag on "hit objects" with very high temporal and spatial precision. Image © COEvent.

Many video games require high levels of input performance. An unusually direct instantiation is Osu!, a rhythm-based game where the player's only goal is to click and drag in time with fast-paced music. From an HCI perspective, these interactions resemble canonical models of human motor performance, such as Fitts' Law [12] and the Steering Law [1]. Studying Osu! players and their community presents a unique opportunity to examine individuals who repeatedly engage in fundamental skilled input tasks for enjoyment.

Osu! is a very community-driven game: it is free to play, all of the levels are made by members of the community, large tournaments and conventions bring players together (Figure 1.1), and the most up to date version of the client is open source. We study Osu! for its culture and most importantly its requirements for extreme input performance, the diversity in input devices used, and its pure focus on fast and precise movement and input.

As far as we are aware, previous work has not explored Osu! in HCI. In psychology, Osu! was studied in relationship to eSports training [16] and attentional function [26], and researchers have used machine learning for Osu! level generation [51]. Previous qualitative work has examined other game communities with a specific focus, such as social interaction [50] or identity representation [46]. To begin investigating Osu! as a naturalistic setting for extreme input performance, we take an exploratory qualitative approach guided by the research question: *What individual and community factors shape players who develop extreme input performance in Osu!?*

We conducted semi-structured interviews with 20 members of the Osu! community as well as the creator and lead developer of the game. This allowed participants to express their thoughts and experiences in ways a controlled study could not capture. Our community participants included top-ranked and recreational players, community members who design game levels ("mappers"), and event organizers. The results reveal insights about the players such as how they learn about Osu! and their motivations for playing, details about mapping and map creation, the strategies they use to improve their input performance, their reasoning behind input device selection, as well as how they participate within the Osu! community.

This thesis contributes an investigation into an under-explored gaming community entirely focused on extreme input performance. Our findings provide valuable insights to inform future HCI research on input devices and the development of input performance.

2

OSU!: AN OVERVIEW

Osu! is a free and popular rhythm game with almost 27 million registered players as of February 2026[1]. It is completely skill-based, requiring a high degree of spatial and temporal precision with no story or objective other than obtaining the highest score possible. This is different than most other rhythm games, such as Guitar Hero, which only require temporal precision. We provide a link to an introductory video describing Osu! and demonstrating gameplay[2]. It was initially developed by Dean *"peppy"* Herbert [55] and released in 2007 with one game mode called *osu!standard* ("Standard"). It has since expanded to contain three more game modes: *osu!taiko* ("Taiko"), *osu!mania* ("Mania"), and *osu!catch* ("Catch").

2.1 GAME MODES

In each game mode, players complete levels known as *beatmaps*. Each beatmap is set to a specific song and contains patterns of "hit objects" which are various kinds of targets. The goal is to click or drag on them in precise timing with the music.

Standard is the most widely played game mode and this thesis' primary focus. The gameplay consists of tracking and precisely interacting with three different types of hit objects, Hit Circles, Sliders, and Spinners (Figure 2.1), all in time with the music as they appear on the screen. A Hit Circle consists of an inner circle and an outer "approach circle" which shrinks towards the inner circle, providing a visual cue for the player to click the inner circle once the two align. The speed that the approach circle shrinks is called the *approach rate* and it adjusts the required temporal accuracy. This is split into 11 distinct levels ranging from 1800ms at the lowest level to 450ms at the highest. As the approach rate level increases, the amount of time a player has to react decreases. The size of all Hit Circles is fixed throughout an individual beatmap play, but varies across beatmaps to adjust required spatial accuracy. A Slider is a Hit Circle at the beginning of an outlined path that can be curved or straight. The player must press-and-hold the Hit Circle while tracking the circle's movement along the path. A Spinner is a large circle requiring the player to press-and-hold while rotating around the center as fast as possible. Using Hougaard and Knoche [23]'s core gameplay tasks, these interactions are a combination of mental and motor tasks under temporal

1 https://osu.ppy.sh/

2 Introductory video: "What is osu? - What's this in 4 Minutes": https://www.youtube.com/watch?v=kVgKGSxx_Ww



Figure 2.1: Osu! Standard hit objects: (a) Hit Circle; (b) Slider; (c) Spinner

constraints. The mental tasks include: *prediction* by anticipating upcoming hit objects through the rhythm; *detection* when locating the next hit object on the screen; and *discrimination* when identifying between hit object types. The motor tasks include: *pointing* by moving the cursor to the next hit object location; and *steering* when tracking a slider through its constrained path.

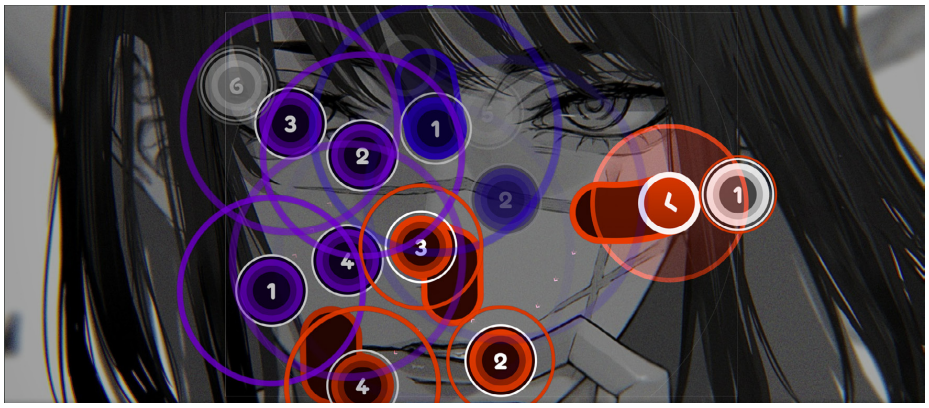
During play, only a small number of upcoming hit objects are visible at any point in time as successfully completed or missed hit objects disappear and new hit objects fade in (Figure 2.2). The hit object types, locations, and hit speeds vary and can be highly complex. Each interaction with a hit object is given a score value of 0, 50, 100, or 300 depending on how close the player's input is to the perfect hit time (with 300 representing a perfect score). The allowable margin of timing error for each score value is scaled by the overall difficulty of the beatmap.

Taiko is a game mode inspired by the Japanese rhythm game series *"Taiko no Tatsujin"*. The player simulates the playing of a taiko drum with four hit object types. A Don is a small or large red circle, a Katsu is a small or large blue circle, a Drumroll is a long note requiring repeated hits, and a Shaker is a circle that requires the player to alternate between Don and Katsu actions until completed.

During gameplay, the hit objects appear from the right side of the screen and move to the left into an action area (Figure 2.3). The goal is to identify the type of hit object and react accordingly by performing the correct action in time with the music once the hit object reaches the action area. Unlike Standard, Taiko is entirely a temporal accuracy and perception task. It does not require the player to manipulate the position of a cursor on the screen but instead interpret and press the correct input key based on the next hit object in the queue. For the same reasons as Standard, the mental gameplay tasks [23] in Taiko consist of prediction, detection, and discrimination. However, the only motor task is activation when pressing a key at the correct time.

The remaining game modes are *Catch* and *Mania*. The goal of Catch is to catch falling hit objects (referred to as "fruits") in time with the beat without letting them hit the ground. The goal of Mania is to press the correct key at the correct time as the hit objects (referred to as "notes")

(a) targets in next 1s sequence



(b) what player sees at start of same sequence

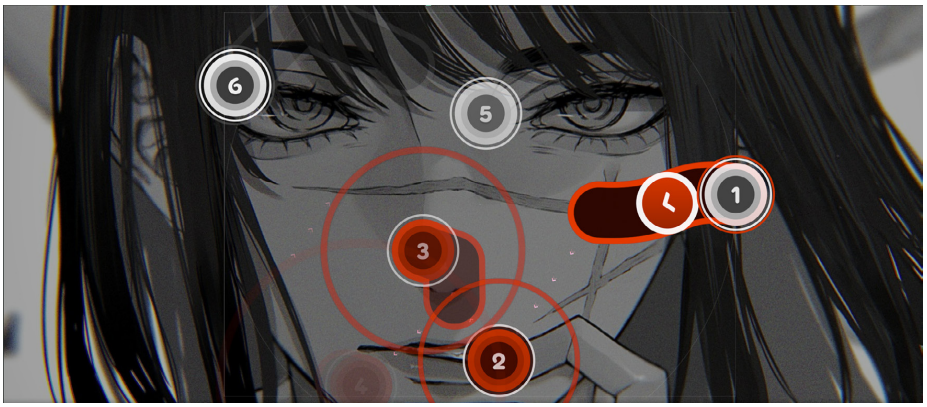


Figure 2.2: Osu! Standard gameplay: (a) the number and placement of hit objects that will be seen over the next second of gameplay; (b) the current state that the player sees. Screenshots from Osu! [19].

proceed down a conveyor, similar to the game Guitar Hero. Only one of our participants discussed them and play them on a regular basis, thus they are not a focus of our study.

2.2 MAPPING

All beatmaps are designed and built by members of the Osu! community, who are known as *Mappers*. Mapping refers to the process of designing and building a playable beatmap using an in-game editor. Mappers skillfully design sequences of hit objects to be played in time with a song. This process is both technical and creative, requiring an understanding of the rhythm as well as beatmap design factors that influence difficulty and flow through hit object type, placement, and timing. Completed beatmaps are shared with the community and can receive nominations from select members to become ranked. Once a beatmap is ranked, players can play it worldwide to compete for leaderboard ranking.

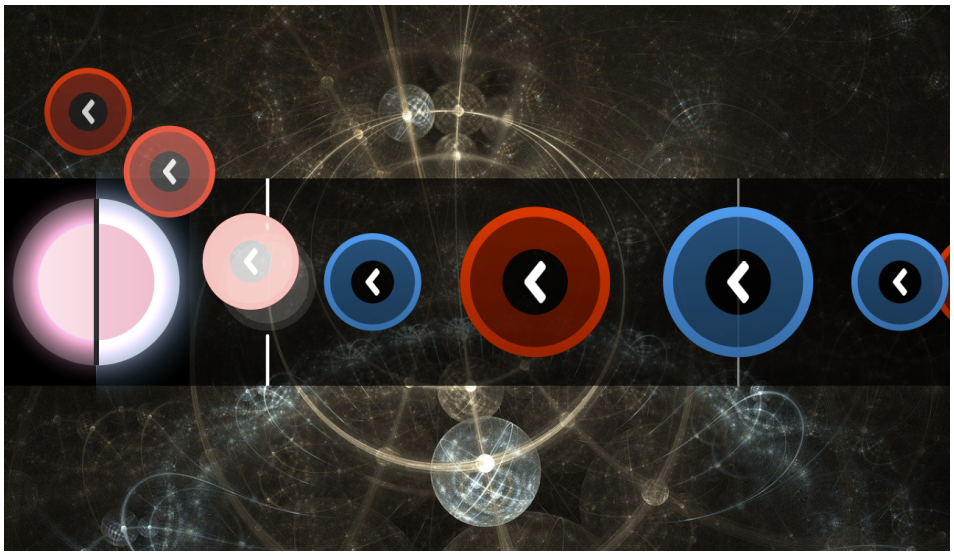


Figure 2.3: Osu! Taiko mode: hit objects scroll right-to-left into an action area. Screenshot from Osu! [19].

2.3 PERFORMANCE POINTS AND COMMUNITY RANKING

Competition is motivated by global, country, and team based leaderboards. Leaderboard rank is determined by the amount of performance points a player has collected (referred to as "pp"). This is an in-game metric to quantify skill [55] that considers the difficulty of the beatmap and the players performance. Scores on the same map are then “weighted” against each other such that only a player’s best scores count towards their overall pp ranking. Only ranked beatmaps provide pp, and the amount of pp a player receives is determined by the difficulty of the beatmap and their performance on an individual play.

There are four main factors that when combined formulate the amount of pp earned from a play: aim, speed, accuracy, and strain. Aim considers the difficulty of consistently moving the cursor quickly and precisely to the correct location to hit consecutive hit objects in a beatmap, with factors such as higher approach rates increasing its difficulty. Aim is not considered in the pp calculation for Taiko and Mania as they do not require cursor manipulation. Speed considers the rate at which elements of a beatmap are presented to the player. Accuracy is a percentage measurement of the number of hit objects that were hit on time during a play. Accuracy is the main factor in determining the player’s performance on an individual play. Strain considers the number of times and the length of time a player is required to complete highly intense sections of a beatmap, such as large jumps between hit objects or streams of hit objects requiring rapid tapping.

Gameplay modifiers (Mods) are optional changes that can be applied to a beatmap, with the goal of increasing the difficulty of the beatmap through affecting the aim, speed, or strain, which in turn increases earned pp. For example, the "hidden mod" removes the approach circles so hit objects fade away before interaction with them. This affects aim and introduces a spatial memory task [23]. The "double time mod" affects speed by increasing the beats per minute (BPM) of the song and rate at which hit objects appear by 1.5x. The "hard rock mod" flips the beatmap on its x-axis, reduces circle size, and increases the approach rate (potentially beyond the standard limit), all affecting aim.

2.4 COMMUNITY

Beyond just gameplay and competitive leaderboard rankings, Osu! has a vibrant community behind it that organizes tournaments, is active on social media, and produces streaming content.

Each year Osu! has many events that bring the community together. For example, the Osu! team [55] (the main developers, designers, and organizers of Osu!), hosts an annual competition called the Osu! World Cup[3] that has national teams compete for prize money and international recognition. There are also many other community events, such as the annual COE (Cavoe's Osu! Event)[4] that brings many community members together for a week to connect and play in a bring-your-own computer area and compete in tournaments (Figure 1.1).

Content creation is also a significant aspect of the Osu! community. Platforms such as YouTube and Twitch feature players showcasing their skills through live streamed gameplay, tutorials, providing tips and advice, and other content related to Osu! culture.

3 https://osu.ppy.sh/wiki/en/Tournaments/OWC
4 https://cavoe.events/

3 RELATED WORK

To our knowledge, Osu! has not been examined in depth from an HCI perspective. A few prior works in other disciplines used Osu! to address very-specific research questions. For example, Hagiwara [16] used Osu! to examine the effectiveness of rhythm games as a training method for eSports athletes, Kihara and Hagiwara [26] examined effects on attentional function, and Wang, Huang, and Li [51] explored machine learning generation of Mania beatmaps. This thesis focuses on gaining a qualitative understanding of Osu! players and their community, establishing the behavioural and social context necessary to inform subsequent research using Osu!-style interactions. In Section 7, we discuss the relationship to models such as Fitts' Law and Steering Law, considering how these might be used to benchmark extreme input performance.

3.1 QUALITATIVE STUDIES WITH PLAYERS OF GAME COMMUNITIES

Previous work has studied game players and their communities using qualitative methods. In particular, using semi-structured interviews to understand topics of meaning such as social experience, identity creation, and motivations. For example, during the Covid-19 pandemic, Tong et al. [50] conducted 25 interviews with *Animal Crossing: New Horizons* players to better understand players' emotional experiences and their social interactions with both other human players and non-player characters. Through interviews with 22 Black players of *The Sims* life simulation game, Smith et al. [46] explored how game modifications can address representational agency. Spors, Buruk, and Hamari [48] asked 16 players how they make sense of representations of nature in games. Using semi-structured interviews in addition to other qualitative methods, Kumari, Deterding, and Freeman [28] investigated how uncertainty motivates players to continue playing. Lei et al. [31] investigated social supports among players of the stigmatized Chinese otome game *Mr. Love: Queen's Choice*, a romance game where players control a female protagonist pursuing multiple male love interests. Rapp [42] interviewed and observed *World of Warcraft* players to explore how they assimilate into online groups and how specific game design elements support their integration.

Semi-structured interviews have also been employed to study professional and dedicated enthusiast game communities. For instance, Lee et al. [30] interviewed five professional *League of Legends* players to gain a better understanding of expert input. Kleinman et al. [27] conducted interviews with 14 competitive eSports players to examine how co-regulated learning

practices manifest in this community. While not explicitly game players, Wohn [53] conducted 20 semi-structured interviews with Twitch [17, 25] moderators to understand pathways into the role, styles, and challenges.

Like these previous works, we use semi-structured interviews to study players and their community, to reveal important social and behavioural details that performance studies could not capture. Similar to some previous studies, we focus on top players and dedicated members of the community. While most of these previous works have focused on specific topics within their group of interest, such as interaction dynamics, representation, or social supports, our objective is to gain a broad and more holistic understanding to establish a solid foundation for future work.

3.2 PLAYER CREATED CONTENT AND COMMUNITY

User-generated content (UGC) can impact player motivation and community building. UGC is content of any form that is developed by an individual rather than a professional [11, 35] and in the context of video games, Duan, Liu, and Cai [11] argue there are two categories, changing gameplay and changing resource files.

Modding is a type of UGC with many forms, such as content creation, level creation, and even hardware alteration [44, 45]. For instance, Smith et al. [46] looked at the types of content mods used by Black sims players to express agency and correct systemic omissions and Zand Miralvand et al. [54] developed a GenAI system to allow for players of any modding skill to make new non-player characters. Hicks, Cateté, and Barnes [20] and Hicks, Liu, and Eagle [21] investigated how to filter out low-quality user-generated levels, as well as how level-editors impact the quality of the UGC. However, these focus on modding from a software and gameplay perspective, not level modders or physcial environment setup and input device modifications. We examine Osu! modding through beatmap creation as well as how players configure and modify their input devices and physical setup.

Prior work has also investigated motivations for modding and how it can increase community engagement. Postigo [40] interviewed modders across a variety of games finding they consider it an artistic and creative endeavour, it allows them to identify with the game which increases enjoyment, and their experience may lead to job opportunities. Sotamaa [47] extended this by studying modders in the game *Operation Flash Point* in more depth and detail, and found similar motivations such as artistic expression and increasing enjoyment through the implementation of their own ideas, as well as the importance of cooperation and community among modders. Beyond individuals, prior work has shown that modding can foster community engagement [39] and prolong the life of games through dedicated modding communities [52].

Osu! and its community is sustained by UGC through open-source contributions to the game itself, as well as beatmap creation for game content. Even further, the community further engages with this UGC through gameplay and external game contributions such as media creation and competitive events.

4 METHOD

We conducted semi-structured interviews with 20 members of the Osu! community. This study was designed to be exploratory in nature to gain a holistic understanding of an Osu! player. Guided by our exploratory research question, the interview guide (Appendix A) was designed around four primary question categories that capture insights into the Osu! player experience: (1) About the Player; (2) Strategies and Subjective Ability; (3) About their Input Devices and Setup; and (4) Involvement in the Osu! Community and Gaming World. In addition, the creator and lead developer of Osu!, Dean *"peppy"* Herbert, was interviewed to provide additional insights. All participants signed a consent form and the research protocol was approved by our REB, including Herbert's explicit permission to have their identity revealed in this thesis.

4.1 PARTICIPANT RECRUITMENT

Convenience and snowball sampling were used to recruit participants. An initial set of participants were recruited by an Osu! player and content creator working with the research team. These, and subsequent participants, proceeded to suggest other members of the community to also take part in the study. In total, eleven interviews were conducted online via Zoom, and nine interviews were conducted in-person at COE 2025 in the Netherlands, a large community Osu! event. All interviews were audio recorded and transcribed for analysis.

4.2 PARTICIPANTS

The 20 community member participants were relatively diverse in age for a gaming community, ranging from 18 to 29. They mostly identified as men with two participants identifying as women. They included elite players, serious recreational players, mappers, content creators, and event organizers. Table 4.1 summarizes participants by global leaderboard rank (in their self-identified primary Osu! game mode), frequency of play, and preferred input device(s). Note that 6 are ranked in the top 100 (5 of which primarily play Standard), and 9 out of 20 are in the top 5000 in their respective game modes. This is a very elite group considering there are almost 27 million registered players, enabling us to gain insights from some of the best players in the world.

Table 4.1: Participant details: 'Frequency' is the player's play frequency per week; 'Input Device(s)' is the preferred set of input devices used by the player; 'Primary Mode' is the primary Osu! game mode the participant plays; 'Rank' indicates the participant's performance tier (Top 100, Top 5000, etc.).

Participant	Age	Gender	Frequency	Input Device(s)	Primary Mode	Rank
P1	29	Man	5+	Mouse + Keyboard	Standard	Top 50k
P2	21	Man	2 - 4	Tablet + Keyboard	Standard	Top 100
P3	25	Man	<1	Tablet + Keyboard	Standard	Top 10k
P4	23	Man	5+	Tablet + Keyboard	Standard	Top 50k
P5	28	Man	2 - 4	Tablet + Keyboard	Standard	Top 10k
P6	24	Woman	2 - 4	Tablet + Keyboard	Standard	Top 100
P7	18	Man	2 - 4	Tablet/Mouse + Keyboard	Standard	Top 100
P8	20	Man	5+	Tablet + Keyboard	Standard	Top 10k
P9	20	Man	5+	Keyboard	Taiko	Top 10k
P10	25	Man	2 - 4	Keyboard	Taiko	Top 10k
P11	19	Woman	5+	Keyboard	Taiko	Top 10k
P12	21	Man	5+	Mouse + Keyboard	Standard	Top 100
P13	21	Man	5+	Tablet + Keyboard	Standard	Top 50k
P14	20	Man	5+	Mouse + Keyboard	Standard	Top 150k
P15	21	Man	2 - 4	Mouse + Keyboard	Standard	Top 10k
P16	21	Man	5+	Mouse + Keyboard	All	Top 100‡
P17	20	Man	2 - 4	Mouse + Keyboard	Standard	Top 100
P18	21	Man	2 - 4	Tablet + Keyboard	Standard	Top 5k
P19	22	Man	1	Tablet + Keyboard	Standard	Top 5k
P20	20	Man	5+	Tablet + Keyboard	Standard	Top 500

‡Participant 16 plays all game modes and is Top 100 in Catch

4.3 ANALYSIS METHOD

Data analysis was based on the six-phase reflexive thematic analysis method outlined by Braun and Clarke [3, 4]. The analysis process began with two HCI researchers assigning preliminary codes to four of the 20 interviews individually. At multiple points throughout the initial coding, they came together to discuss and refine codes as well as to formulate initial themes. A codebook was then formed to guide the remainder of the coding process. This was a collaborative and iterative process, where the coders had discussions and debates around seeking understanding and agreement on subjective participant meaning. As such, an inter-rater reliability score was not calculated as recommended by Braun and Clarke [4] and common practice in HCI [34]. The two coders then proceeded to split up the remainder of the transcripts and code them individually. At any point, if either of the coders found new codes that did not fit within

the current codebook, they came together to discuss and refine the codes and codebook.

The analysis of the lead developer interview was conducted by the primary author. The process was to review the transcript and identify points and statements that correlated with the codes and themes identified from the analysis of the 20 participant interviews as well as interesting insights that only they could provide. Interesting points about Osu! and its potential in relation to HCI research were also identified for discussion.

5 RESULTS

The transcript analysis revealed five themes: *About the Player*, *Mapping*, *Strategies*, *Setup*, and *Community*.

5.1 ABOUT THE PLAYER

This theme focuses on player experience, preferences, and perceived challenges in discovering, learning, and playing Osu! (Table 5.1).

Table 5.1: Sub-themes (bolded) and codes about the interviewed players themselves

Code	*Description*
Avenues of Discovery	Methods of being introduced to Osu!
Algorithmic Discovery	Digital or Automated recommendations
Human Oriented Discovery	Human recommendations (e.g. friends, streamers, etc.)
Motivation	Application behaviour after execution
Likes Challenge	When a player is motivated by difficulty
External Motivation/Validation	Unique external motivation to individual
Internal Motivation/Validation	Unique internal motivation to individual
Enjoyment from Music	If they are motivated by the music used in a beatmap
Recognized Mapping Experience	Mapper motivations when their work is recognized
Game genre preference	Enjoyment of rhythm based games/genres/formats
Game Skills	All visual aspects before, during, and after running the application
Technical Skill/Skill set	The players skill ability in the game (eg. main skill set is stream maps)
Music preference influences skill set	If the type of music used in maps affects the skill training maps a player plays
Dexterity based skill	References to any dexterity skills used within the game
Perception/Interpretation based skill	References to any perception or interpretation skills within the game
Miscellaneous	Additional codes that could not be grouped
Mindset	The mindset of the player and how they approach all aspects of Osu!
Skill Translation/Skill Transference	Osu! skills that can be applied to other games or scenarios
Competitive Background	Anything to do with the player competing in tournaments or leaderboard position
Understanding via Game Play/Experience	Understanding the game or a skill better from playing/experience with the game

5.1.1 *Avenues of Discovery*

Osu! players learn about, discover, and get into Osu! in a variety of ways. We found that most players discovered Osu! through human oriented avenues, such as recommendations from friends *"I wasn't able to spend money for games at the time, but my friend introduced me to [Osu!] and said that it's free."* [P13], a streamer they watched play the game, or from seeing a stranger play at school *"I saw someone playing [Osu! Tatakae! Ouendan] in elementary ... when I went to high school, I saw someone playing Osu! ... so I was like, what is this game?"* [P6]. P1 and P9 also noted that they initially got into Osu! from recommendations that they play between matches of other games due to the short nature of Osu! beatmaps compared to the long queue times of other games, *"League of Legends players would play Osu! in between their competitive matches, because it's like a long time to queue up between everything and Osu! is like really quick. You can play in 2 minutes and be done"* [P1]. An alternate method of discovery was algorithmic avenues. These were more narrow and included pathways such as a YouTube recommendations *"I've seen random YouTube videos about rhythm games. ... And yeah, I've seen videos of Osu!, ... okay, I really want to try that"* [P16], discovering an iOS version of the game on the app store, or rediscovering the game through an easter egg *"there was a game that had two Osu! mascots as easter eggs, and I found out about that, and I got into Osu! again"* [P7].

Overall, players discover Osu! through a variety of methods that include relying on peer validation and social trust, using it as a filler activity between matches in other games, as well as serendipitous discovery through recommendation systems or easter eggs in other games.

5.1.2 *Motivation*

Participants described staying motivated as one of the biggest challenges in Osu!. *Internal motivation* was a very common topic that came up in various forms. P2 said that *"the most challenging part would be being able to motivate myself to kind of practice and grind every day"* and P19 said that *"It's hard to want to keep grinding when the number one player is, like, LeBron James, and everyone else is, like, pick up basketball, like, on the street"*. These suggest that staying motivated can be difficult when improvement requires consistent long-term effort and goals seem unattainable. On the opposite side, Osu! players also rely on *external motivation* to achieve their goals. This can come in multiple forms such as achieving a high rank on the leaderboards by *"playing ... highly optimized maps for gaining ranks, which kind of made it a lot easier than it was in the past to rank up"* [P18]. External motivation can also come from social factors such as generating online views, which can influence things like the input devices they use. P15 explained *"the reason I'm a mouse player ... is content. It's cooler, people think 'oh my god, his aim's insane' if I use a mouse."*

Enjoyment of the music is another significant motivator when it comes to players wanting to play Osu!. Participants described how music is integral to the gameplay experience and that the game would not be fun without the it, suggesting that enjoyment of the game is closely tied to enjoyment of the music: *"I cannot imagine playing the game without music ... First off it makes the game way less fun because it's like a big part of the game is listening to music"* [P1]. Some participants also mentioned that they only play songs they like: *"If I don't like the music, then I won't play it"* [P10] and *"I just scroll through the song select for like 30 minutes until I find a song which I like to play"* [P16], showing how personal music preferences influence a player's motivation to seek out specific songs and beatmaps.

Osu! players also describe liking challenge, P2 said *"I like the idea of challenging games"* and P13 said *"I like to play maps that challenge my aim in all sorts of ways"*. When P9 first started play Taiko, they *"had no clue what was going on ... If you don't know what's going on, it looks it looks impossible so I just tried it"*. This highlights how challenge itself can be motivating, and that players get satisfaction from attempting to overcome tasks that initially appear to be beyond their capabilities.

Mappers have their own set of special motivations in order to be recognized for their mapping experience. Both P1 and P8 have been recognized for their maps and have had great opportunities due to their experience: *"when I was making maps early on, I was a lot more in the mindset of trying to I guess you could say make popular maps that would like receive a lot of attention in terms of play, count and whatnot"* [P1], and *"I've definitely gotten my rise in the mapping scene, and I've even been able to interact with some of the most influential and talented people this game has to offer, and I could not be more grateful for that"* [P8]. Mapping is motivated by more than being a creative outlet alone but also as a means of building social connections and reputation in the community.

5.1.3 *Mindset*

Many participants said that maintaining a positive attitude while playing is extremely important to be successful. They described how getting frustrated leads to entering a "rabbit hole" which leads to more frustration, creating a negative feedback loop where performance declines as emotional control is lost. For instance, P17 explained *"when I get frustrated, my mental state ... it makes it so much harder to come back from. ... if you're not enjoying it, there's really no point in playing"*, showing how emotional state directly impacts game performance. This suggests that performing well in Osu! is not just about technical skill, but also tied to emotional regulation. Participants also noted it is important to maintain a good mentality because, as P6 explained *"it's literally just you and the tablet and the computer"*. Successful play depends on a player's ability to regulate

their own emotions and maintain a level-headed and positive attitude, as there are no teammates or external supports to offset negative emotions.

5.1.4 *Game Skills*

We identified three different skill categories: dexterity, perception, and game skills. Dexterity-based skills were highlighted in the physical movement that participants were required to do in order to complete beatmaps: *"skill-wise the hardest part of the game for me would have to be tapping, like it's a lot easier to aim and to read maps. But to make your fingers physically move quicker is like really tough"* [P15]. Perception-based skills were focused around how participants were able to read a beatmap such as: *"I have always been very rhythm based. And I would always like predict what the music was gonna do or what the map was gonna do based on the music"* [P3]. Finally, game skills are focused around Osu! specific abilities such as streams, jumps, or high complexity: *"there's this kind of subgenre of maps called tech maps, which is like, very slider focused ... tech meaning like technical. So it's like, it's just mechanically complex as it can get"* [P1]. Some participants were surprised by the depth and breadth of required skills to play Osu! when they first started: *"I guess maybe it's being unaware of different skill sets that I could have practiced a lot earlier on"* [P2]. Together, this suggests that becoming skilled in Osu! requires improving in all three distinct but interrelated skills. Without these, a player lacks the ability to perform on high difficulty beatmaps.

5.1.5 *Skill Translation and Transference*

The majority of participants outright rejected the notion that their skills in Osu! directly translate to other video games. This is despite the once-common belief that Osu! could be used as an aim trainer for tactical first-person shooter games such as Valorant or Counter-Strike, *"back in the day, a lot of people would start playing Osu!, because people, would think it's, like, an aim trainer"* [P18]. Multiple participants outlined the differences between 2D and 3D aim for it to be effective. While both 2D and 3D aim require precise pointing, they differ in their spatial and perceptual demands. 2D aim occurs on a fixed plane, while 3D aim additionally requires depth perception and the interpretation of targets in 3D space. A few participants did claim that Osu! skills could potentially transfer in less direct ways, such as the mechanics of manipulating an input device: *"with stuff like Valorant, where it's very mechanics [-based] ... I feel like after learning mouse on Osu! I was a lot better at that as well"* [P12]; and *"You can get more mastery over a mouse by playing Osu! and have more APM (Actions Per Minute)"* [P19]. One skill Osu! was positively identified in assisting in was musical understanding and comprehension: *"I have really good rhythmic ability. I do compose music*

sometimes, and Osu! has definitely helped in that" [P4]; *"I personally play piano as well. And I feel like Taiko has helped me a lot more with piano than the other way around"* [P9]; and *"It did actually help my sense of rhythm in general, and that also helped me like in at school, in music classes"* [P16]. Skill translation and transference in Osu! is highly contentious, participants rejected a one-to-one transfer of skills to other games, yet identified possible transfer of indirect skills like input device manipulation or rhythmic understanding.

5.2 MAPPING

This theme captures game level design practices, known as "mapping". This includes music influences, creative expression, and potential for designing to develop specific input skills (Table 5.2).

Table 5.2: Sub-themes (bolded) and codes about creating beatmaps

Code	*Description*
Map Creation	Ideas behind creating beatmaps
Music style/genre influences map design/type	Mapping for a specific song or music genre
Mapping for movement	Map design considering movement to navigate game objects
Mapping for skill development/practice	Creating or editing maps to practice or develop skills
About The Mapper	Information regarding the person making beatmaps
Creative expression	Discussing personal expressions on how to implement map
Game experience inspires mapping	The experience of a mapper affecting the beatmap

5.2.1 *Map Creation*

The style or genre of music has a big impact on beatmap design. The rhythms, beats, and speed of a song influence the types of maps created with it, such as jump maps or stream maps (Figure 5.1b, d). P2 said that "*over time, certain music genres started creating styles that mappers would kind of implement. ... electronic music would have a certain connotation ... certain song styles will generally make certain maps, you know, like a very simple song of rock anime intro would probably make a good jump map, whereas an electronic song with a lot of polyrhythm or a lot of more strange sounds would lead to maps with crazy sliders or rhythms"* and P20 described representing a song accurately with a beatmap: *"a heavy metal, like, power metal kind of song, so I tried to represent it in a way that's, like I guess goes along with the song"*. Mapping is more than just level design, it is also a form of translating audio into a visual representation that can be interacted with and experienced.

It is also important for map makers to consider the movements that players will be required to perform when playing a beatmap. P4 describes that patterns that follow circular flow are easier than ones that don't: *"we*

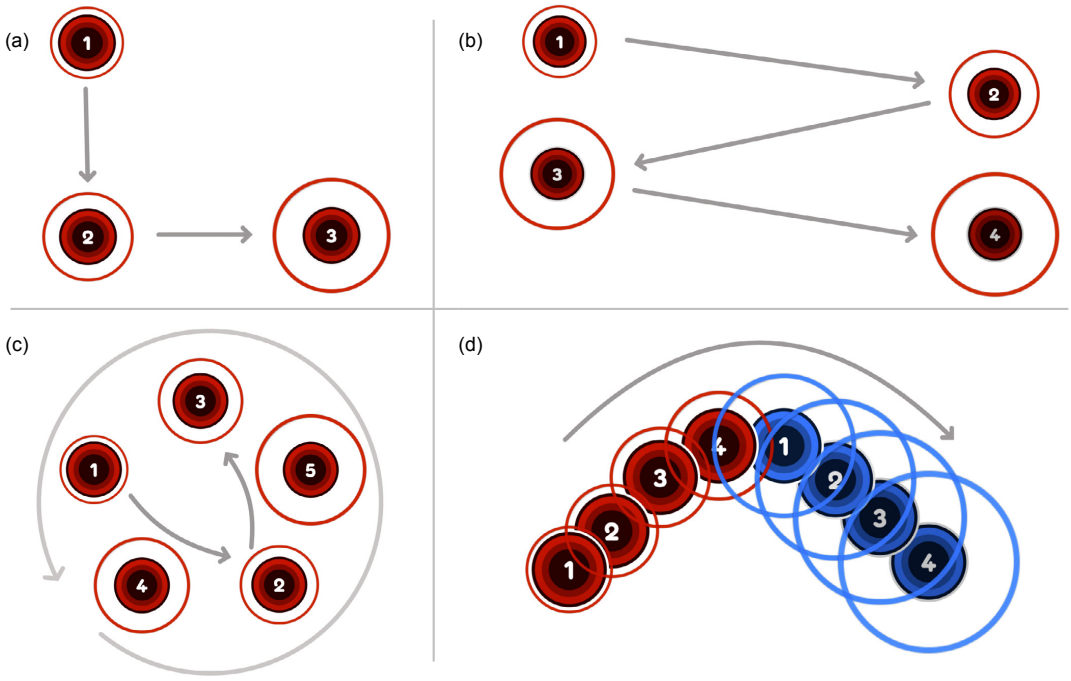


Figure 5.1: Illustrations of selected mapping sub-patterns: (a) triangle with 90-degree change in direction; (b) large jumps between hit objects; (c) circular flow where cursor momentum is counter-clockwise; (d) stream of hit objects.

have a sort of natural tendency, ... to move in circles, so patterns that follow circular flow are inherently easier than patterns that don't, and map design often incorporates this". This ease was attributed to the preservation of cursor momentum through smooth, continuous movement (Figure 5.1c), while patterns that require abrupt changes in direction and a complete shift in directional momentum interrupt this flow and increase difficulty (Figure 5.1a). When designing a new beatmap and thinking about the patterns and movements the player will do P8 says they *"think of something on paper, and if I want to like test that skill more, I guess I can like nerf it or buff it to like the exact specifications I need in order for that to happen"*, meaning they can tweak the difficulty to match what they have in mind. P1 describes how over time the movements required by players have become more intense and the spacing between objects has gotten bigger *"It's like jump maps and stream maps have sort of–imagine that you can just scale things up. Things have just physically scaled up in terms of spacing between objects"*. As player skill has improved over time, beatmap design has evolved to meet the demand for increasingly challenging gameplay.

Creating and using maps for skill development and practice is another aspect of map creation. Maps can be edited to test skills: *"if I have a map that I like, but I think it's too easy ... I can make it faster, I can make the approach*

rate higher ... maps that I'm good at, I'll speed up and see if I can play them even faster" [P6]. Players also make maps specifically to practice a skill they are not good at: *"Only mapping I've done is really for like to make something I'm bad at just to practice it"* [P9]. They can purposely be made long and over time accelerate to challenge players: *"one of the first maps I ever downloaded was like this death stream compilation. It's like 12 min of you start out at 120 bpm streams, and there's nothing to the map, it's just literally xz, xz, etc..., for like a minute at one bpm, and then it goes to a new song, which is like 130 bpm, and ends at like 200 something bpm"* [P1]. Beatmap creation goes beyond just making fun levels to play, but they also can form deliberate and challenging training systems that allow players to push their limits in a specific skillset.

Map creation is an important aspect of Osu! as the game revolves around community-created beatmaps. There are multiple factors that go into beatmaps such as how the style of the music influences the design, player capabilities and movement, and what the objective of the beatmap is.

5.2.2 *About the Mapper*

Due to the importance of map creation, mappers are one of the driving forces behind Osu!, without them there would not be a game to play. Mappers have full creative freedom and many find that making beatmaps allows them to express themselves based on their interpretation of a song. P6 outlines this by saying *"each map is made by a specific mapper, and they have their own styles"* and P7 reaffirms this with *"in terms of mapping, a song can be mapped in several different skill sets. It just depends on how you execute it and what the vision you have"*. P7 continues and says they want *"players to feel certain impacts that songs have, like if there's like a really strong part of the song, I want players to feel that. And so I take that into consideration a lot"*. P1 tells us that when they are making a beatmap, they repeatedly test it and ask themselves *"'does this feel how I'd want it to feel?', both in terms of representing the song and also gameplay-wise"*.

Understanding the game and having experience playing it is critical for mappers to make sure their beatmaps are cohesive and enjoyable to play. *"They haven't played the game as much as I have or they just want to create something else which which is completely fine. There's nothing wrong with that. Everyone has their own reasons for creating. It's just the reasons I have for creating is making maps that I would enjoy, and also other players like me would enjoy, that's my priority"* [P8].

Mappers operate as both creative interpreters of the music as well as designers of embodied player experience. They require an in depth understanding of how different patterns translate into physical movements, including how timing, strain, and directional changes are experienced during play. In addition, they need to understand how these movements

align with the rhythm of the song, otherwise the beatmap will not feel "correct" to play.

5.3 STRATEGIES

This theme surfaces different strategies to improve performance, including warmup routines, regular practice, external physical factors, and post-game gameplay analysis (Table 5.3).

Table 5.3: Sub-themes (bolded) and codes about techniques used to play Osu!

Code	*Description*
Physical Strategies	Techniques used outside of Osu!
Warmup	Warming up hands for a play session
External Physical Factors	Factors outside of Osu! that influence performance
Regular Practice	Consistently playing osu! to improve or prepare for an event
Gameplay Strategies	Techniques used for the game and gameplay
Increase Play Time	Increasing the amount of play time to improve
Software Tools	Any tool used external to osu! to help players in some form
Gameplay Analysis	Used if a player directly mentions reviewing gameplay to improve
Game Skins	Customizing the appearance of the game to improve gameplay

5.3.1 *Physical Strategies*

Multiple participants including [P1, P3, P9, P11, P16, P18] described a variety of external physical factors that affect their performance in-game. These factors include sweaty hands affecting grip and tendinitis: *"I got tendinitis in specifically my left arm, which is the one that's doing the tapping. I wasn't able to play Osu! for a bit, because it just really hurt those muscles"* [P1], cold hands [P3], prior wrist issues [P9], weak forearms: *"my forearms are the the main muscle I use for playing and they're not that strong"* [P11], left hand is weaker [P16], and straining and hurting their wrists [P18].

Some of these external factors are actively combated by partaking in a warmup routine. Many participants described taking part in some form of warmup, whether it involved stretching, playing specific beatmaps, or both. P1 discussed how they stretch their hand to limit pain from their tendinitis: *"I like to stretch my hands ... makes it so the pain doesn't come up"*. Other participants also discussed stretching and there were multiple mentions of a specific YouTube video titled "Hand Exercises for Gamers"[1]. Some of the participants jump straight into the game for their warmup and play a specific set of maps to get ready for their main session or just play

1 "Hand Exercises for Gamers" by Tykato Fitness video: `https://www.youtube.com/watch?v=H6y0D_8kRoU`

some songs for fun, like P12: *"I'll always like warm up with the same maps every time I play"* or P3: *"I just started playing the songs and maps I enjoyed. And then during the session, I would feel more what I was capable of during that session"*. Warmup routines serve not only as performance preparation at the start of the session, but also as a way to reduce the risk of hand injuries which are detrimental for Osu! play.

Regular practice was another important factor discovered during analysis. This included both general practice to improve at the game, but also practising the set of maps for a tournament. P9 describes practising to improve over long periods of time: *"playing things that are like right outside of your comfort zone ... like I played 200 bpm streams for like half a year, my accuracy improved, but I didn't really improve that much. And recently I've been playing like higher bpms more and more, and I'm actually improving"*. This illustrates the importance of consistent practice on beatmaps that are just beyond a player's current capabilities, supporting skill improvement through incremental challenge. For tournament practice, P6 said *"They give you the map pool a week in advance ... I'll play the entire pool once ... if there's a map that I think I'm really good at, I won't play it until the match. I don't want to overplay it in my mind. I don't want to get bad habits. If there's something I think I can improve, I'll play it a couple more times before the match"*. This shows how the objective of the practice can alter practice strategies. In this instance P6 avoids beatmap repetition when possible to prevent the development of bad habits.

5.3.2 *Gameplay Strategies*

Players described a variety of strategies they use for improving, including increasing playtime, using software practice tools, replay analysis, and using different game skins. It was noted that it is a meme in the Osu! community that the best way to improve is to play more, *"a lot of it is just play more, which is something that you've probably heard a couple of times, play more is like the meme in the community"* [P16]. Playing more is more than just a meme, it implies that the community finds volume of play to be one of the best tools for improvement in Osu!. Software tools such as McOsu[2] provide specialized features to practice a beatmap such as the ability to override approach rate or circle size, and makes it *"easy to make ... slowed-down versions of songs to ... practice"* [P18]. Some players perform replay analysis in order to review and correct their mistakes in future plays like P10: *"because I use the full alt technique, sometimes I need to make sure that I actually do the full technique. So I record my inputs, and then I can see like, oh, this is correctly full alt'd, or this is incorrect"*. There are also players that use specific game skins, which are visual changes to how hit objects look without changing gameplay, to help with differentiating between hit

2 https://store.steampowered.com/app/607260/McOsu/

objects. For example, P4 uses a skin with Kanji numbers instead of the default Arabic numerals to make it easier to visually parse layered hit objects: *"they're more different from each other than Arabic numerals are so ... for stacks, they're more easily differentiated"*.

Overall, strategies for play and improvement go beyond just playing more. They include the use of specialized practice environments, identifying and correcting mistakes through replay analysis, and improving perception ability through game skin alteration.

5.4 SETUP

This theme examines participants' gameplay setup, including general preferences, input device features and positioning, physical and software customization, novel input techniques, and motivations for changing or updating devices (Table 5.4).

Table 5.4: Sub-themes (bolded) and codes about the physical and digital setup players have to play Osu!

Code	*Description*
Input Device	Information related to input devices
Input device physical customization	Physical customizations done to augment their input device
Input device configuration	Digital customizations done to configure their input device
Novel input strategies	Input strategies that are not commonly used within the community
Input device features	Specific aspects of the input devices used by players
Input device preference	The input devices that a player prefers to use within and outside of osu!
Absolute positioning	One to one movement between input device and cursor
Relative positioning	Movement based on displacement instead of absolute coordinates
Setup Changes	Changes to the players physical Osu! setup
Reasons to change/update setup	Reasons behind altering the gameplay setup used for Osu!
Device wear and tear	Physical degradation of input devices used to play Osu!
Physical and General Setup Preferences	Any discussion about the setup of non-input devices

5.4.1 *Input Device*

Input devices are central to what makes Osu! so interesting. We focus on Standard mode where the main two input devices for aiming are a drawing tablet with a pen (Figure 5.2b, c, d), or a mouse (Figure 5.2a). In either case, the main clicking device is a keyboard. One of the main reasons a drawing tablet is used is because it enables absolute positioning, where each specific point on the tablet maps to an exact point on the display: *"tablet is the main one, just because absolute input"* [P1]. In contrast, the mouse uses relative positioning, where the display position is based on movement direction and distance. This introduces an issue called "mouse

drift": *"you flick your mouse to some point on your mouse pad, it's gonna be different on your monitor every time"* [P18]. This means that the player can run out of mousepad space, requiring continuous mouse position awareness and potential repositioning during play. In Taiko, players only click the right key at the correct time so input requirements are different: *"for Taiko ... it's advantageous to have a keyboard with less travel distance"* [P9]. Players press keys so quickly that reducing how far the key travels to trigger an event minimizes finger movement to increase speed and stamina during play. A specific keyboard model, the *BFKB113PBK* featuring low travel and a quick return scissor-switch mechanism is so common that it is known as the *Taiko keyboard*.

Players customize their input devices in a variety of ways. A popular keyboard brand in the Osu! community is called "Wooting", it is popular because of a feature called "rapid trigger" which allows the key actuation depth to be configured by the user, for example, P16 configures it to be very shallow: *"with rapid trigger on and actuation point set to 0.4 or something like that, like very low actuation point"*. Beyond software level configurations, players make physical customizations to their devices as well, such as the addition of a grip to a pen, or the addition of a paper folder to a tablet to add friction: *"I have this massive blue square. This is actually a–it's a piece of ... those paper folders in like office supply stores. I kind of cut out a piece from this and just use it as a cover ... because it has a nice balance of friction"* [P2] (Figure 5.2b).

There are also a lot of novel input devices that people use for fun. Some of these include tapping with foot pedals, double mouse, touch screen, or a "mablet" according to P3: *"I know a guy who try who tried a mablet, they call it. They drill a hole inside of a mouse, and then put a tablet pen in it and then they play with the mouse on top of the tablets to have that absolute input. You don't have to hold a pen. You hold the mouse"*. This shows how the Osu! community likes to push the limits with input devices and experiment with fun and potentially viable ways to play the game.

Overall, input devices are an extremely important aspect of Osu! and players like to select, optimize, and craft them to create an input setup suited to their individual preferences for optimal performance.

5.4.2 *Physical and General Setup Preferences*

The physical environment and setup is important to Osu! players, and they take the time to customize and tailor it to suit their needs. This customization ranges from things such as how a drawing tablet is setup so it does not slide around, *"this is the wall in front of me, and this is a big book that I use to like, push against the wall and the book and it will stay in place, and I don't have to worry about taping it down"* [P8] (Figure 5.2d), to how a player sits at their desk: *"I'm pretty specific with the way I sit because of the desk height and my armrests. ... I need the armrest to be in the perfect spot. ...*

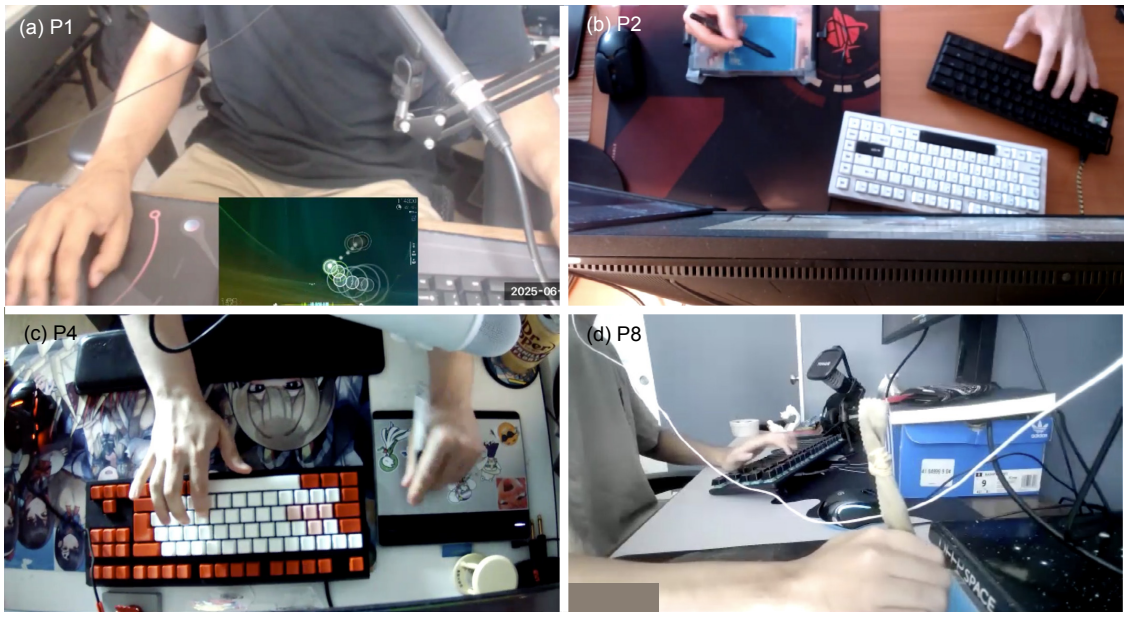


Figure 5.2: Example input device and physical environment setups: (a) P1 uses mouse and keyboard; (b) P2 uses drawing tablet and keyboard, note the blue square of folder paper on the drawing tablet; (c) P4 uses drawing tablet and keyboard; (d) P8 uses a drawing tablet and keyboard, note the book pressed against the wall to stabilize the tablet.

there's a lot of core engagement, there's a lot of like legs action, and where my feet are and that is a byproduct of my tablet area being so big because I'm throwing my arm around. So my body is moving. So that's why, I'm more specific about how I sit in my desk setup" [P6]. It is not only input device preferences that affect performance, but also a personalized general setup that is configured for a player's comfort and supports an individual's play style.

5.4.3 *Setup Changes*

While several participants try not to change their setup, *"Almost never. ... I kind of have this mindset of it's usually it's not the input, it's me"* [P2], we also heard potential reasons for making changes or updates. For example: social stigma, *"I didn't like the idea of if I want to play Osu! like very, very casually ... in some free periods ... I wouldn't like the idea of like bringing out a whole tablet setup because it just like draws unwanted attention"* [P1]; loss of ability with current input device, *"I randomly overnight, just like lost the ability to aim with the pen. I don't know how to explain why"* [P12]; and device wear and tear, *"because the the old ones broke or didn't work anymore"* [P3]. Players generally avoid changing their setup and try to work through any issues with the input devices there currently have. When they do change

their setup, the reasons are typically externally driven through factors such as social stigma or device failure.

5.5 COMMUNITY

This theme highlights community influences, including input device influences, how the culture shapes perceptions of skill and performance, and community development, outreach, and contributions (Table 5.5).

Table 5.5: Sub-themes (bolded) and codes about the community and culture of Osu!

Code	*Description*
Cultural Preferences	How Osu! culture shapes common decisions
Input device meta evolution	How the community favourite input device has changed over time
Input device meta	The current state of input device use in the community
Cultural meta effects input device perception	How the current popular opinion on input device use skews perception
Social recommendation of device	Player was recommended the use of a device by someone else
Community Participation	How participants are involved in the Osu! community
Community outreach	How participants expand the community and communicate with others
Community development	Actively working on/for the osu community and events
Game Contributions	Contributions to the game itself

5.5.1 *Cultural Preferences*

For a long time, the Osu! community has held the belief that tablet was better for playing the game over mouse. Many explained how this perception in the community guided their choice of input device, *"I saw a lot of players try [tablet] out, and I thought to myself that there are many players that prefer it, so there is very high likelihood that I will also like it"* [P13]. Others commented about the way opinions on what the best input device is have changed over time and how mouse is starting to become more popular *"there's 3 mouse players in the top 5, ... number 3, 4 and 5 are all mouse players, which is really cool"* [P17]. Additionally some participants mentioned how this community preference affected the way they viewed their choice of input device, *"it feels like I'm at a disadvantage because I play with mouse"* [P16]. This shows how a community preference around one opinion can influence the perceptions of others in the community and shapes the input device selection of new players.

5.5.2 *Community Participation*

Osu! has been shaped and sustained by an active community that includes mappers, players, event organizers, and content creators. Participation is

predominately in three main ways, Outreach, Development, and Game Contributions. Some participants help expand the player base through streaming, video creation, and advertising tournaments: *"I've helped with casting the World Cup for a few years. I've helped with pooling the World Cup, more specifically, test playing for the last 2 years"* [P5]. Other participants create and host in-person tournaments and online events, as well as manage community hubs such as discord groups to coordinate players. For example, P3 hosts an annual in-person event with tournaments and socialization where *"the whole community really gets together and everyone hangs out"*. Some community members contribute more directly by helping in actively developing new features and extensions for Osu! like P13 who develops things useful for the community, *"the most notable would be BTMC pp counter ... it's a program that shows your performance through the map and I helped develop that graph, not the graphic. ... I did the functional parts, some functional parts of the system for his stream"*. Together, these three forms of participation show how the game is sustained and functions as a community-extended ecosystem that goes beyond what is supplied by the main game developers.

6 CREATOR INSIGHTS

We also interviewed the creator and lead developer of Osu!, Dean *"peppy"* Herbert. He provided authoritative insights into the inspiration of the game, the importance of the community, the importance of music in Osu!, beatmap design, and player motivations. These support and refine our findings in Chapter 5.

6.1 OSU!'S INSPIRATION

The original inspiration for Osu! was a Japanese Nintendo DS game titled *"Osu! Tatakae! Ouendan"*. Herbert and his friends would play a variety of Japanese games, one of which was Osu! Tatakae! Ouendan. He had previous experience with other rhythm games such as *Beatmania* and *Dance Dance Revolution*, but Osu! Tatakae! Ouendan was the first Nintendo rhythm game that really interested him. He would play it during work lunch breaks, and then while working and listening to the latest pop tracks played on the radio he would picture Osu! Tatakae! Ouendan levels, *"I used to hear them, and in my mind, all I could see was, like, Osu! Tatakae! Ouendan levels, in the time of the songs I was listening to, and I could hear the hit sounds and everything"*. He then decided *"the original game was just so limited in tracks, it had something like 15 tracks, and they were all, like, covers of the original ... I have to make this"*.

6.2 COMMUNITY IMPORTANCE

Herbert outlined the importance of the Osu! community and how to him the community matters more than the game, saying *"From the start, Osu! to me is not about the game, it's about the community. The whole game has been structured, it's been developed around the community, every feature we've added has been the request of someone else. So to me, the game only really exists for the purpose of serving the community"*. The community has even gotten big enough as to require some core systems such as the pp system to be offloaded to a community team.

With the development of the Osu!Lazer client (the new open-source client for Osu!), there were a couple of big changes for the Osu! community that helped to bring them more together. First, *Herbert* wanted the game to support anyone being able to make their own gamemode/ruleset, *"One of the core philosophical design directions that we were going with Lazer is to create a very modular system where anyone, hopefully anyone could design a new ruleset, or a new game mode for the game"*, he continued to say that there

are now unofficial rulesets in Osu! that can be played by anyone. Another community gain from Lazer being open-source was that anybody could now contribute to Osu!'s development, there was a *"a huge influx of people with ideas, people with bugs, people wanting to contribute"*. However, that had its own issues: *"at first, we were trying to get people on board, we were trying to get more people involved, but as the project scaled up and more people did get involved, we realized how much work it is to actually maintain the code standards we want, and also just, you know, triage incoming issues and figure out what is most important to get done first"*. This shows how involved the community is with Osu! beyond just playing the game and how people want to contribute to a game and community they love.

6.3 WHY MUSIC IS IMPORTANT IN OSU!

Herbert also emphasized the importance of music, both for the enjoyment of the game but also for the tournament scene as they have had songs made specially for tournaments. He said *"I would say that music is important for the enjoyment side of the game ... and over the last few years, we have had original tracks commissioned for the tournament scene. ... I think without the music would be a lot less enjoyable"*.

He continued on to describe how music affects the actual gameplay of Osu!, *"A lot of the time, the music drives the track, and it drives your hype and anticipation for what is coming up in the beatmap"*. This corresponds with the prior discussion in Section 5.2 showing how the music affects beatmap design and the creativity of the mapper.

6.4 BEATMAP DESIGN AND CHALLENGES

Herbert also shared his opinions on beatmap designs and what he finds most challenging. He stated *"I really despise patterns which hide objects under other objects"*. This reflects how it is difficult to discern the number of layered hit objects and supports why P4 uses a skin with Kanji numbers to make the number of hit objects clearer when they are layered (Section 5.3.2). Herbert also commented on patterns *"where it's not a matter of readability, then I think triangle patterns for me are the worst. And it's probably better on tablet, but on mouse I find it very hard to do consistent 90-degree angles in triangles"* (Figure 5.1a). This supports P4's explanation of patterns that follow circular flow being the easiest since they help to maintain cursor momentum rather than require a complete shift in direction like a 90-degree angle in a triangle (Section 5.2.1).

6.5 PLAYER MOTIVATION

Herbert also gave his perspective about motivation challenges for competitive players in regards to climbing the leaderboards and earning pp: *"everyone's competing for the pp these days. And maybe it's, like the community feeds into itself, this is the thing we are aiming for, we need the highest ranks, and ranks are based off pp, so everyone's always looking for the, not necessarily the shortcuts, but the maps which are going to give the best pp and the best way to improve their pp"*. The current priority of constantly climbing the ranks and seeking the best beatmaps to gain pp changes the player's focus from enjoyment of the game to focusing on competitive outcomes. This goes against what Herbert wants the game to be: *"... maybe not focusing on the enjoyment of the game, which is kind of where I still am in my perception of what I want the game to be"*.

7 DISCUSSION

We discuss how our study of Osu! players and community contributes to HCI and games research in general, then discuss Osu! in the context of motor performance models which leads to future work.

7.1 IMPLICATIONS FOR HCI AND GAMES RESEARCH

Osu! players use input devices configured in ways beyond the traditional mouse and keyboard setup used in many computer games. The most popular device is a drawing pen and tablet to take advantage of absolute position input. Interestingly, this device places the absolute input space away from the display, an *indirect* relationship. This is quite different from the more common *direct* relationship where input space and display are coincident [14], such as using a pen with an iPad. Early work compared an absolute indirect tablet with a mouse and found similar target selection performance [10, 33]. Yet, this style of input has not been widely adopted as a general-purpose method outside of specialized domains such as digital art [22]. Osu! provides a large number of expert users that voluntarily use absolute indirect input for a fast and demanding pointing task. This on its own is interesting enough to warrant further investigation into whether a pen and tablet can or should be used for other games or applications. Beyond that, players in the community use a variety of devices such as a trackpad, game controller, and "mablet" (as discussed in Section 5.4.1). Previous work evaluated some of these [36–38, 41], but not a novel device like the mablet, and not necessarily in the context of games and general computing applications.

Osu! players exhibit a high degree of input control, but the emphasis on temporal accuracy makes their skills different compared to normal computer usage or even games using mainly fast reaction time. It is important to investigate whether input with high temporal and spatial precision transfers to (and even from) other types of games. We found this a contentious topic in the Osu! community, most participants said their skills do not translate to other games. However, some suggested input device manipulation mechanics or music and rhythm understanding can translate to other domains. P19 explicitly cited a need for formal studies regarding skill transfer, *"I think you need science papers to actually ... run some experiments to do that"*.

Osu! has a very large player base engaged in gameplay that resembles Fitts' Law and Steering Law experiments, but for fun and enjoyment. Even though there is the additional complexity of temporal precision, discussed



Figure 7.1: Bring-your-own-computer area at COE 2025

further in Section 7.2, this provides HCI researchers with a community of expert users to apply or extend these models and understand extreme input performance. Since all beatmaps are made by members of the community, an ecosystem emerged fostering creativity and innovation in beatmap design. Participants highlighted how game experience and gameplay understanding are required to make a map that is simultaneously challenging, achievable, and enjoyable. Given their implicit understanding of how humans move their input devices, analyzing how mappers think of movement and input is beneficial for HCI and games researchers designing novel interactions and systems.

The community itself is interesting for how this game has brought so many people together. Herbert discussed the importance of the community and how Osu! exists to serve it. Members have enhanced the community in multiple ways, from content creation and game enhancement, to event and tournament organization. A great example is COE 2025 where attendees participated in tournaments and played Osu! (among other games) with each other in the "Bring-Your-Own-Computer" area for an entire week (Figure 7.1). Future work should further investigate this community, building on previous work related to UGC and community engagement [39, 47, 52].

7.2 PERFORMANCE MODELS

The gameplay of osu!standard is a real-world application that in many ways resembles experiment tasks used to assess input performance. Clicking on Hit Circles (Figure 2.1a) resembles Fitts' Law tasks, where users move their cursor to select a target quickly and accurately. Similarly, drag-

ging along Sliders (Figure 2.1b) resembles Steering Law tasks, where users need to navigate their cursor through a constrained path. This has implications for using Osu! to conduct performance evaluations in a real-world setting.

Almost all Fitts' Law and Steering Law experiments have been in a lab setting with purpose-built experiment applications [6, 8, 24]. Very few used real-world gaming environments, some exceptions include investigating the validity of Fitts' Law [32] and comparing input device performance [37] in first-person shooter games, and a Steering Law evaluation using a racing game [2]. They examine tasks and models independently: target selection with Fitts' Law and navigating along a constrained path with Steering Law. In contrast, Osu! provides a hybrid interaction in which players combine rapid target selection and traversal within constrained paths.

However, the gameplay of osu!standard violates a key assumption made by Fitts' Law and Steering Law, which is that the user is selecting a target or navigating through a path as quickly as possible. In Osu!, the music and rhythm are an integral part of the game, and the hit objects must be clicked on or dragged through at the correct time. This means Osu! players are both spatially precise and temporally precise. This makes Osu! a unique environment for examining input performance in a real-world setting. This is especially relevant given that collecting ecologically-valid data is challenging [30].

7.3 FUTURE WORK

Due to the temporal precision requirement in Osu!, Fitts' Law and Steering Law modelling would likely not be accurate for Osu! pointing and dragging. Lee and Oulasvirta [29] investigated how to model error rates in temporal tasks such as the casual Flappy Bird game, but do not propose a model that combines both spatial and temporal precision. Thus, we propose an investigation to explore how to design and test a model to accurately predict Osu! spatial and temporal performance. A key resource for this modelling is the large publicly-available archive of Osu! play logs that this community shares online for others to view.

Informed by this combined spatial and temporal model, we also plan a quantitative assessment of Osu! input performance. This study would recruit people with skill levels ranging from top-ranked Osu! players to everyday computer users, in order to further test the validity of the model and quantitatively test the theories and beliefs from players regarding practice and mastery of Osu! play.

Since osu!standard gameplay is comprised of core pointing and steering interactions, Osu!-like interactions could be ported to different computing contexts. We propose incorporating Osu!-like exercises into everyday computing interfaces such as web browsing and text editing. Our study

showed that motivation has a large impact on whether people play, so we suggest this approach can be applied across a *"want to"* versus *"have to"* motivational spectrum. Leveraging the tools and framework proposed by Hougaard and Knoche [23], we imagine targeted integrations for various user goals and motivations. Ranging from users who want to improve their input performance in video game play, to users who have to work on regaining their input performance after injury, such as after a stroke.

In particular, patients who suffered from stroke and partook in therapy outside of clinical therapy appointments have significantly greater improvement in strength, range, and movement speed [49]. Previous work has used Fitts' Law in the context of rehabilitation [15] and for motor control assessment for those with cerebral palsy [5], as well as evaluating motivation and playfulness in children with cerebral palsy [18, 43]. Rhythm games specifically have been used for hand therapy exercises [13] and to learn manual motor skills [9]. With the correct motivations, integrating Osu!-like dexterous exercises into daily computing interfaces could be a kind of physical therapy, and for some users, a way to boost their general input performance.

7.4 LIMITATIONS

This research may be limited by our recruitment method. The participants interviewed may not be representative of the Osu! community as a whole due to the initial recruitment using convenience sampling and other participants found through snowball sampling. This meant that all participants either had some form of social network connection to either the content creator on the research team or another participant, or they attended COE 2025 in the Netherlands. However, without the convenience and snowball sampling approaches, this study could not have been completed since gaining access to top-ranked players as well as the creator of the game required an introduction from a trustworthy source who could vouch for the research being conducted.

The participant sample also lacked gender diversity which may also be a byproduct of the sampling methods discussed, or perhaps the overall gender composition of Osu! players. The role of gender in rhythm-games like Osu! could be a topic for future work.

8 CONCLUSION

We investigated players of the Osu! rhythm game which is focused on spatial and temporal precision through clicking and dragging targets. Beyond an emphasis on input performance, Osu! is notable because of a significant self-organized community. Using a reflexive thematic analysis of semi-structured interviews with 20 participants including elite players, serious recreational players, mappers, content creators, and event organizers, as well as a feature interview with the lead developer, we gained insights into this remarkable game and community. The results reveal insights about the players such as how they learn about Osu! and their motivations for playing, details about mapping and map creation, the strategies they use to improve their input performance, and how players curate their setup including which input devices they use and why. We also learned about the role that the community plays in shaping motivation, growth, and development through competitive play, map design, and content creation. This thesis brings this under-explored gaming community, entirely focused on extreme input performance, to the attention of HCI researchers. The findings increase our qualitative understanding of people with very high input performance and how that extreme input performance is developed, and they can form a basis to inform future research on input devices and the development of input performance in general.

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APPENDICES

A

INTERVIEW GUIDE

1. About the Player:
   - How long have you been playing Osu!?
   - How did you learn about and get into Osu!?
   - Do you have any favourite types of beatmaps?
   - What do you find is the most challenging aspect of Osu!?
   - What Osu! pattern do you find to be the most difficult or frustrating?
   - Do you do any mapping?:
     - When you're designing patterns, do you consciously think about the physical difficulty or hand coordination required to play them?
     - Do you ever create sections in a map to train or test specific input skills (e.g. finger control, alternating taps, cursor stability)?
     - Have players ever told you that one of your maps helped them improve things such as their speed, control, or tapping accuracy?
     - Do you believe it's possible to design maps specifically for training certain physical skills, like in a deliberate practice routine?
2. Strategies and Subjective Ability:
   - What strategies do you use when playing Osu!? What is your approach to the game?
     - Does the map type alter your strategy? (eg. accuracy vs stream maps)
     - Physical vs mental strategies?
   - Do you have a warm up or exercise routine? If so, what does it entail?
   - How much of an impact do you think the music/rhythm has on your ability?
     - Do you perform better when you know the song?
   - How did you improve things like your accuracy, speed, control, precision, etc... with your chosen input devices to become an elite player?
     - Do you think your improvement came more from practice, learning new techniques, input device selection, or something else entirely?
   - What kind of training do you currently do to improve?
     - Do you do any post-game analysis?

  - Software or hardware tools?

3. About their Input Devices and Setup:
   - What does your current input setup look like/consist of?
     - How often do you change/modify it?
   - How do you configure your input devices to fit your needs?
   - Could you give me a tour or send me some pictures of your setup and input devices?
   - Why do you use ___ as your primary input devices?
   - Have you had any previous setups in the past that you have evolved from? Could you tell me about them and why you made the change?
   - Are you aware of other common setups or input devices that are used in the Osu! community?
   - Are there any setups or input devices that you haven't tried yet but would like to? Do you think that they may help you improve?
4. Involvement in the Osu! Community and Gaming World:
   - What does that involvement look like in the Osu! community?
   - What other video games do you play?
     - Does your skill in Osu! translate to or help you in other games?
     - Do you use the same input devices in other games or is your selection game dependent?