

# An Analysis of WoW Players' Game Hours\*

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## ABSTRACT

Online gaming has become increasingly popular in recent years. Currently, the most common business model of online gaming is based on monthly subscription fees that game players pay to obtain credits, which allow them to start or continue a journey in the game's virtual world. Therefore, from the perspective of game operators, predicting *how many players will join a game* and *how long they will stay in the game* is important since these two factors dominate their revenue.

This paper represents a pilot study of the predictability of online gamers' subscription time. Specifically, we study the gameplay hours of online gamers and investigate whether strong patterns are embedded in their game hours. Our ultimate goal is to provide a prediction model of online gamers, which takes a player's game hours as the input and predicts whether the player will leave in the near future. Our study is based on real-life traces collected from World of Warcraft, a famous MMORPG (Massively Multiplayer Online Role-Playing Game). The traces contain the gameplay histories of 34,524 players during a two-year period. We believe that our study would be useful for building a prediction model of players' future game hours and unsubscription decisions; i.e., decisions not to renew subscriptions.

## 1. INTRODUCTION

Online gaming has become increasingly popular in recent years. In [6], it is reported that over 55% of Internet users are now also online gamers. Currently, the most common business model of online gaming is based on monthly subscription fees that game players pay to obtain credits, which allow them to start or continue a journey in the game's virtual world. Therefore, from the perspective of game operators, predicting *how many people will join a game* and *how long they will stay in the game* is crucial, since these two

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factors dominate their revenue.

Predicting how many gamers will join a game before a game's launch is very difficult, if not impossible, since it involves many non-game-related factors, such as the release date of the game (whether it is launched during the summer vacation), the artistic design (whether it is comic-like or realistic), cultural issues (whether it is Eastern- or Western-style), and even advertising strategies. Predicting how long players will stay once they join a game is more feasible, as it should correlate with the extent of users' involvement in the game's virtual world. Usually, this can be inferred from the players' external behavior, such as how quickly their avatars advance to new levels and how long they spend in the game each day.

This paper presents a pilot study of predicting online gamers' subscription times. A player's subscription time denotes the length of time since he/she first joined the game to the time of his/her last login, i.e., the player has not logged in since then. Specifically, we study the gameplay hours of online gamers and investigate whether strong patterns are embedded in their game hours. Our ultimate goal is to provide a prediction model of online gamers that takes a player's game hours as input and predicts whether the player will decide not to continue in the game once his/her current subscription expires. In this paper, we use the term *unsubscription decisions* to describe such decisions. Predictions about players' unsubscription decisions are important to game operators because the decisions affect the operators' revenue directly. Our rationale is that, if we can predict the subscription time of players before they actually leave a game, the game operator can take remedial action to prevent the players' departure and improve the game based on feedback provided by those players.

Predictions about players' subscription time can provide the following benefits:

1. Players usually quit a game because they are dissatisfied with the game's design or content, or even other players' cheating activities. Thus, to some degree, player unsubscriptions should indicate low user satisfaction. In other words, if we can predict which players will leave the game in the near future, we may have a chance to stop them leaving, or at least understand their reasons and make future improvements. To this end, operators could conduct surveys to determine the causes of player dissatisfaction and improve the game accordingly. However, it is more likely that operators would receive useful comments because dissatisfied players who have been totally disappointed with

a game may reluctant to take surveys from game companies.

2. The predictions about players' subscription times also facilitate predictions about the number of future players. Even though we can predict the number of players directly by using time series modeling [4], subscription time prediction provides more information because we can predict "which" players will leave the game rather than just "how many" players will leave. With such information, game operators can plan their network and server allocation beforehand and optimize resource arrangements in the future.

Our study is based on real-life traces collected from World of Warcraft [1], a famous MMORPG (Massively Multiplayer Online Role-Playing Game). The traces contain the game play histories of 34,524 players during a two-year period. Our results indicate that, although short-term prediction is feasible, long-term prediction is much more difficult because players may become more involved in the game or lose interest over time.

The remainder of this paper is organized as follows. Section 2 contains a review of related works. In Section 3 we summarize our traces and describe the collection methodology. We analyze how much time gamers spend playing the game in Section 4 and when they play the game in Section 5. In Section 6, we evaluate the feasibility of using players' short-term game hours to predict their long-term gameplay behavior. Then in Section 7, we summarize our findings and discuss possible avenues of future research.

## 2. RELATED WORK

In a previous work that focused on an MMOG called *RockyMud* [10], the authors collected a set of traces of session inter-arrival times, session lengths, avatars' transition probabilities between different regions, and region stay times. The authors' analysis showed that the inter-arrival times of game sessions follow an exponential distribution. In addition, the transition of avatars between different regions can be well modelled by a first-order Markov chain, while the region stay time and session length can be described by a Pearson distribution and a Pareto distribution respectively.

Based on a set of World of Warcraft traces, Pittman et al attempted to propose a realistic, empirical model for simulating users' gameplay behavior and the fluctuations in game servers' popularity over time [13]. The authors conjectured that at least four types of information are required to establish a prediction model: 1) the server's population changes over time; 2) the arrival rate and session duration of players; 3) the spatial distribution of avatars in the virtual world; and 4) the movements of avatars over time (how many distinct regions the avatars visit and how long they stay in a region). They observed that the number of players fluctuated in a diurnal pattern and there can be an approximate 5-fold increase in the number of players between 4 am and 6 pm. In addition, they found that session times appeared to follow a power-law distribution where approximately 50% of the gamers remain online for 10 minutes or less. They also discovered that the number of players versus the rank of each zone, from the most populated to the least populated, exhibited a power-law relationship.

Chambers et al [4] conducted a user behavior study of Counter-Strike, a famous FPS game. Their work focuses

on two issues: users' satisfaction with a game, and the predictability of the game server's workload. They analyzed the number of connection attempts and session times, and found that it is extremely difficult to satisfy users. If a game server is not stable, gamers tend to go elsewhere without considering "loyalty". Chambers et al. also found that users have short attention spans, and users' session times are usually shorter than one hour. They also analyzed the popularity of game servers and found that the number of users on different servers follows a power-law distribution. Moreover, the server workload exhibits predictable patterns in terms of day and week scales, but the predictability diminishes with larger time scales.

## 3. DATA DESCRIPTION

In the following, we introduce World of Warcraft, and describe how we collect players' game hours in an automated fashion. We conclude this section with a summary of the collected traces.

### 3.1 World of Warcraft

World of Warcraft is the fourth game set developed by Blizzard Entertainment Incorporation, and it is currently the most popular MMORPG in the world. According to MMOGChart [11], the game's 10 million subscribers accounted for 62% of the MMOG market in May 2008 [2]. Because of its high popularity, it has become a field for researchers to study psychology [15], social behavior [8, 12], and game play behavior [4, 7, 9, 10, 13].

### 3.2 Data Collection

We used the `who` command, which is publicly available to every player in the game, to collect our traces. The command asks the game server to reply with a list of players who are currently online. Thus, anyone can obtain the gameplay history of all the users on a server by issuing the `who` command with a regular interval. To do so, we create a character on a World of Warcraft server and keep it online all the time. Our character is controlled by a program and automatically collects a list of the online users every 10 minutes. If a player logs in and logouts within 10 minutes, we may not be able to observe his/her re-login activity in consecutive snapshots. However, we do not think this problem is significant because most WoW session times are much longer than 10 minutes [14].

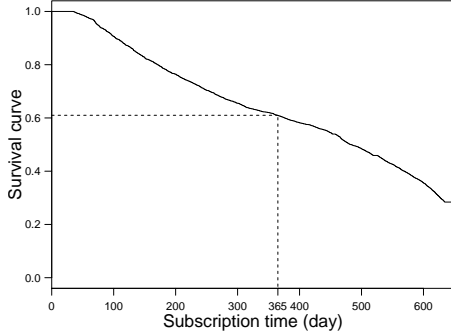
For scalability consideration, the World of Warcraft server restricts the number of users returned by a query to a maximum of 50 accounts. Thus, we have to narrow down our query ranges by dividing all the users into different races, professions, and levels. For example, we need to first ask the server to list all the users with the "Fighter" class with the first query, and then ask the server to list all the users with the "Wizard" class with the second query, and so on. This technique allows us to systematically list the entire set of online players despite the restriction of the query function.

### 3.3 Trace Summary

We collected our traces from Dec. 2005 to Oct. 2007. During the monitored 664 days, 34521 accounts are observed, as shown in Table 1. However, only 7043 of those accounts remained active for more than 30 days, which indicates that most accounts were never used after the free trial period expired. As we focus on the long-term gameplay pat-

WoW trace	
Start date	2005-12-22
End date	2007-10-17
Length	664 days
Total sessions	1,672,820
Accounts observed	34,521

**Table 1: Trace description**



**Figure 1: The survival curve of players' subscription times**

terms of WoW players, in our analysis, we only use the 7043 accounts whose subscription periods are longer than 30 days.

## 4. HOW LONG DO GAMERS PLAY?

In this section, we examine “how long” gamers play from various in terms of the overall subscription time, consecutive gameplay days, and daily gameplay activity.

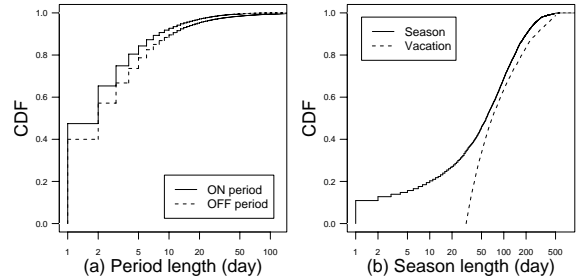
### 4.1 Subscription Time

In this study, we consider that a player has quit a game if he/she does not login into the game for three months. Note that some players' subscription periods are censored, i.e., some players started playing WoW before our measurement started, and some continued playing after our measurement ended. Thus, we cannot directly estimate the distribution of players' subscription times by a cumulative distribution function (CDF). Instead, we use the Kaplan-Meier estimator [3], which takes account of the censored status of each subscription period, to estimate the distribution of players' subscription times. The Kaplan-Meier estimator's output is called the *survival function*, which reduces to the cumulative distribution function if none of the subscription periods are censored.

The survival function of players' subscription times is shown in Figure 1. We observe that, probabilistically, 60% of users will subscribe for longer than 500 days. This result indicates that the game is indeed very attractive, and most players seem to become addicted to its fantasy world once they become creatures in it.

### 4.2 Consecutive Game Play Days

Intuitively, if users regularly play the game every day for a long period, they are probably addicted to the game. Thus, we consider the distribution of consecutive game play days in order to understand the extent of addiction of WoW gamers.



**Figure 2: Cumulative distribution functions of ON/OFF periods and season lengths**

We define an ON period as a group of consecutive days during which a player joins the game everyday, and an OFF period as the interval between two ON periods.

Figure 2(a) is the cumulative distribution function of the length of ON and OFF periods. We observe that OFF periods are slightly longer than ON periods on average, but the difference is insignificant. In addition, probabilistically, around 80% of the gamers' ON and OFF periods are shorter than 5 days. In other words, players tend to alternate between ON and OFF periods shorter than 5 days. This might be due to MMORPG's addictive characteristics; that is, a player may not like to leave the game for a long time, as doing so may cause him to lose the sense of playing a role in the game world, and become less familiar with the virtual world. Therefore, players tend to come back to the game world frequently to continue their onward journey or simply to keep company with their partners or guild companions.

We observe that some OFF periods are extremely long; for example, 3% of OFF periods are longer than 1 month, and 1% are longer than 3 months. This may be due to personal reasons that force gamers to stop playing the game for a long period, such as preparing for exams, beginning a new job, or running out of money to purchase subscription credits. In addition, we find that, even after a long OFF period, gamers may come back and play the game as seriously as before. Hence, we need to divide a player's subscription time into a number of active periods, where two adjacent active periods are separated by a long rest period from the game. We call each active period a *season*, and a long rest period between two seasons a *vacation*. More specifically, we define a vacation as an OFF period that is longer than 30 days, and a season as an active period between two vacations.

The cumulative distribution functions of the lengths of seasons and vacations are shown in Figure 2(b). From the graph, we find that vacations are generally longer than seasons, but the difference is not significant. Furthermore, we find that around 50% of the seasons are longer than 60 days. This indicates that WoW gamers tend to become addicted to the game, so it is common for them to spend longer than 2 months without a vacation during their adventure in the game's virtual world. In addition, we can see that less than 20% of vacations are longer than 180 days, which indicates that, after a vacation longer than half a year, only 20% of the gamers will return to the game. We also observe that around 20% of the seasons are shorter than 10 days, which indicates that some gamers will come back from a vacation to join the game for only a few days and then take another vacation.

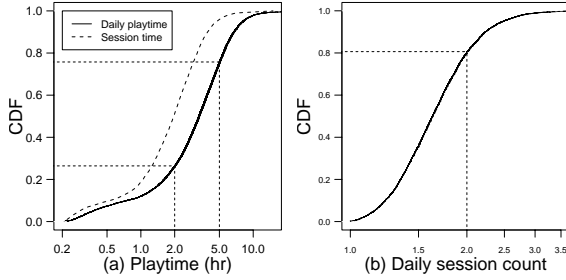


Figure 3: CDF of daily playtime and session times

	(Mean, SD)	Quantiles (5%, 25%, 50%, 75%, 95%)
Session time (hr)	(2.8, 1.8)	(0.4, 1.0, 1.8, 3.0, 5.5)
Daily session count	(1.7, 0.9)	(1.0, 1.1, 1.4, 2.1, 3.3)
Daily playtime (hr)	(3.7, 2.8)	(0.5, 1.6, 3.1, 5.1, 8.8)

Table 2: Summary of daily activities

### 4.3 Daily Activities

Here, we consider the characteristics of users’ daily behavior, including the average daily playtime, average daily session count, and average session playtime. Note that if a gamer does not play the game for some days, we do not include those days in his average daily playtime. For example, if a gamer’s subscription time is a year, during which he only played for 200 days, then his average daily playtime will be his overall playtime divided by 200 days.

The CDFs of the average daily playtime and the average session playtime are shown in Fig. 3(a). We find out that 75% gamers play longer than 1.9 hours per day on average, and 25% longer than 4.9 hours per day, which indicates that the game is very attractive for its gamers. If we analyze the average session playtime, we find significant “knees” around 1 hour and 5 hours, which indicates that after logging into the game, there is a high probability that players will stay for at least one hour, but usually no longer than 5 hours. Because of the long session property, players probably do not login into the game too many times a day; hence the daily session count is not large, as shown in Fig. 3(b), where more than 80% of gamers’ session counts are less than 2 per day on average. We summarize the quantiles and averages of the average daily playtime, average session playtime, and average daily session count in Table 2.

## 5. WHEN DO GAMERS PLAY?

We now consider the question: When do gamers play?. Our analysis is based on the day scale and week scale, i.e., whether gameplay occurred during the night or in the daytime, and whether it occurred on weekdays or weekends. The results are shown in Fig. 4. Intuitively, we might think that the average daily playtime of the gamers on weekends would be higher than that on weekdays, and playtimes of each weekday would be similar to each other. However, the results do not support our intuition. The average daily playtime on the weekends is indeed higher than that on weekdays, but the difference is not significant. This might be due to two reasons: 1) WoW is such an attractive game that users play every night, even if they have to work the next day; and 2) it is much more fun to play a MMORPG like

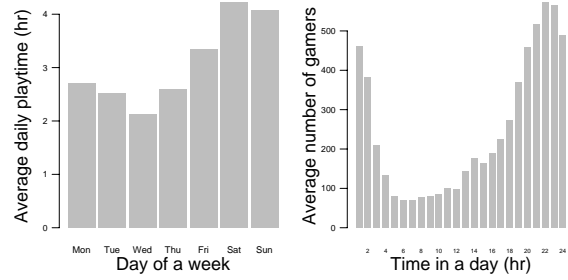


Figure 4: Bar chart of login count versus day and bar chart of login count versus hour

WoW with partners. WoW encourages multi-party gameplay by providing many missions and dungeons that are difficult so that only teams of players can conquer. For example, for a strong “boss,” players often need to gather at least two fighters, one wizard, and one priest to defeat it. The fighters concentrate on attacking the boss, the priest takes care of the damages caused by the boss, and the wizard keeps casting protective magic on partners and damaging magic on the enemy.

Furthermore, Fig. 4 shows that the average daily playtimes for each weekday are significantly different. This may be because, as the weekend draws closer, gamers start to extend their playtimes, so the average daily playtime begins to increase from Thursday. After the weekends, the game’s attraction continues, so gamers cannot concentrate on their work, and play the game whenever they can, even during working hours. This effect is the lowest on Wednesday, and starts to increase as the weekend approaches again.

With regard to playing hours a day, we observe that 1) there is an obvious difference between the number of gamers during night hours and morning hours. The number of gamers begins to increase most rapidly around 6 pm, which indicates that most gamers begin to play immediately after they finish work. The number of gamers reaches a peak from 10 pm to midday, and is the lowest from 5 am to 7 am. 2) The number of gamers increases from 6 am to 10 pm; hence, even during working hours, players continue to join the game. This may be because students skip classes to play the game, or workers play secretly during business hours.

## 6. PREDICTABILITY ANALYSIS

In this section, we investigate whether users’ gameplay behavior is predictable, i.e., can we predict players’ future game hours based on their gameplay history. Our analysis is comprised of two parts. In the first part, we analyze whether players’ short-term behavior can be used to predict their long-term behavior. In the second part, we assess whether temporal dependence exists between consecutive time periods in four different time scales, namely days, weeks, ON periods, and seasons.

### 6.1 Predictability of Short-term Behavior

To determine whether players’ short-term behavior is a reliable indicator of their long-term behavior, we use the average session time, average daily session count, and average daily playtime as a summary of players’ short-term behavior. We expect that some variables, such as the average

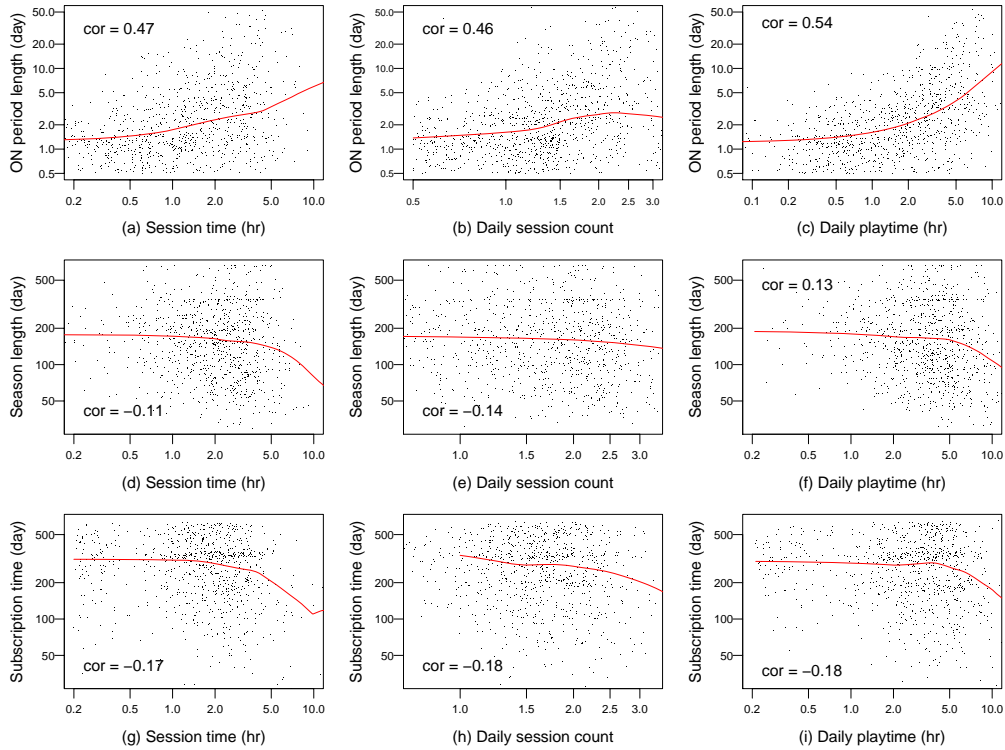


Figure 5: Predictability of daily playtime, daily session count, and session time

length of ON periods, the average season length, and the overall subscription time may correlate with players’ long-term behavior.

Fig. 5 shows the plots of the correlations between the three short-term behavioral factors and the three long-term behavioral factors. We observe that the lengths of the average ON periods are moderately correlated with all the short-term behavioral factors, and the average daily play time has the strongest predictability. Fig. 5(c) shows that, if players’ average daily game time is shorter than 1 hour, then their average ON periods will probably be less than 2 days, i.e., these players tend not play the game for three consecutive days. On the other hand, the average daily playtime of highly addicted players can be as high as 10 hours, and they may play the game for more than 20 days without interruption. However, it is clear that the average length of seasons and the overall subscription time do not correlate with all the short-term behavioral factors. Since this indicates that players’ interests may change significantly over time, we cannot simply use an overall average of players’ short-term behavior to predict their long-term gameplay behavior. Instead, we need to monitor the evolution of players’ game hours over time and keep track of their interest in the game [5] in order to accurately predict when unsubscription will occur. We will consider this issue in our future work.

## 6.2 Players’ Game Hours in Consecutive Periods

We also consider the temporal dependence of players’ game hours in consecutive periods. In other words, we examine whether players’ gameplay behavior in one time period will be carried over to the following period. As shown in Fig. 6,

five types of time periods are considered: session, day, week, ON period, and season. Not surprisingly, the overall playtime between consecutive weeks exhibits the strongest auto-correlations among all the time scales we consider. Session time and daily playtime are also strongly auto-correlated; however, the magnitude is not as strong as that of weekly playtime. The reason may be that the weekly patterns are the most regular for most people, while session times and daily playtimes are more easily affected by events and the different schedules on weekdays and weekends. On the other hand, the auto-correlation of ON period playtime is also moderate, although the length of consecutive ON periods is less regular. The season length has no auto-correlations at all, which we consider reasonable as consecutive seasons are actually separated by a rest period longer than 30 days. Moreover, a season might be long enough to affect or change players’ interest in the game. This implies that the prediction of players’ unsubscription should be performed in a time scale shorter than a season.

Table 3 summarizes the findings discussed in this section.

## 7. SUMMARY AND FUTURE WORK

In this paper, we study players’ game hours for a famous MMORPG, the World of Warcraft, during a 2-year period. We analyze when gamers join the game’s virtual world and how long they stay in the game. In addition, we investigate whether players’ future game hours can be predicted by their previous behavior. Our results indicate that although short-term prediction is feasible, long-term prediction is much more difficult as players’ interest in the game may increase or decrease significantly over time.

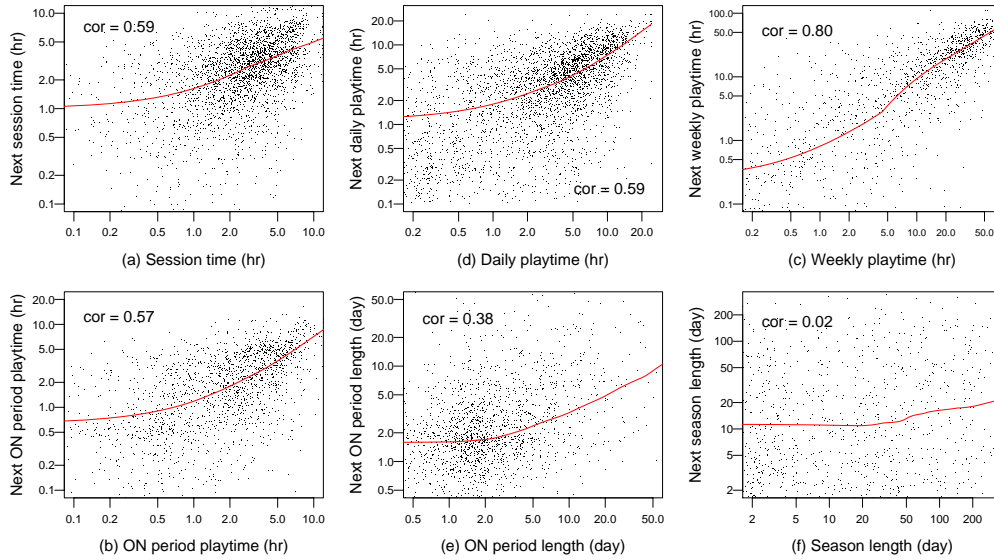


Figure 6: Strength of the temporal dependence in day, week, ON period, and season scales

	Daily playtime	Session time	Session count
Subscription time	×	×	×
Season length	×	×	×
ON period length	★★	★	★

	Session	Day	Week	ON period	Season
Playtime Length	★★	★★	★★★	★★	×
Length	NA	NA	NA	★	×

Table 3: Predictability of daily playtime, session time, session count, and temporal dependence in day, week, ON period, and season scales

The symbols represent the correlation strength.

- ★★★: strong correlation ( $\text{cor} \geq 0.8$ );
- ★★: medium correlation ( $0.8 > \text{cor} \geq 0.5$ );
- ★: weak correlation ( $0.5 > \text{cor} \geq 0.3$ );
- ×: no correlation ( $0.3 > \text{cor}$ ).

In spite of the difficulties involved in prediction, we will continue with prediction modelling. Our goal is to construct a model that can predict whether a player will leave a game in the near future. Predicting players' future behavior (in terms of leaving or staying in a game) would be advantageous to game operators as it would help them prevent the loss of subscribers and enable them to determine how to improve the game by surveying players that lose interest in it.

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