Forecasting Online Game Addictiveness

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Thrall yells: The courtyard is ours! Onward to the inner sanctum!

[2. Trade] [Eligo]: lvl 87 tailor
[Phlay] has invited you to join a group.
Looting changed to Group Loot.
Loot threshold set to Uncommon.
[2. Trade] [Stonedfire]: Stoned goods [Enchanting], [Alchemy] elixir spec, pm me for more
[2. Trade] [Snuggles]: WTS [Trollwoven Spaulders] 500g, obo
World of Warcraft by Blizzard

4.5 years and $63M USD for development before release on 2004*

> $37M USD for upkeep and expansions during 2004 to 2010**

**http://online.wsj.com/article/SB10001424052748703467304575383443343071562.html?mod=googlenews-wsj
Online Game Industry is Competitive

$1M to $200M USD dev cost per game*

> 200 game titles each year**

**http://www.gamespot.com/
The Terrifying Truth

Most of them survived only 4--9 months.

Usually long before a game’s investment could ever be paid off...

http://www.slideshare.net/TomSente/casualconnect2012-honeytracks-game-lifecycle-kpis
The Question

Is a game’s lifetime predictable?
In other words ...

Is a game’s addictiveness predictable?

addictiveness [noun]:
the ability to retain players active in the game for a long time.
The Significance

- **STOP** developing hopeless games
- **SUGGEST** better design decisions during development
- **CHOOSE** better games to publish (for game publishers)
State-of-the-Practice

- Intuition of game designers
- Feedbacks from focus groups
- Psychologically inspired methods
  - E.g., the think aloud method

Subjective and thus tends to be biased
Our rationale

Why a player addicts to an online game?

- Being entertained
- Having various emotions arisen, e.g., joy, excitement, tension
Our Approach

- Lab emotion studies
- Published games
- Performance on market
- Prediction Model
- Performance on market
- An unpublished game X

An unpublished game X

Lab emotion studies

Published games

Performance on market
GROUNDTRUTH DATASET DESCRIPTION
Our Collaborator

- Gamania, the no. 1 game company in Taiwan
- Gamania released player session information (every player’s login and logout events) of 11 games to us
## Overview of Games

<table>
<thead>
<tr>
<th>Game</th>
<th>Publish Year</th>
<th>Trace Period</th>
<th># Accounts</th>
<th>User Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT1</td>
<td>2009</td>
<td>240 days</td>
<td>500K+</td>
<td>8.6</td>
</tr>
<tr>
<td>ACT2</td>
<td>2009</td>
<td>730 days</td>
<td>100K+</td>
<td>8.9</td>
</tr>
<tr>
<td>ACT3</td>
<td>2009</td>
<td>773 days</td>
<td>500K+</td>
<td>8.9</td>
</tr>
<tr>
<td>ACT4</td>
<td>2010</td>
<td>609 days</td>
<td>1,000K+</td>
<td>8.0</td>
</tr>
<tr>
<td>FPS1</td>
<td>2009</td>
<td>732 days</td>
<td>1,000K+</td>
<td>8.2</td>
</tr>
<tr>
<td>FPS2</td>
<td>2010</td>
<td>556 days</td>
<td>100K+</td>
<td>7.4</td>
</tr>
<tr>
<td>RPG1</td>
<td>2009</td>
<td>385 days</td>
<td>100K+</td>
<td>7.5</td>
</tr>
<tr>
<td>RPG2</td>
<td>2009</td>
<td>323 days</td>
<td>100K+</td>
<td>8.0</td>
</tr>
<tr>
<td>RPG3</td>
<td>2010</td>
<td>486 days</td>
<td>100K+</td>
<td>7.5</td>
</tr>
<tr>
<td>RPG4</td>
<td>2010</td>
<td>732 days</td>
<td>50K+</td>
<td>8.3</td>
</tr>
<tr>
<td>RPG5</td>
<td>2010</td>
<td>820 days</td>
<td>50K+</td>
<td>8.3</td>
</tr>
</tbody>
</table>
Account Activity Records (AAR)

- **AAR Format**

<table>
<thead>
<tr>
<th>Account</th>
<th>Login Timestamp</th>
<th>Logout Timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serena</td>
<td>2009–01–01 14:05:32</td>
<td>2009–01–02 01:05:25</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

- **Dataset Overview**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># games</td>
<td>11</td>
</tr>
<tr>
<td>Total observation days</td>
<td>6,206</td>
</tr>
<tr>
<td>Total accounts</td>
<td>8,506,647</td>
</tr>
<tr>
<td>Total game sessions</td>
<td>1,311,618,907</td>
</tr>
<tr>
<td>Avg. sessions per account</td>
<td>154.2</td>
</tr>
<tr>
<td>Avg. sessions per day</td>
<td>211,347</td>
</tr>
</tbody>
</table>
QUANTIFYING GAME ADDICTIVENESS
Attempt #1: Subscription period

INTUITION
A game is more addictive if its gamers tend to play it as much as they can.

- Subscription period
  - The time span (in days) of a player’s first and last game sessions.

- Issues
  - The actual time players spent in game is not considered.
 Attempt #2: Ratio of Presence

- **Ratio of presence (RoP)**
  - The total number of days that the gamer entering the game at least once during the subscription period.
  - E.g., Entering the game on 20 days with 100 subscription period → RoP = 20/100 = 0.2

- **Issues**
  - Bias toward games with short subscription periods
  - E.g., average 4 online days over 5 subscribed days = RoP 0.8
Subscription period and RoP

- **ACT1**: 0.48
- **ACT2**: 0.32
- **ACT3**: 0.26
- **ACT4**: 0.20
- **FPS1**: 0.20
- **FPS2**: 0.17
- **RPG1**: 0.47
- **RPG2**: 0.46
- **RPG3**: 0.46
- **RPG4**: 0.28
- **RPG5**: 0.46

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RoP Generalization

- RoP(OP)
  - RoP with a certain observation period

<table>
<thead>
<tr>
<th>Jan 1st</th>
<th>Jan 2nd</th>
<th>Jan 3rd</th>
<th>Jan 4th</th>
<th>Jan 5th</th>
<th>Jan 6th</th>
<th>Jan 7th</th>
<th>Jan 8th</th>
<th>Jan 9th</th>
<th>Jan 10th</th>
<th>Jan 11th</th>
<th>Jan 12th</th>
<th>Jan 13th</th>
<th>Jan 14th</th>
<th>Jan 15th</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoP(5)</td>
<td>4/5 = 0.8</td>
<td>RoP(10)</td>
<td>7/10 = 0.7</td>
<td>RoP(15)</td>
<td>9/15 = 0.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- RoP curve
  - The curve formed by RoPs over a range of OP

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The RoP curve of FPS2

RoP curves follow a power-law relationship with OP.
**RoP(OP) \approx a \cdot OP^\beta + b**

![Graphs showing RoP as a function of OP with different power laws and R^2 values.](image)
Defining Addictiveness Index

- $\beta$: The decline rate of RoP over time
- genre-independent

RoP(RO) ≈ $a \cdot OP^\beta + b$

<table>
<thead>
<tr>
<th>Game</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>Game</th>
<th>$\beta$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT1</td>
<td>-0.44</td>
<td>1.00</td>
<td>RPG1</td>
<td>-0.38</td>
<td>0.98</td>
</tr>
<tr>
<td>ACT2</td>
<td>-0.49</td>
<td>1.00</td>
<td>RPG2</td>
<td>-0.50</td>
<td>0.98</td>
</tr>
<tr>
<td>ACT3</td>
<td>-0.37</td>
<td>1.00</td>
<td>RPG3</td>
<td>-0.50</td>
<td>0.99</td>
</tr>
<tr>
<td>ACT4</td>
<td>-0.43</td>
<td>1.00</td>
<td>RPG4</td>
<td>-0.58</td>
<td>1.00</td>
</tr>
<tr>
<td>FPS1</td>
<td>-0.45</td>
<td>0.99</td>
<td>RPG5</td>
<td>-0.43</td>
<td>0.99</td>
</tr>
<tr>
<td>FPS2</td>
<td>-0.65</td>
<td>0.99</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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MEASURING PLAYER EMOTION
Corrugator supercilli muscle groups

Negative Emotion

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Zygomaticus major muscle groups

Positive Emotion
Facial EMG approach
(EMG: Electromyography)

1. Continuous emotion measures (can be at a rate of 1000 Hz or even higher)

2. Does not disturb game play

3. Objective since the emotional indicators are directly measured rather than told by subjects
Facial EMG Measurement Setup

- Corrugator Supercilii muscle
  - Negative emotions
- Zygomaticus Major muscle
  - Positive emotions
Measurement Devices

Electrodes

Wires

PowerLab 16/30
Measuring Facial EMG during game play
Experiment Design

- 84 subjects are asked to play the 11 games
- A subject must be new to the games he played
- Each game session lasts >= 45 minutes continuously

<table>
<thead>
<tr>
<th># subjects</th>
<th>84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>74</td>
</tr>
<tr>
<td>Females</td>
<td>10</td>
</tr>
<tr>
<td>Ages of the subjects</td>
<td>19–34</td>
</tr>
<tr>
<td># total traces</td>
<td>192</td>
</tr>
<tr>
<td># traces per subject</td>
<td>1–3</td>
</tr>
<tr>
<td># traces per game</td>
<td>15–19</td>
</tr>
<tr>
<td>Total hours of traces</td>
<td>155</td>
</tr>
</tbody>
</table>
Quantifying the Measurement

- EMG samples are taken at 1,000 Hz, so a 45-minute trace comprises
  \[45 \times 60 \times 1,000 = 2,700,000\] samples

- The average absolute differences between adjacent samples is taken as the representative index
  - Given a time series of electrical potential samples \(P = \{p_1, p_2, \ldots, p_n\}\)
    \[f(P) = \text{mean}(\text{abs}(p_2 - p_1), \text{abs}(p_3 - p_2), \ldots, \text{abs}(p_n - p_{n-1}))\]

- CS: corugattor supercilii muscles \(\rightarrow\) negative emotion
  ZM: zygomaticus major muscles \(\rightarrow\) positive emotion
FORECASTING GAME ADDICTIVENESS
Emotion vs. Addictiveness

![Graph showing correlation between Beta and CS (mV) with cor = -0.20.](image)

![Graph showing correlation between Beta and ZM (mV) with cor = 0.38.](image)

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Modeling Game Addictiveness

- **ES**: the emotional strength
  - **ES = CS + ZM**
  - The combined emotional strength arisen

\[ \theta = \omega_0 + \omega_1 \cdot CS + \omega_2 \cdot ZM + \omega_3 \cdot CS:ZM + \omega_4 \cdot CS:ES + \omega_5 \cdot ZM:ES \]

| Variable    | Coef. | Std. Err | t   | Pr > |t| |
|-------------|-------|----------|-----|------|-----|
| (constant)  | 4.30  | 0.43     | 9.87| 0.00018 |
| CS          | -4.19 | 0.51     | -8.18| 0.00044 |
| ZM          | -11.59| 1.04     | -11.07| 0.00010 |
| CS:ZM       | 3.53  | 1.06     | 3.31| 0.02119 |
| CS:ES       | -0.21 | 0.24     | -0.87| 0.42263 |
| ZM:ES       | 4.89  | 0.66     | 7.37| 0.00072 |
Leave-One-Out Validation

Pearson cor: 0.86
Kendal cor: 0.78
Avg. error rate: 11%
Applications of the model

- Early evaluation of game design
- Market value assessment before publishing

1. Optimize the odds of successful investments
2. Target more accurately the provision of better entertaining experience.
Ongoing Work & Future Plan

- More sophisticated modelings and more validations
  - Game addictiveness may change over a game’s lifetime

- Develop models that can explain WHY a game’s lifetime is longer than another?
  - Due to particular game designs?
  - Due to commercial promotions or others?
Thank You!

Kuan-Ta Chen
Academia Sinica

http://www.iis.sinica.edu.tw/~swc