Mon 10/1 Internet Telemetry

Wed 9/26 Difficulty

Fri 9/28 Incentive Structures

Today @ 11:59pm: Alpha Report

Wed 10/3 Beta Testing 1

10/5 Beta Testing 2

Wed 10/3 @ 10:10am: Beta Prototype

10/10 Beta Testing 3

FALL BREAK

10/12
Review: Flow
Review: Flow

- Anxiety
- Boredom

Skills vs Difficulty graph with a path between Anxiety and Boredom areas.
Review: Progressions

Challenge vs Task

Mechanic 1

Mechanic 2

Mechanic 3
Today: Impact of challenge

QWOP, Bennett Foddy
Outline

- The Inverted-U Hypothesis
- Research on the Inverted-U Hypothesis
- Design considerations
Outline

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The importance of challenge for the enjoyment of intrinsically motivated, goal-directed activities

Sami Abuhamdeh and Mihaly Csikszentmihalyi

Analysis of Chess Players

- Studied impact of skill difference on fun in chess
- Measured skill through Elo ratings
  - Base score: 1400
  - Expert: 2000
  - Grandmaster: 2600
- Win probability:
  - +0 = 50%
  - +200 = 16%
  - +400 = 3%

Abuhamdeh and Csikszentmihalyi 2012
Analysis of Chess Players

Players preferred playing players ranked:

-1000   -500   0   +500   +1000

Abuhamdeh and Csikszentmihalyi 2012
Analysis of Chess Players

Players preferred playing players ranked:

0  +125  +250  +375  +500

262 points

Abuhamdeh and Csikszentmihalyi 2012
Analysis of Chess Players

Abuhamdeh and Csikszentmihalyi 2012
“Players most enjoyed competing against opponents who had ratings that were 262 points higher than their own ratings.”

“The probability of a player winning such a game is approximately 20%.”

Abuhamdeh and Csikszentmihalyi 2012
Inverted-U hypothesis
Pair activity: quick discussion

- Pick your favorite game
  - How difficult was your experience with this game?
  - Is this game easier or harder than other games?
  - Does the inverted-U hypothesis predict your engagement?
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How to design an experiment?
Experiment #1

Optimizing challenge in an educational game using large-scale design experiments

Derek Lomas, Kishan Patel, Jodi Forlizzi, Kenneth Koedinger

CHI 2013
Battleship Numberline
Large-scale experiment

Click on fraction

Type fraction

Smaller ship

Larger ship

Less time

More time
Impact of input type

Click on fraction

Type fraction

Lomas et al. CHI 2013
Impact of target size

Smaller ship  Larger ship

Lomas et al. CHI 2013
Impact of time limit

Less time

More time

Lomas et al. CHI 2013
Experiment: 28,800 conditions!

- Input types: *click on number line vs. type fraction*
- Ship sizes: 4, 6, 8, 10, 16, 20, 24, 30, 40%
- Time limits: 2, 3, 4, 5, 8, 10, 15, 30 seconds
Experiment: 70,000 people

Lomas et al. CHI 2013
Results

- Clicking on target = more time played
- Bigger target = more time played
- Longer time limit = more time played
Inverted U?

Lomas et al. CHI 2013
“In contrast to the Inverted-U hypothesis, which predicts that a moderate level of challenge should lead to maximum engagement, we found that the easier the game, the longer people played”

Lomas et al. CHI 2013
Supports Inverted-U hypothesis?
Experiment #2

Operationalising and Evaluating Sub-Optimal and Optimal Play Experiences through Challenge-Skill Manipulation

Madison Klarkowski, Daniel Johnson, Peta Wyeth, Mitchell McEwan, Cody Phillips, Simon Smith

CHI 2016
Review: *Left 4 Dead 2*

Review: *Left 4 Dead 2*

Boredom
Overload
Balanced
Overall

Klarkowski et al. CHI 2016
Positive Affect

Klarkowski et al. CHI 2016
Negative Affect

Klarkowski et al. CHI 2016
Supports Inverted-U hypothesis?
Not another Z piece!: Adaptive Difficulty in TETRIS
Katta Spiel, Sven Bertel, Fares Kayali
CHI 2017
Tetris

Score: 3780
Level: 3
Lines: 32
Bastet
Analysis of Tetris

Closed Holes

Pile Height

Bumpiness
The sum of column-wise differences

Spiel et al. CHI 2017
Algorithms

- **Nicetris**
  - Ranks pieces by current goodness-of-fit, chooses best

- **Bastet**
  - Ranks pieces by current goodness-of-fit, chooses worst

- **Grab Bag (original game)**
  - Pieces drawn randomly without replacement

- **True Random**
  - Pieces chosen randomly at all times

- **Skewed Random**
  - 50% probability of | or |, otherwise random
Pair activity: rank easiest → hardest

- **Nicetris**
  - Ranks pieces by current goodness-of-fit, chooses best
- **Bastet**
  - Ranks pieces by current goodness-of-fit, chooses worst
- **Grab Bag (original game)**
  - Pieces drawn randomly without replacement
- **True Random**
  - Pieces chosen randomly at all times
- **Skewed Random**
  - 50% probability of  or  , otherwise random
Performance: Lines cleared

- Nicetris
- Grab bag
- True Random
- Skewed Random
- Bastet

Spiel et al. CHI 2017
Perceived difficulty

Spiel et al. CHI 2017
Pair activity: rank least fun → most fun

- **Nicetris**
  - Ranks pieces by current goodness-of-fit, chooses best

- **Bastet**
  - Ranks pieces by current goodness-of-fit, chooses worst

- **Grab Bag (original game)**
  - Pieces drawn randomly without replacement

- **True Random**
  - Pieces chosen randomly at all times

- **Skewed Random**
  - 50% probability of  or  , otherwise random

Spiel et al. CHI 2017
Fun

Spiel et al. CHI 2017
Fun vs. Difficulty

Spiel et al. CHI 2017
Findings

“players tended to have more fun in TETRIS the easier they perceived the game to be”

Spiel et al. CHI 2017
Findings

“Interestingly though, individually, **only eleven out of the sixteen** players found the game *more fun* when it was perceived as *less difficult.*”

“The others attributed *more fun* to algorithms they perceived as *more difficult,* indicating that engagement and enjoyment are linked differently for different types of players.”

Spiel et al. CHI 2017
Supports Inverted-U hypothesis?
Experiment #4

Is difficulty overrated?: The effects of choice, novelty and suspense on intrinsic motivation in educational games

J. Derek Lomas, Ken Koedinger, Nirmal Patel, Sharan Shodhan, Nikhil Poonwala, Jodi Forlizzi

CHI 2017
Impact of Choice

You play games for their story and experience, not for their challenge or competitiveness. Enjoy the Deus Ex experience!

Deus Ex: Human Revolution
## Choice

<table>
<thead>
<tr>
<th>Choice</th>
<th>Information about difficulty (Feedforward)</th>
<th>No Information about difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Choice</strong></td>
<td><img src="image1.png" alt="Difficulty Choice" /></td>
<td><img src="image2.png" alt="Arbitrary Choice" /></td>
</tr>
<tr>
<td><strong>No Choice</strong></td>
<td><img src="image3.png" alt="Random, No Choice" /></td>
<td><img src="image4.png" alt="Blind, Random" /></td>
</tr>
</tbody>
</table>

Lomas et al. CHI 2017
Supports Inverted-U hypothesis?

![Graph showing Engagement vs. Challenge]
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• The Inverted-U Hypothesis
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is when there's a clear idea that you come to see in the process of solving it, right?

*The Witness*
Review: Interesting decisions

“a game is a series of interesting decisions”

(GDC 2012)

Sid Meier
Search spaces

Now

Act

Act
Friday: Incentive Structures

Cow Clicker: Ian Bogost (2010)