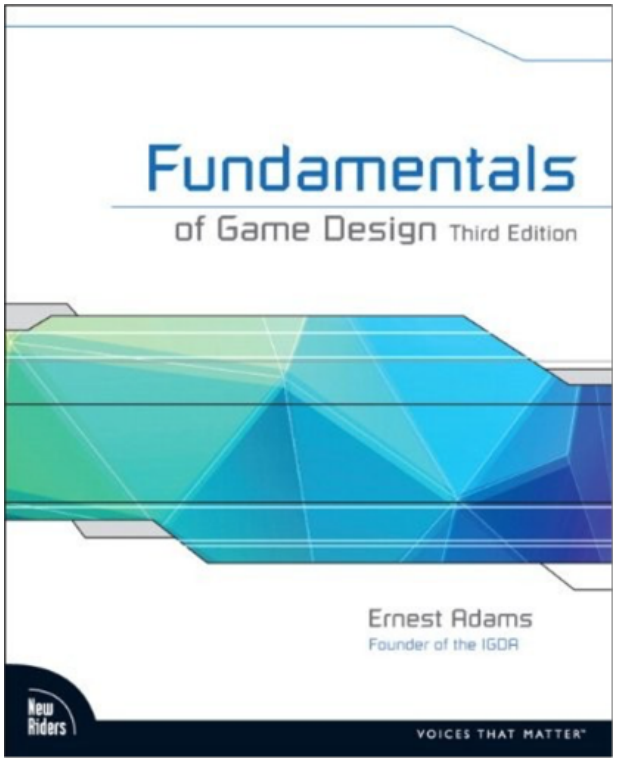
Balance and Difficulty

(Or, How I Learnt to Stop Punishing Players and Love Flow)

In This Lecture



- Balancing Mechanics
- Difficulty
- Exercise to Rebalance a Game

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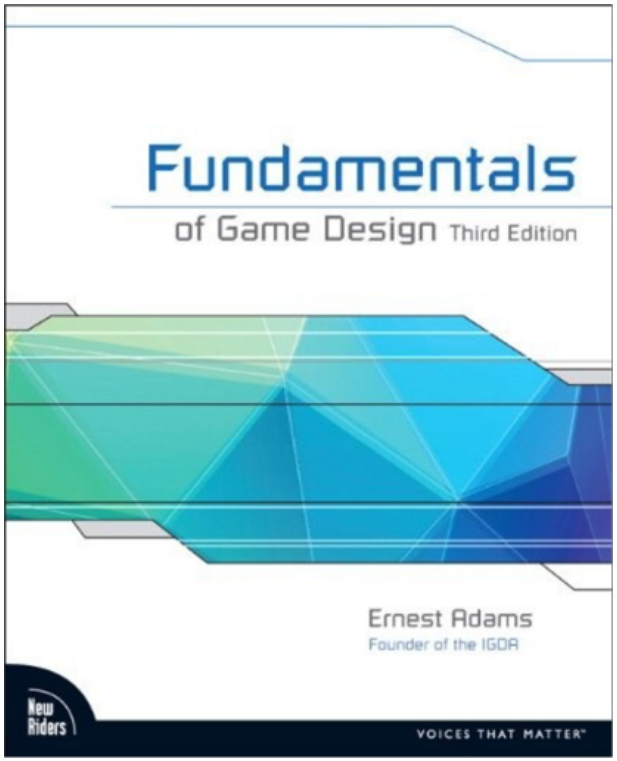

- Balancing Mechanics
- Difficulty
- Exercise to Rebalance a Game

Nothing replaces good old fashioned play testing.

Watch someone else play!

TrapAdventure 2

What is Balance?

Mario Cart

PvP
Player vs Player

PvE
Player vs Environment

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Player vs Player

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Game Provides Meaningful Choices

Players perceive the game to be fair

Chance does not outweigh player skill

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PvP
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PvE
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Chance does not outweigh player skill

Players can catch up before game end

Seldom results in stalemate

Level of difficulty should be consistent*

*does not mean it never changes

PvP fairness

Chess

- **Equal chance of winning (excepting skill)**
- Symmetry
  - starting player
- Asymmetry
  - harder to balance
  - test permutations
- Point assignment - for asymmetry
  - let player choose
  - orthogonally related

PvE fairness

Prince of Persia

- No sudden spikes in difficulty
- Avoid learn-by-dying (TrapAdventure 2!)
- Enough (in-game) information to make decisions
- Challenges should be genre-relevant
  - Avoid challenges that are non-sequiturs for this type of game
  - E.g. Critical path *Racing Game* in *RPG*

Depth vs Complexity

Dwarf Fortress

- **Depth**: amount of experiences possible from mechanics
- **Complexity**: mental burden put on player
  - data to remember
  - rules to process
  - calculations to make
  - (function of mechanics and interface)
- Complexity enables depth, but…
- Too much complexity limits depth

Depth vs Complexity

Civilization 4

- Aim for **maximum** depth, **minimum** complexity
  - Can avoid by re-using/combining mechanics
  - Or slowing down the pace of play
- Avoid **Irreducible Complexity**
  - Otherwise is impossible to learn
  - Can the player compartmentalize the system?
- James Portnow: *"Elegance is a high depth to complexity ratio – e.g. Go"*

Part I - Balancing Mechanics

Dominant Strategies

Command and Conquer

- A **clearly superior** strategy that will win
  - E.g. Tank Rush!!!
- Removes meaningful choice -> boring
- Can completely break asymmetric PvP games
- How to avoid?
  - Test to avoid unstoppable exploits
  - In live games -> buffs and nerfs
  - In design, depends on whether you have
    - Transitive or Intransitive relationships

Transitive Relationship

Frostpunk

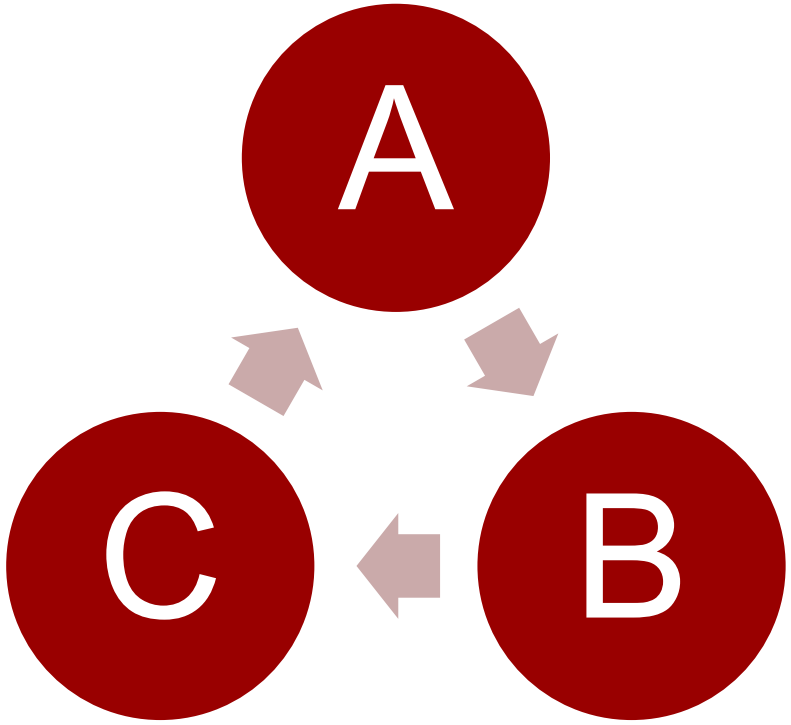
Problem:

- If A > B and B>C
- Then A > C
- Strategies: why ever use C!?

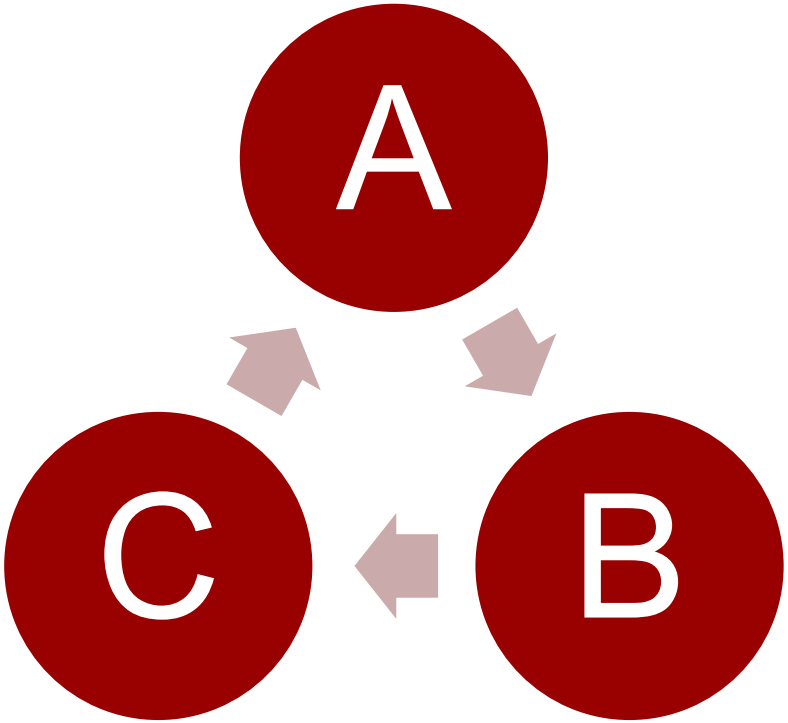
Solution:

- Impose *direct cost* (A costs more than C)
- Impose *shadow cost* (a hidden cost, or consequence, of that decision)

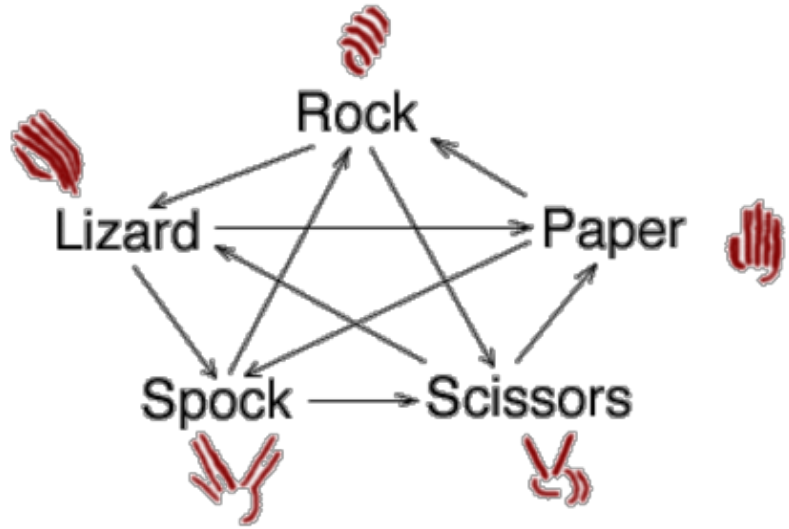
Intransitive Relationship



Intransitive Relationship



- Rock-Paper-Scissors(-Lizard-Spock)



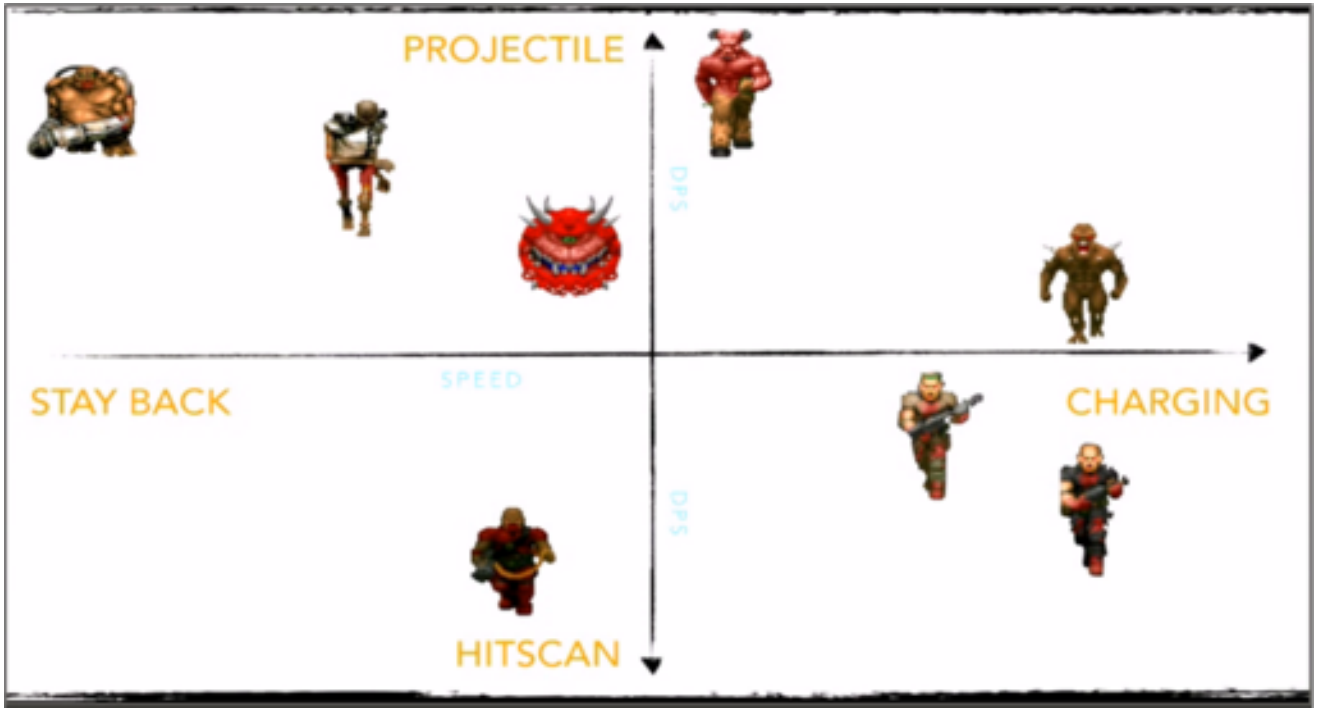
Scissors cuts Paper covers Rock crushes Lizard poisons Spock smashes Scissors decapitates Lizard eats Paper disproves Spock vaporizes Rock crushes Scissors.

http://www.samkass.com/theories/RPSSL.html

Balancing the Environment

Doom

- **Orthogonal Unit Differentiation**
- (Same for weapons/equipment)

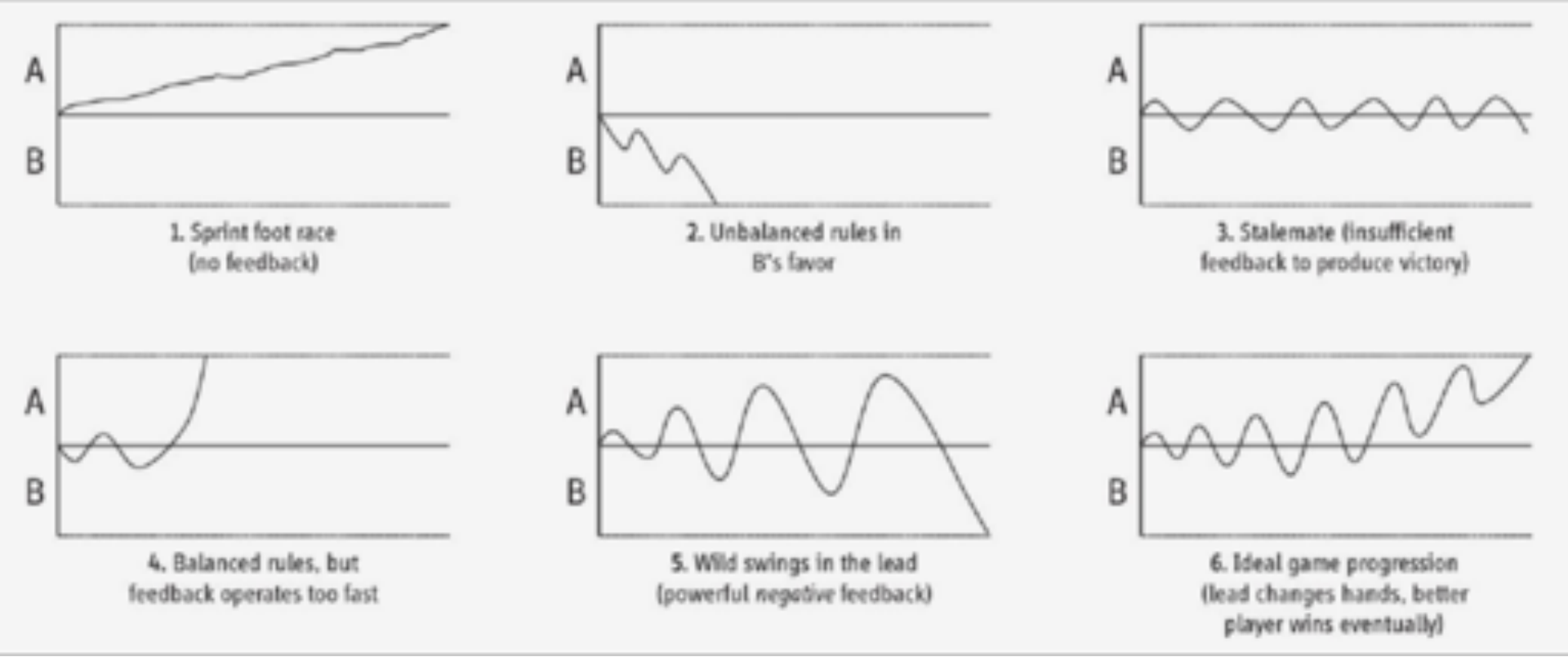


Harvey Smith, GDC 2003

Balancing Player Competition

- Feedback is when the state of the system is an input into the system
- Positive Feedback
  - Advantages to the winning player
  - E.g. FPS: weapons, equipment
- Negative feedback
  - Advantages to the losing player
  - E.g. FPS: random respawn, full health
- Need to tune feedback carefully!

Imbalanced and Ideal Feedback Loops



Controlling Positive Feedback

Fortnite

- ↗Tune the reward of power
  - ↗Artificially limit the player's power
  - ↗Associate costs
  - ↗Allow players to collaborate against leader
- ↗Raise difficulty of challenges
- ↗Use chance!

Use of Chance

Settlers of Catan

- Randomness
  - Can moderate positive feedback
- Use sparingly, and rules-of-thumb
  - Small risk & reward
  - Let player play the odds
  - Let player choose their stake

Part II - Difficulty

Challenge Hierarchy

- PvE is a series of predefined challenges
- Balancing is selecting the level and order of these!

Challenge Hierarchy

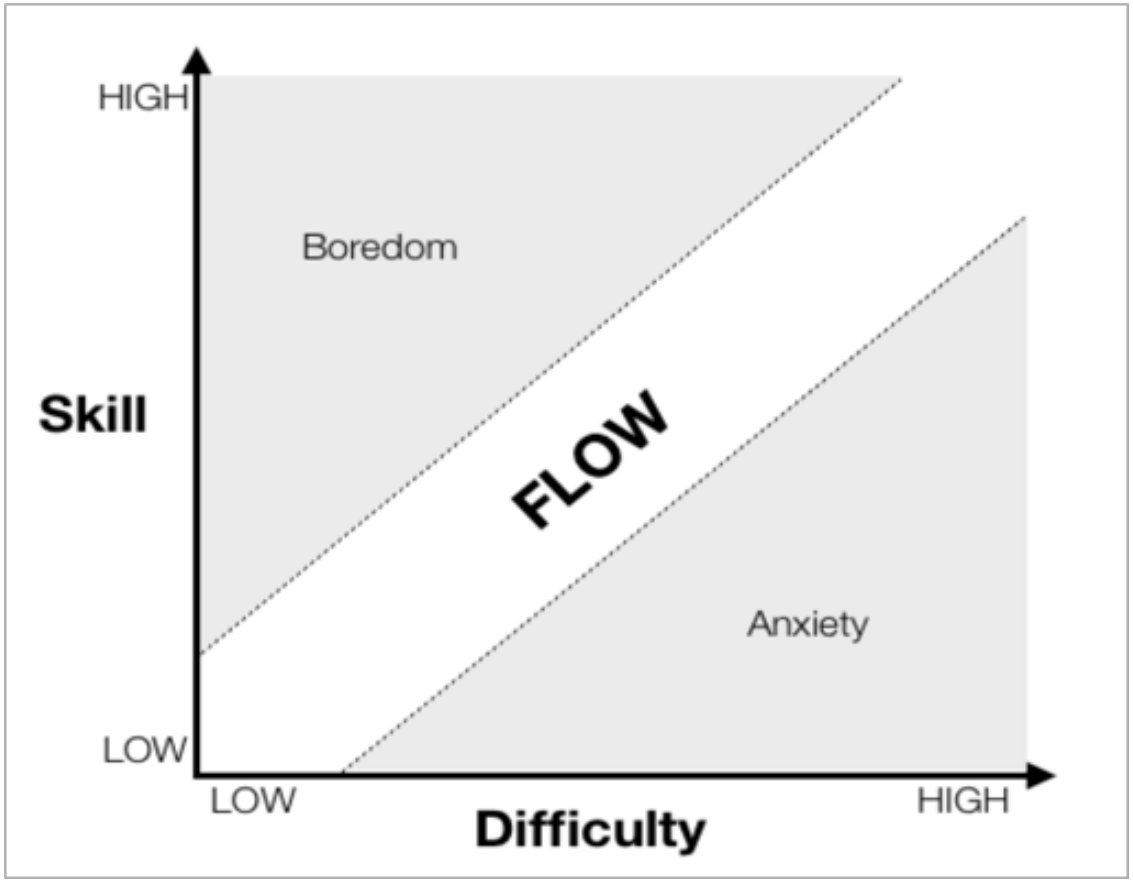
- PvE is a series of predefined challenges
- Balancing is selecting the level and order of these!

- Overlap levels
  - Give breathing space
  - Get back in the zone after a break from game

Flow

flOw

- Mihaly Csikszentmihalyi



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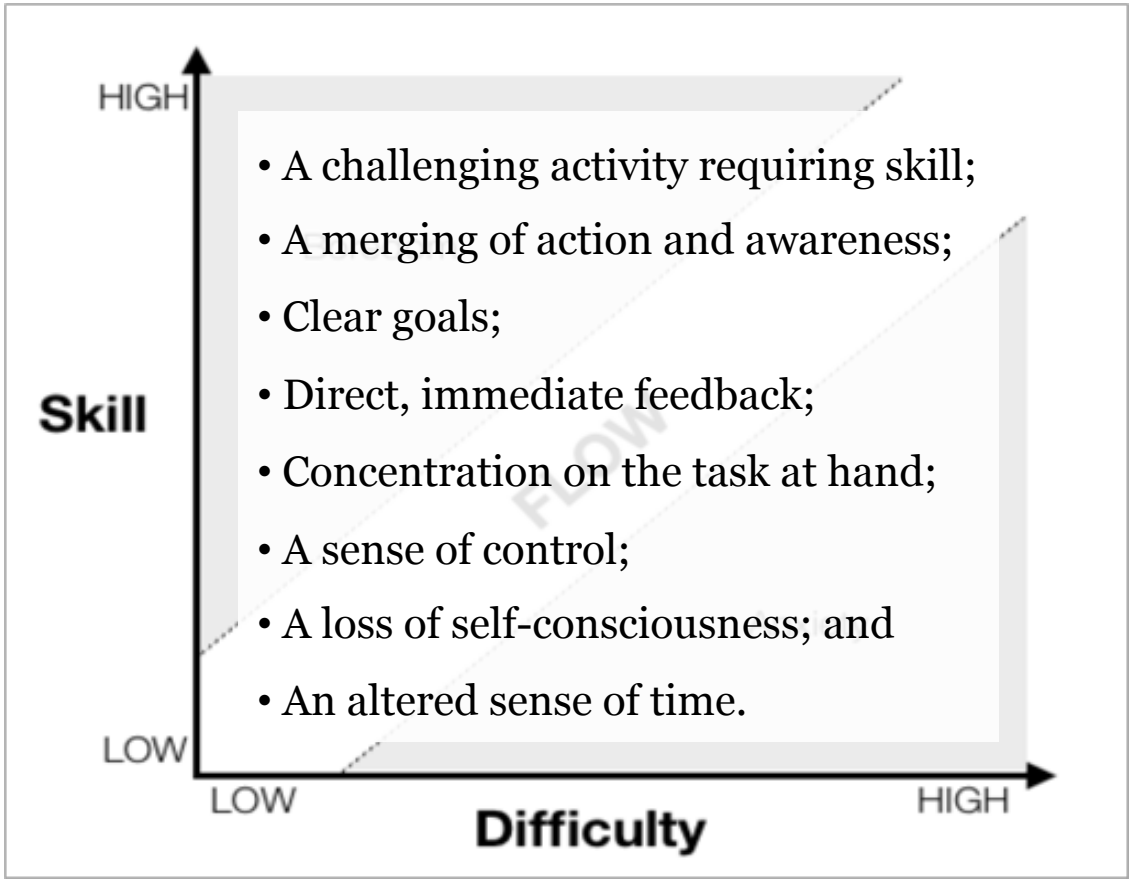
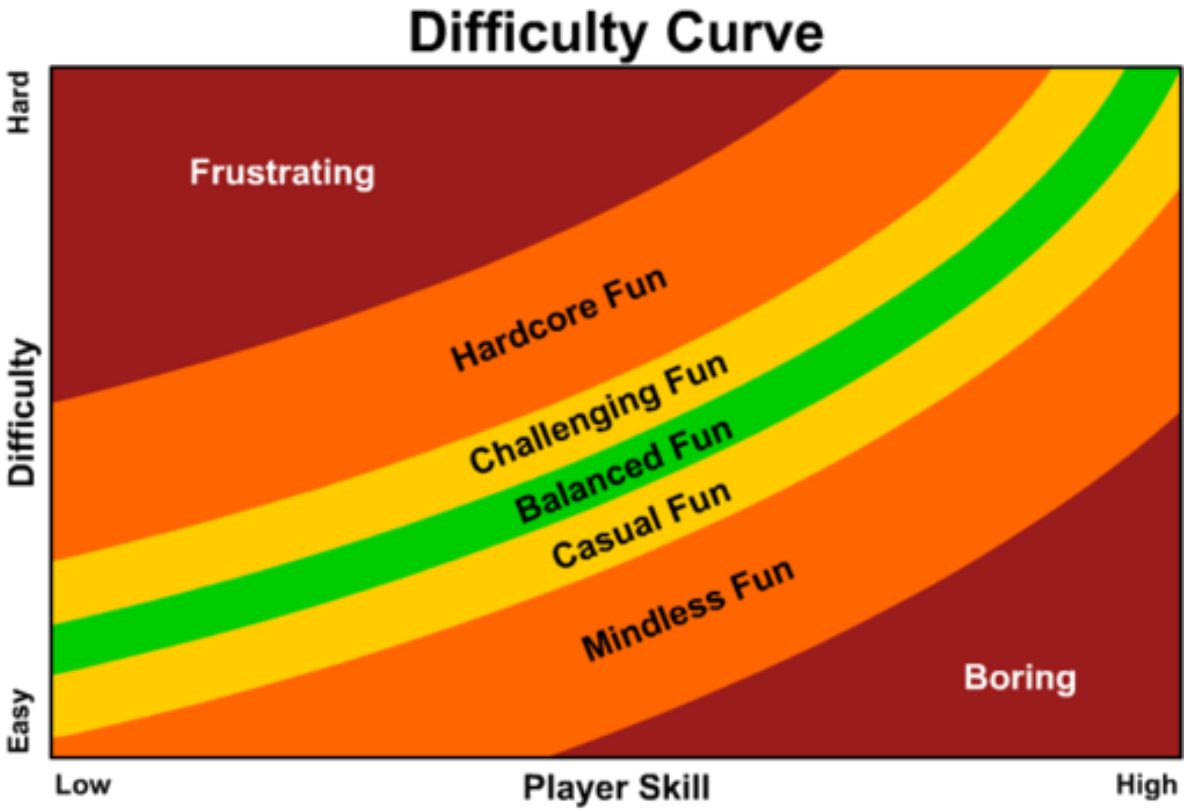


Flow

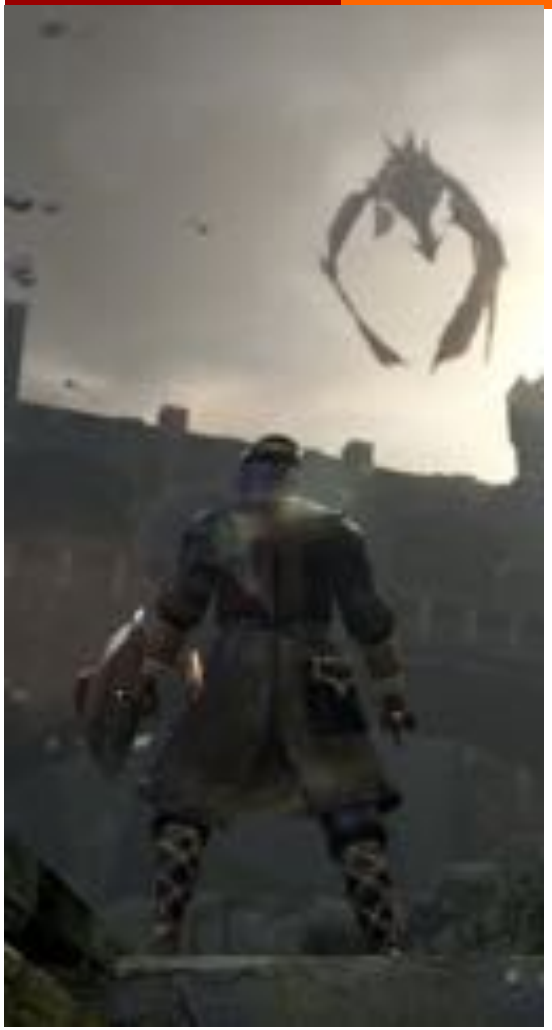
1. Know your audience
2. Underestimate the player's learning curve.
3. Don't reward skilled players by making the game easier!
4. Allow players to change the game's difficulty.

"No matter how well you balance the game yourself, unless you are the sole audience of the game, you will need to know what it's like for others"



Four Tricks to Improve Game Balance, David Maletz, Gamesutra Sept 12

Estimating Difficulty



Dark Souls (Remastered)

- **Absolute Difficulty**
  - versus trivial baseline challenge
- **Power**
  - player or avatar's strength and stats
- **Relative Difficulty**
  - absolute difficulty adjusted for power
- **In-game experience**
  - amount of practice at this type of challenge

Perceived Difficulty

We want to tune **Perceived Difficulty**

= *relative difficulty - in-game experience*
= (*absolute difficulty - power*) - *in-game experience*

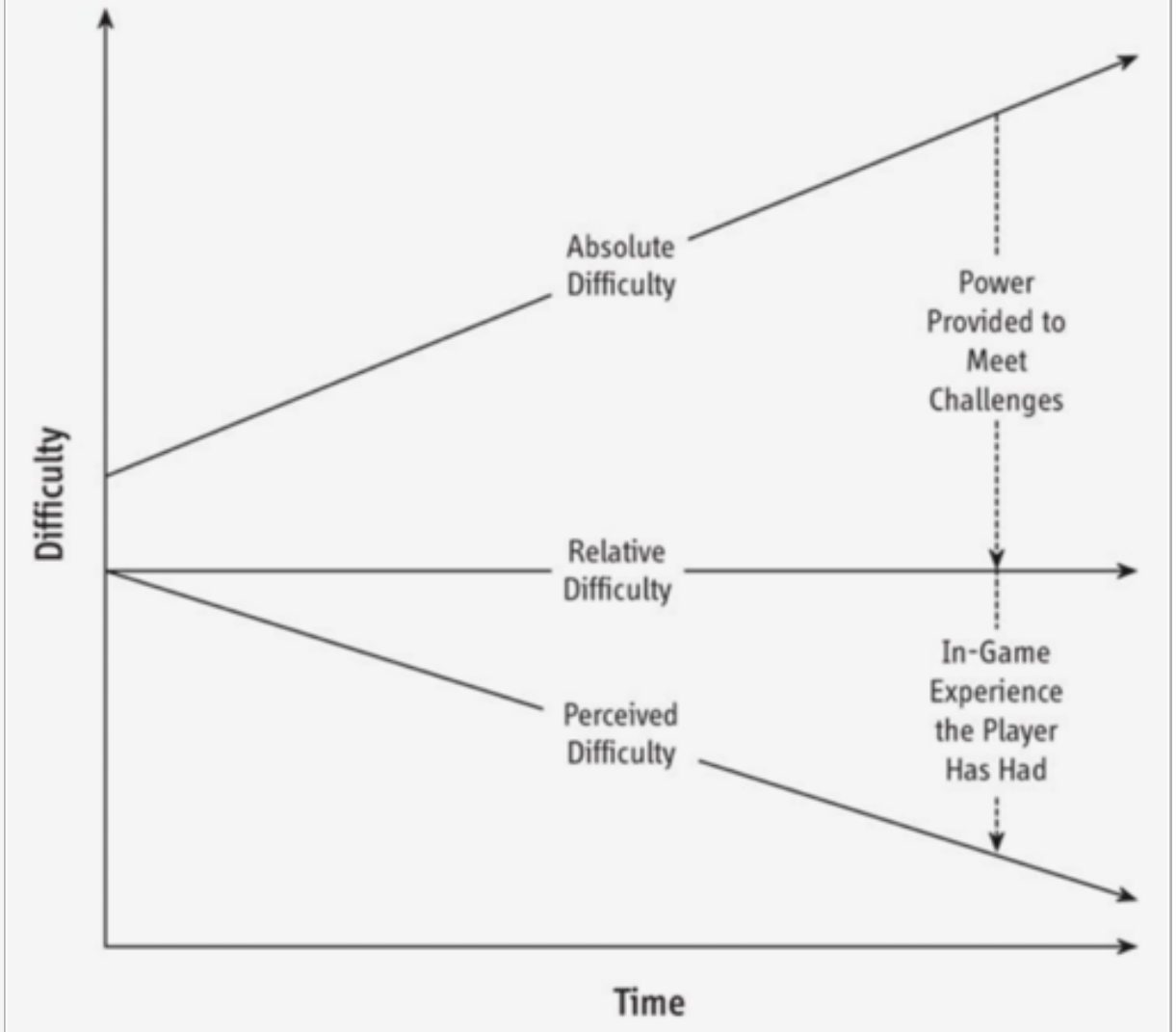
= *absolute difficulty* - (*power* + *in-game experience*)

Static Relative Difficulty

Static Relative Difficulty

means

Perceived Difficulty **must drop**

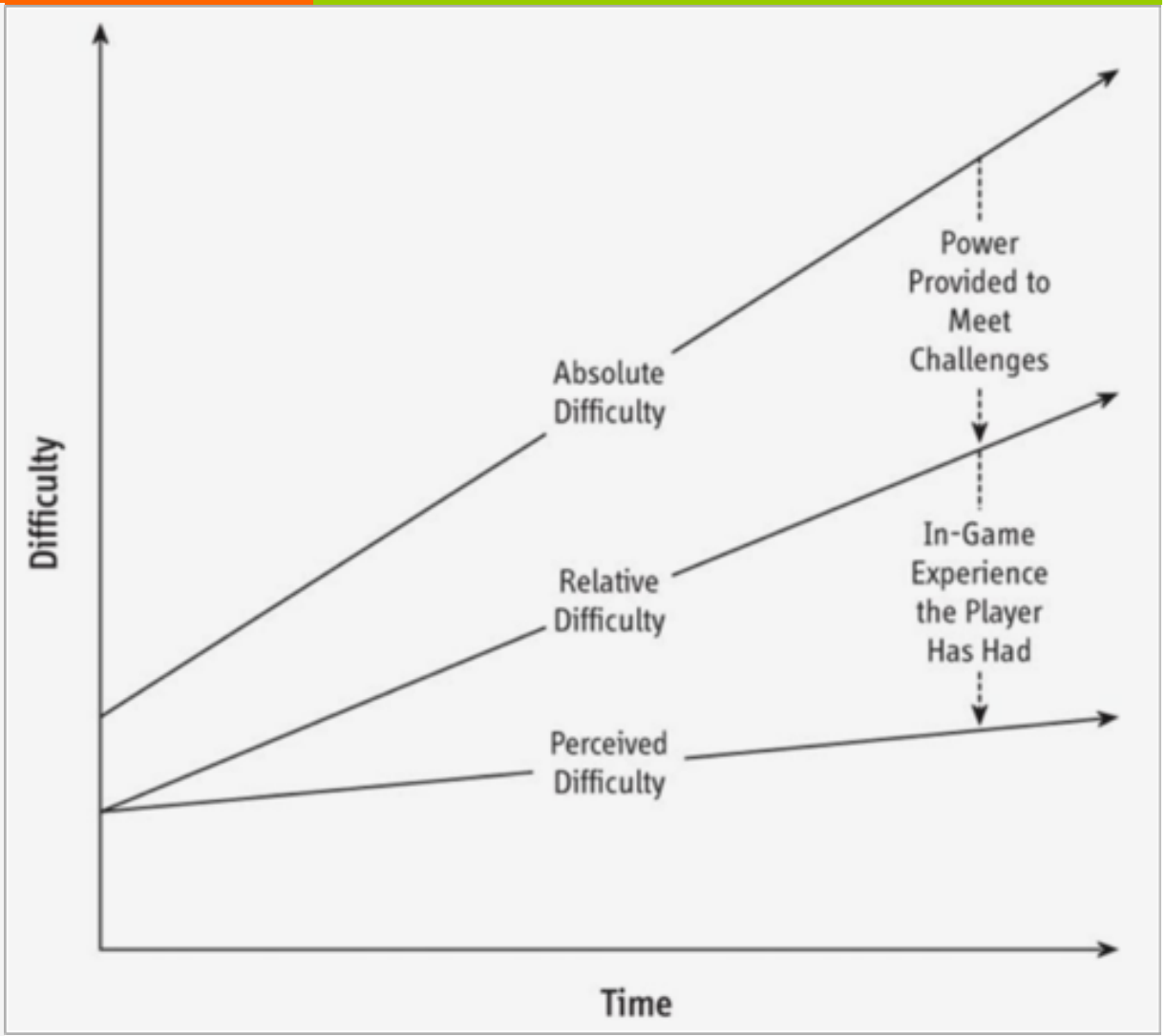


Rising Relative Difficulty

Rising Relative Difficulty

means

Perceived Difficulty **can rise**

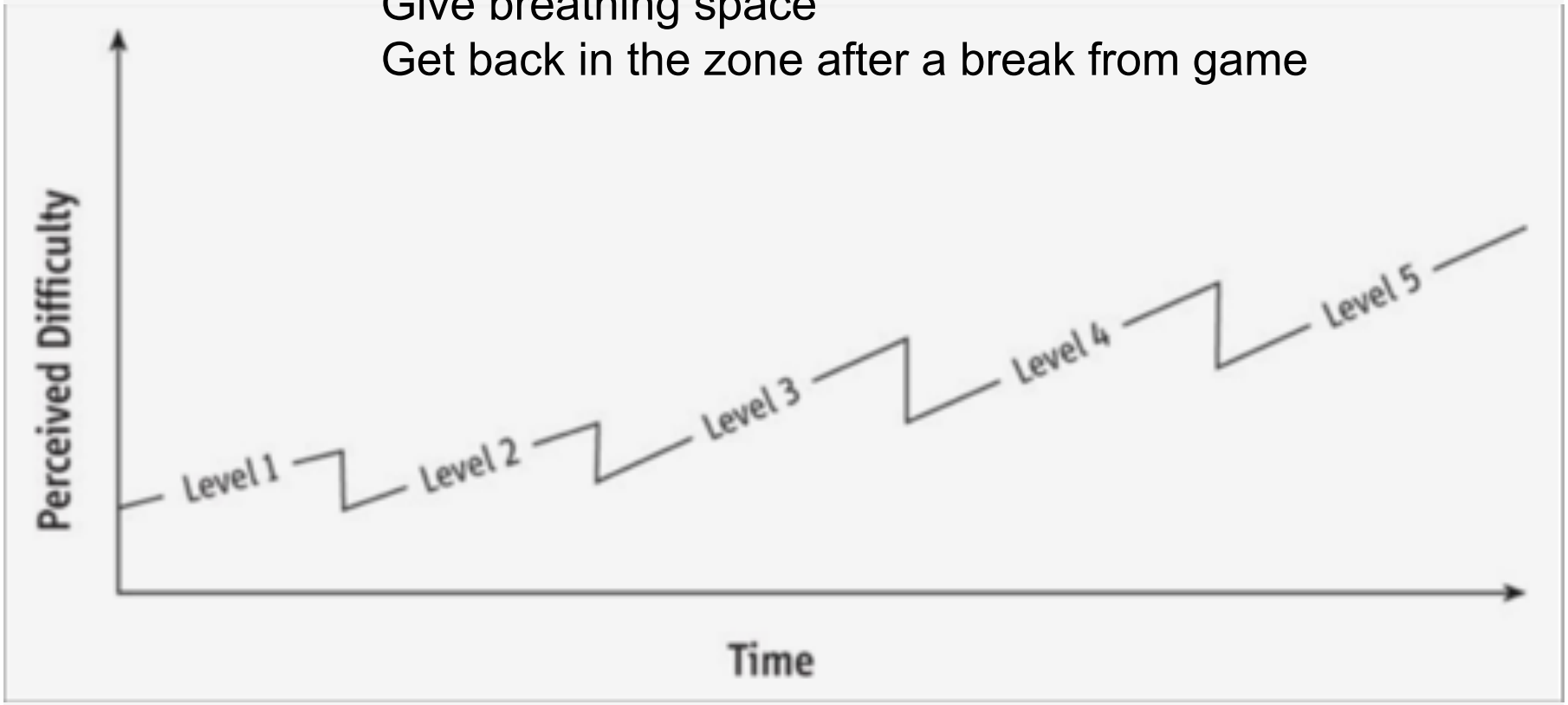


Sawtooth levels

Overlap levels

Give breathing space

Get back in the zone after a break from game



Difficulty vs Punishing

Grim Fandango

- Punishing Games
  - Make players repeatedly do the same thing with small chance of success
  - Or worse: Contain uninformed choices
  - Even worse: Have inconsistent rules (play tricks)
- Be less punishing
  - Usable controls, logical rules
  - Lower iteration times help (respawn!)
    - (TrapAdventure 2: 12 attempts in 90 sec)
- Good Designers – design to challenge
- Bad Designers – design to win!

Tuning for Median Skill

- Test with hardcore
- Test with casual
- Aim in between

Practicalities of Tuning

- Design your code to make tuning easy
  - load rules parameters from an external source *(public properties in Unity)*
  - fix the random seed
- Change 1 parameter at a time
- Binary search
- Keep records

Grim Fandango

Questions

Break

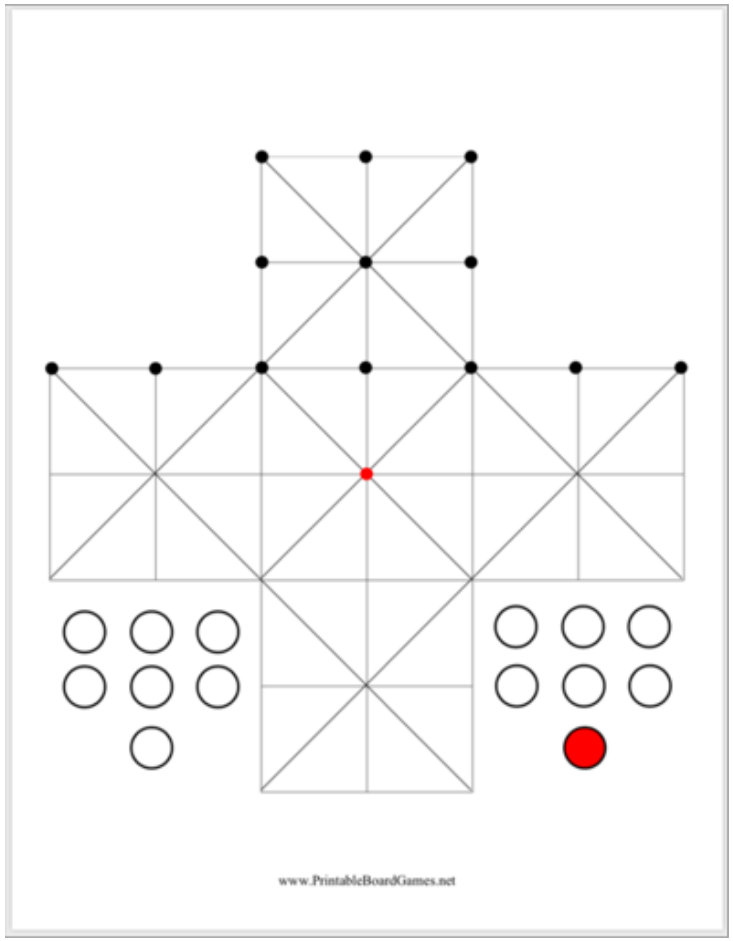
Don’t just sit there, get up, stretch, wander off (then come back)

Part III - Exercise

Balancing an Asymmetric Game

Fox and 13 Geese

- In 2-3s
- English solitaire board
- 1 fox, 13 geese
- Fox and geese can move to any empty adjacent space
- Geese cannot move backwards
- Fox can also jump over and capture
  - Chain jumps
  - Doesn't have to jump
- Game is unbalanced in favour of fox. **Fix it!**



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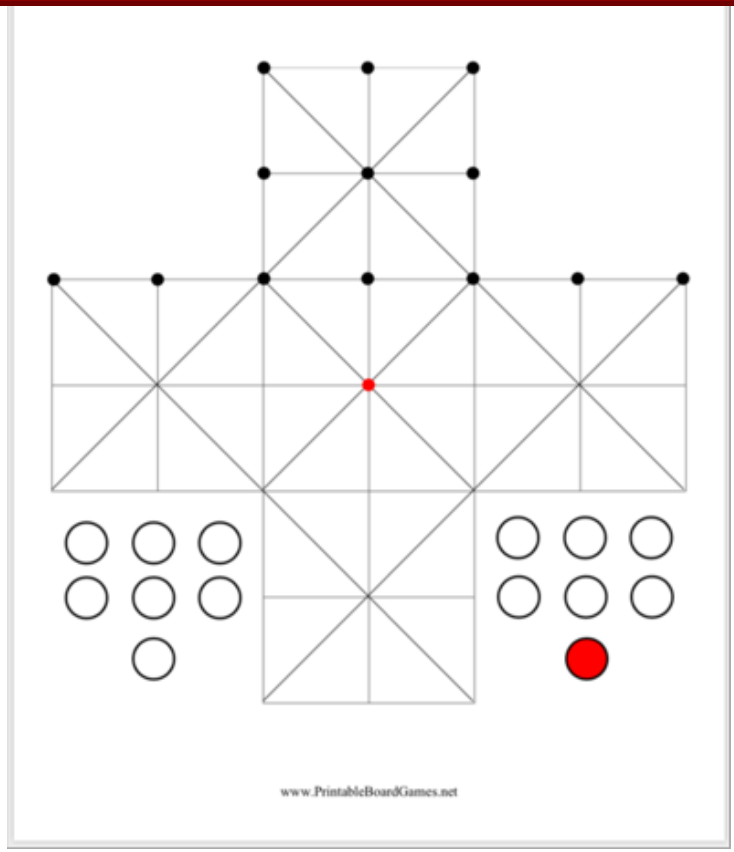
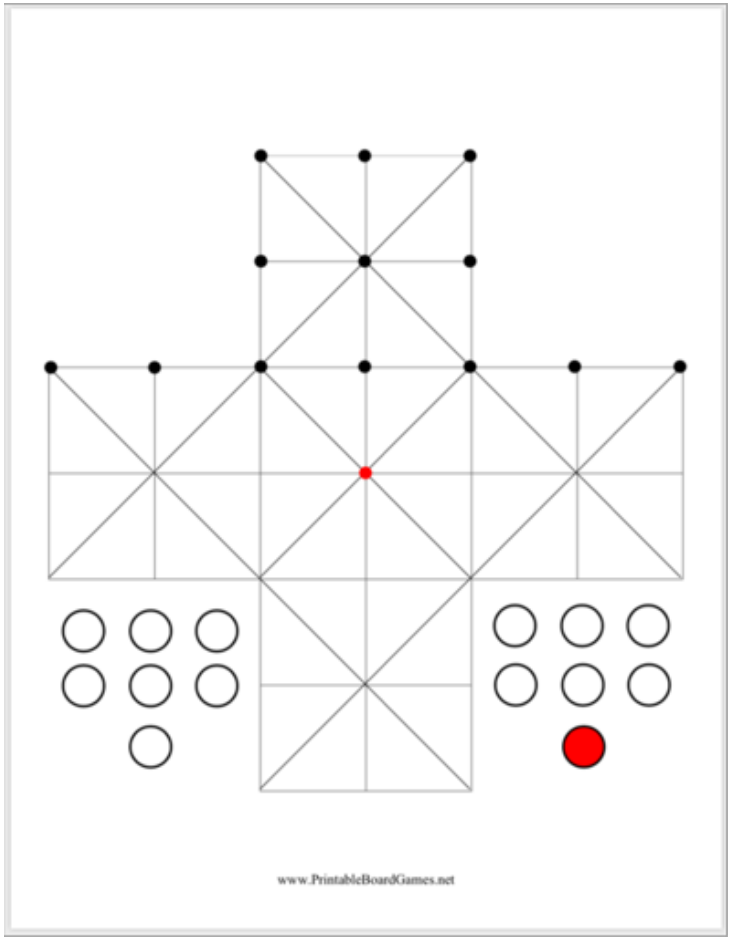
What could we vary?

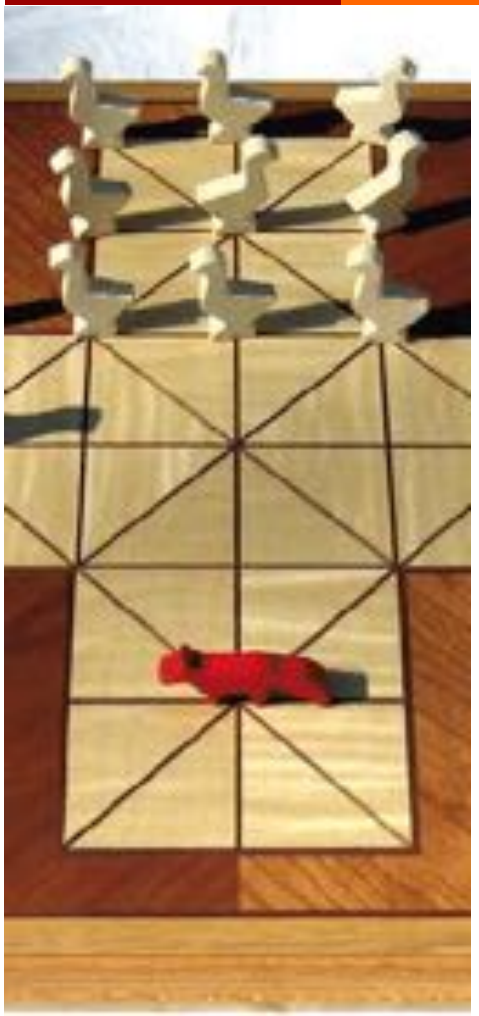


Fox and 13 Geese

- This is a two-player game. One person plays the red circle (the “Fox”) and the other player plays the thirteen white circles (the “Geese”). The two players have different objectives for winning.
- Cut out the white and red pieces. Place the Geese on the black circles along the points of the board. Place the Fox in the red circle in the middle of the board (or anywhere else on the board, for more variation).
- The Geese move first. Players alternate turns after that.
- During their respective turns, the Fox and the Geese may move along the lines in any direction, but only to the next available point.
- The Fox captures the Geese by jumping over them to a vacant spot beyond them. The Fox can jump over multiple Geese if possible.
- Geese cannot jump over each other or the Fox.
- The Geese win if they hem in the Fox and make it unable to move. The Fox wins if it captures enough Geese so that they cannot do this



Discussion



Fox and Geese

- What did you change first?
- What did you hope to achieve?

- Which changes:
  - made play time longer/shorter?
  - made fox win more?
  - made geese win more?

Strongly Solving Fox-and-Geese on Multi-core CPU

Stefan Edelkamp and Hartmut Messerschmidt

TZI, Universität Bremen, Germany

Abstract. In this paper, we apply an efficient method of solving two-player combinatorial games by mapping each state to a unique bit in memory. In order to avoid collisions, such perfect hash functions serve as a compressed representation of the search space and support the execution of an exhaustive retrograde analysis on limited space. To overcome time limitations in solving the previously unsolved game *Fox-and-Geese*, we additionally utilize parallel computing power and obtain a linear speed-up in the number of CPU cores.

1 Introduction

Strong computer players for combinatorial games like *Chess* [2] have shown the impact of advanced AI search engines. For many games they play on expert and world championship level, sometimes even better. Some games like *Checkers* [7] have been decided, in the sense that the solvability status of the initial state has been computed.

In this paper we strongly solve *Fox-and-Geese* (*Fuchs-and-Gänse*[1]), a challenging two-player zero-sum game. To the authors knowledge, *Fox-and-Geese* has not been solved yet.

Fox-and-Geese belongs to the set of asymmetric strategy games played on a cross shaped board. The lone fox attempts to capture the geese, while the geese try to block the fox, so that it cannot move.

The first probable reference to an ancestor of the game is that of *Hala-Tafl*, which is mentioned in an Icelandic saga and which is believed to have been written in the 14th century. According to various Internet sources, the chances for 13 geese are assumed to be an advantage for the fox, while for 17 geese the chances are assumed to be roughly equal.

The game requires a strategic plan and tactical skills in certain battle situations[2]. The portions of tactic and strategy are not equal for both players, such that a novice often plays better with the fox than with the geese. A good fox detects weaknesses in the set of geese (unprotected ones, empty vertices, which are central to the area around) and moves actively towards them. Potential decoys, which try to lure the fox out of its burrow have to be captured early enough. The geese have to work together in form of a swarm and find a compromise between risk and safety. In the beginning it is recommended to choose safe moves, while to the end of the game it is recommended to challenge the fox to move out in order to fill blocked vertices.

[1] http://en.wikipedia.org/w/index.php?title=Fox_games&oldid=366500050

[2] An online game can be played at http://www.osv.org/kids_zone/foxgeese/index.html

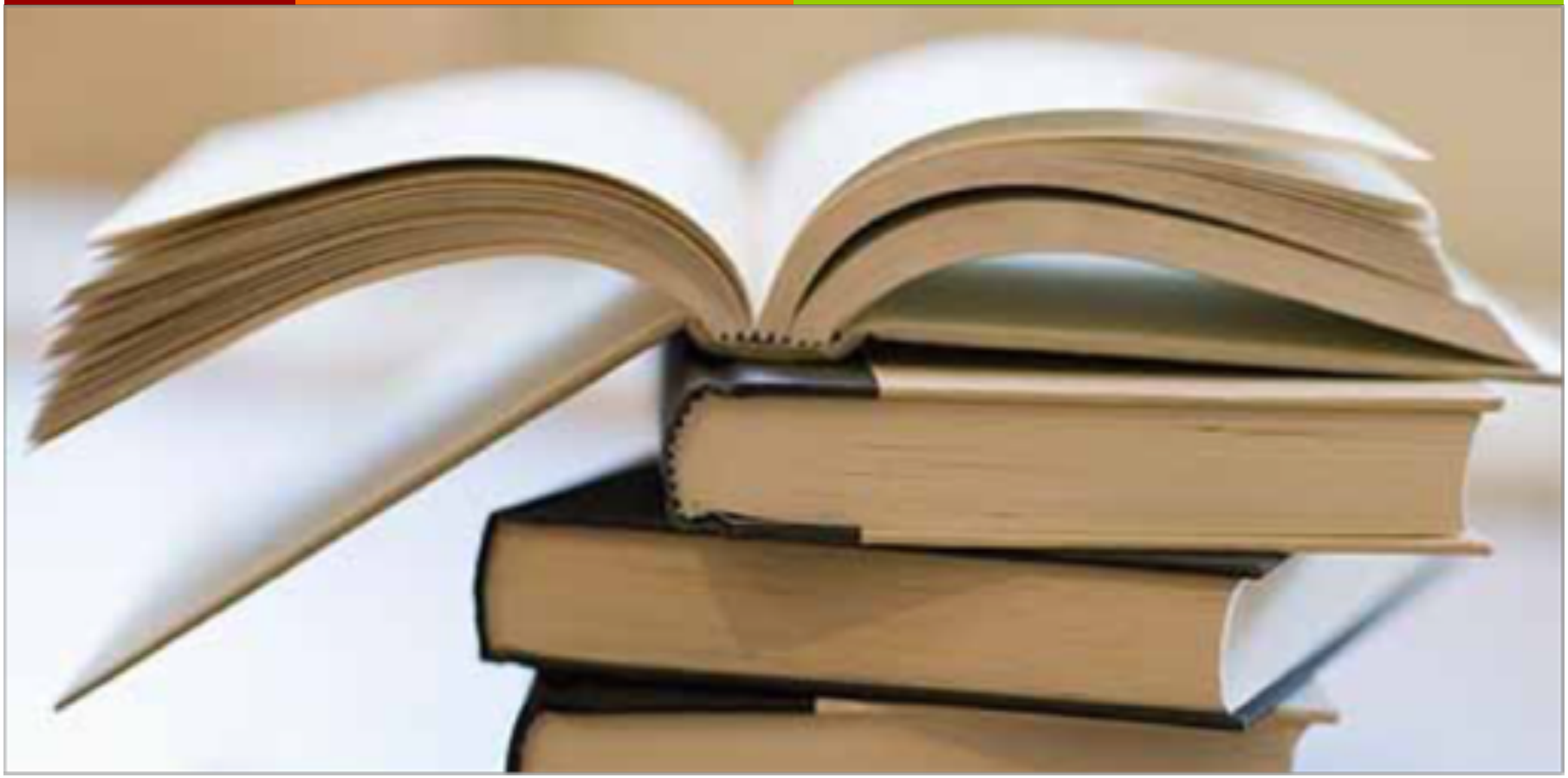
R. Dillmann et al. (Eds.): KI 2010, LNAI 6359, pp. 291–298, 2010.

Solved

Table 1. Retrograde Analysis Results for *Fox-and-Geese*

Geese	States	Space	Iterations	Won	Time Real	Time User
1	2,112	264 B	1	0	0.05s	0.08s
2	32,736	3.99 KB	6	0	0.55s	1.16s
3	327,360	39 KB	8	0	0.75s	2.99s
4	2,373,360	289 KB	11	40	6.73s	40.40s
5	13,290,816	1.58 MB	15	1,280	52.20s	6m24s
6	59,808,675	7.12 MB	17	21,380	4m37s	34m40s
7	222,146,996	26 MB	31	918,195	27m43s	208m19s
8	694,207,800	82 MB	32	6,381,436	99m45s	757m0s
9	1,851,200,800	220 MB	31	32,298,253	273m56s	2,083m20s
10	4,257,807,840	507 MB	46	130,237,402	1,006m52s	7,766m19s
11	8,515,615,680	1015 MB	137	633,387,266	5,933m13s	46,759m33s
12	14,902,327,440	1.73 GB	102	6,828,165,879	4,996m36s	36,375m09s
13	22,926,657,600	2.66 GB	89	10,069,015,679	5,400m13s	41,803m44s
14	31,114,749,600	3.62 GB	78	14,843,934,148	5,899m14s	45,426m42s
15	37,337,699,520	4.24 GB	73	18,301,131,418	5,749m6s	44,038m48s
16	39,671,305,740	4.61 GB	64	20,022,660,514	4,903m31s	37,394m1s
17	37,337,699,520	4.24 GB	57	19,475,378,171	3,833m26s	29,101m2s
18	31,114,749,600	3.62 GB	50	16,808,655,989	2,661m51s	20,098m3s
19	22,926,657,600	2.66 GB	45	12,885,372,114	1,621m41s	12,134m4s
20	14,902,327,440	1.73 GB	41	8,693,422,489	858m28s	6,342m50s
21	8,515,615,680	1015 MB	36	5,169,727,685	395m30s	2,889m45s
22	4,257,807,840	507 MB	31	2,695,418,693	158m41s	1,140m33s
23	1,851,200,800	220 MB	26	1,222,085,051	54m57	385m32s
24	694,207,800	82 MB	23	477,731,423	16m29s	112m.35s
25	222,146,996	26 MB	20	159,025,879	4m18s	28m42s
26	59,808,675	7.12 MB	17	44,865,396	55s	5m49s
27	13,290,816	1.58 MB	15	10,426,148	9.81s	56.15s
28	2,373,360	289 KB	12	1,948,134	1.59s	6.98s
29	327,360	39 KB	9	281,800	0.30s	0.55s
30	32,736	3.99 KB	6	28,347	0.02s	0.08s
31	2,112	264 B	5	2001	0.00s	0.06s

Reading List



Chapter 15 and 13 of “Fundamentals of Game Design”
Chapter 10 of “Game Design Workshop”

Play List

Super Meat Boy

- Play (or Let's Play) a hard game:
  - Anything by FromSoftware
    - Demon's Souls
    - Dark Souls
    - Bloodborne
  - Super Meat Boy
  - Hotline Miami
- Consider:
  - How does it avoid being punishing?
  - How does it remain feeling fair?

Summary

Bloodborne

- *Depth* is not *Complexity*
- Avoid *Dominant Strategies*
- Do you have *Transitive* or *Intransitive* relationships
- Are your *Feedback Loops* working?
- Use *Chance* sparingly and carefully
- Create a *Challenge Hierarchy*
- Aim for *Flow* (balance of difficulty and skill)
- Aim for rising *Perceived Difficulty*
- Aim for *Difficulty* not *Punishment*

- ***Playtest* and *Tune* (a lot!)**

Thank You

COMP3218 Website: https://secure.ecs.soton.ac.uk/module/COMP3218/

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