



UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI INFORMATICA

OGD Lesson 006: System dynamics

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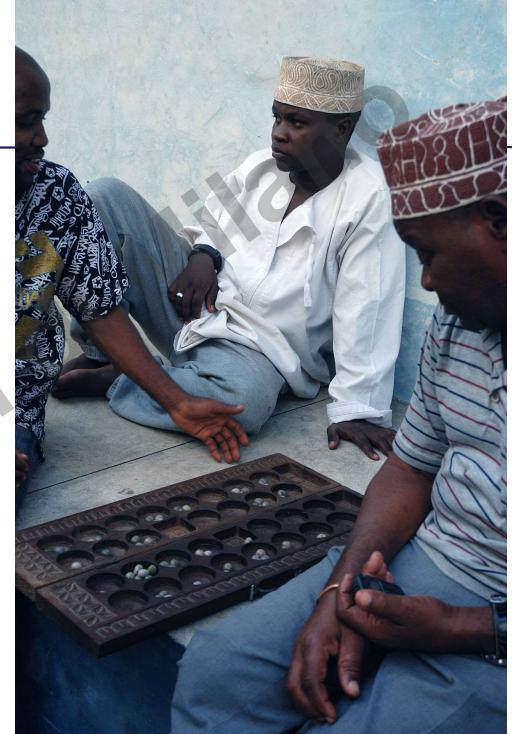
006. Summary

- Games as Systems
- System Dynamics
- Interacting with Systems
- Game balancing
- References:
 - Chapter 5 “Game Design Workshop” by T. Fullerton
 - Chapter 12, 13 «The art of game design» by J. Schell
- Suggested readings:
 - “Games Are Math: 10 Core Mechanics that Drive Compelling Gameplay”
by R. Koster



Questions & definitions ...

1. how the elements (Formal & dramatic) fit together to form playable systems?
2. how designers can work with system properties to **balance** the dynamic nature of games?



A **system** can be defined as:
a set of *interacting elements*
that form *an integrated whole*
with a *common goal or purpose*

Games are systems

- Systems exist wherever we see complex behaviours emerging from the interaction among discrete elements
- At the heart of every game is a **set of formal elements** that, **when set in motion, create a dynamic experience** in which the players engage



- How the **interaction of the formal & dramatic elements** is structured forms the game's underlying system and determines the nature of the game and the experience of the players



Games are systems!

- systems:
 - Simple or complex
 - precise, predictable results,
or
widely varied, unpredictable effects

- It's up to the GD to find the **perfect mix** ...



Basic elements of systems

- The basic elements of systems are:
 1. Objects
 2. Properties
 3. Behaviors
 4. Relationships
- **Objects** within the system interact with each other according to their **properties**, **behaviors**, and **relationships**, causing **changes** to the system state
- How those changes are manifested depends on the nature of the objects and interactions



1. Objects

- basic **building blocks** of a system
- Systems can be thought of as **a group of interrelated pieces** (objects), which can be **physical, abstract, or both:**
 - Pieces/pawns
 - in-game concepts (Monopoly's bank)
 - Players or their representations (e.g. avatars)
 - squares on a grid board
 - yard lines on a playing field
 - ...



2. Properties

- qualities or attributes that define physical or conceptual aspects of objects (set of values that describe the object => e.g. stats)



- descriptive data that can be essential to determining interactions of objects in a game system:
 - The simplest types of game objects have very few properties, and those properties do not change based on gameplay (e.g. checkers)



2. Properties

- Checkers have only three properties:
 - **Color:** B/W - *never changes*
 - **Location:** coordinates in the grid - *can change*
 - **Type:** normal/king - *can change*



three properties completely define the state of each checker within a game

- What would be an example of a game object with more complex properties?
- How about a character in a RPG?



3. Behaviors

- Potential actions that an object might perform in a given state



- The more potential behaviors an object has, the less predictable its actions within the system:
 - E.g. checkers vs Diablo



Does this make the game more fun?

- Note: the addition of more potential behaviors tends to add choices and lessen the predictability of outcome in a game, not necessarily to increase fun ...

3. Behaviours ... BAO game

- You cannot predict the effect of more than 10 turns of the board ...



4. Relationships

- Relationships can be expressed in various ways (position, hierarchy, etc.):
 - How relationships are defined plays a large part in how the system develops (e.g. checkers or Monopoly vs The Sims)
- Change in relationships can be determined by:
 - choices made by the players (checkers, chess)
 - Combination of chance & rules (Warcraft combat algorithm, RPGs)

NOTE: no relationships \Leftrightarrow no system, but collection (e.g. a set of blank cards)



System dynamics

- A system requires that all elements are present for it to accomplish its goal(s)
- a system's components **must typically be arranged in a specific way**
 - if that arrangement is changed, the results of the interaction will change (imagine the effect of changing WoW combat algorithms, ...)



System dynamics

- systems are greater than the sum of their parts



- games can only be understood during play, when their dynamics become evident
- GDs have to craft a “**possibility space**” as best as possible, and playtest it as rigorously as possible, but in the end, they just do not know how each and every play of the game will go !!!

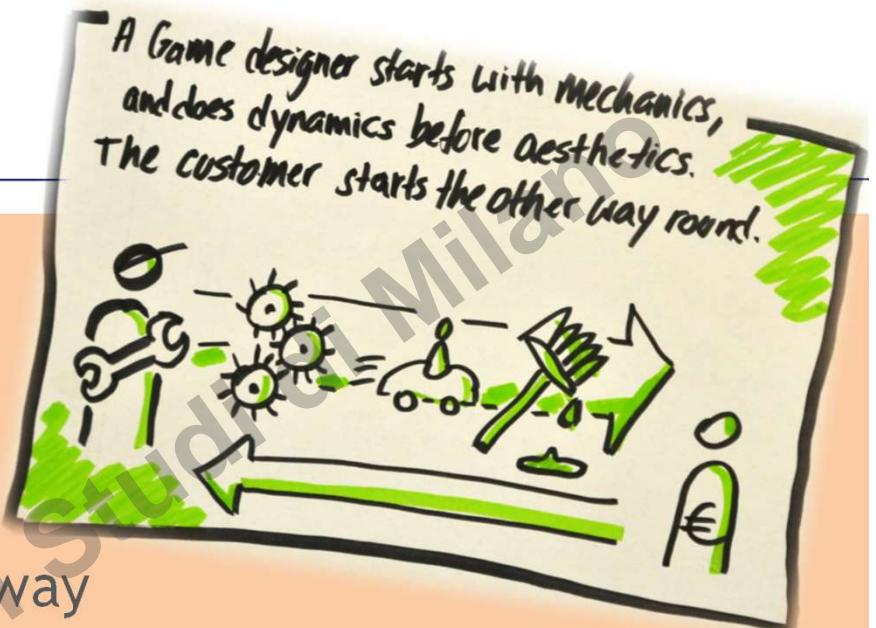
Game dynamics

Balancing your game



Game mechanics

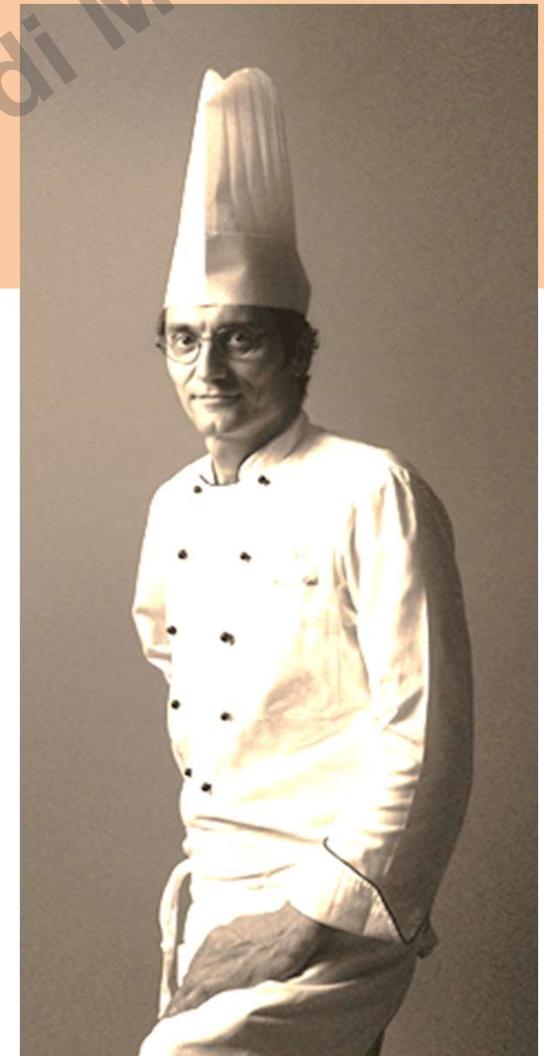
- GMs are **the core of what a game truly is**
 - Interactions & relationships remaining after aesthetics, technology and story are stripped away
- No universally agreed upon taxonomy
 - Mechanics of each game are quite complex and difficult to disentangle
 - They are strictly related to mental models ... !!! => difficult to describe



Game dynamics emerge from mechanics and need to be balanced!

Game balancing

- **Balancing a game** = adjusting its elements until they deliver the experience you want!
- It's the most artful part of GD
 - Understanding & managing the subtle nuances in the relationships among the game elements
 - It's like a «chef» creating a new recipe!



Several aspect to balance in games

1. Fairness
2. (challenge & success => flow)
3. Meaningful choices
4. Skill vs chance
5. Heads vs hands
6. Short vs long

Strictly related to
specific audience

1. Balancing fairness

- **Symmetrical** games
 - All the players have equal resources and powers (checkers, chess Monopoly, etc.)
- **Asymmetrical** games
 - Opponents have different resources and abilities to:
 - Simulate real-world situations
 - Give players another way to explore the game space
 - Personalize
 - Level the playing field
 - Create interesting situations
 - Etc.



1. Fairness: balancing asymmetrical games

Plane	Speed	Maneuverability	Firepower
Piranha	Medium	Medium	Medium
Revenger	High	High	Low
Sopwith Camel	Low	Low	Medium

How can we balance this?



1. Fairness: balancing asymmetrical games

Plane	Speed	Maneuverability	Firepower	Totals
Piranha	Medium (2)	Medium (2)	Medium (2)	6
Revenger	High (3)	High (3)	Low (1)	7
Sopwith Camel	Low (1)	Low (1)	Medium (2)	4

Unfair
advantage?

- After a certain amount of playtesting:
 - Piranha and Revenger are evenly matched because of their firepower, but Sopwith Camel is in disadvantage ...

??????

1. Fairness: balancing asymmetrical games

Plane	Speed	Maneuverability	Firepower	Totals
Piranha	Medium (2)	Medium (2)	Medium (2)	6
Revenger	High (3)	High (3)	Low (1)	7
Sopwith Camel	Low (1)	Low (1)	Medium (2)	4



Plane	Speed	Maneuverability	Firepower	Totals
Piranha	Medium (2)	Medium (2)	Medium (4)	8
Revenger	High (3)	High (3)	Low (2)	8
Sopwith Camel	Low (1)	Low (1)	Medium (4)	6

- Ok, now - with the improved model - we can balance well our game ...

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1. Fairness: balancing asymmetrical games

- Is our game now balanced?
- NOTE:
 - You **NEED** playtesting
 - **HALF** the development time is devoted to balancing
 - Balancing can only really begin once you have a **PLAYABLE** prototype
 - Balancing improves model, which is used to improve balancing, that improves model ... etc.



PS: the lens of Fairness can be of help too ...

1. Fairness

Fairness is a slippery subject

- In some cases one side has an advantage, but the game is still fair ...
 - Player with **unequal skills**
 - **Disequalities justified by the game itself**



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The Lens of
Fairness



Illustration by Nick Daniel



To use this lens, evaluate the game from each player's point of view and skill level. Find a way to give each player a chance of winning that each will consider to be fair. Ask yourself these questions:

Illustration by Nick Daniel



To use this lens, evaluate the game from each player's point of view and skill level. Find a way to give each player a chance of winning that each will consider to be fair. Ask yourself these questions:

- Should my game be symmetrical? Why?
- Should my game be asymmetrical? Why?
- Which is more important: that my game is a reliable measure of who has the most skill, or that it provide an interesting challenge to all players?
- If I want players of different skill levels to play together, what means will I use to make the game interesting and challenging for everyone?

3. Meaningful choices

- «Good game» =>
gives players meaningful choices
 - they have an impact on the remaining of the game
- Beware of **«dominant strategies»** (exploits)
 - Once discovered the game is ruined

A good game leads players to ask questions:

- Where should I go?
- How should I spend resources?
- What should I practice and try to perfect?
- How should I dress my character?
- Should I try to get through the game quickly or carefully?
- Should I focus on offense or defense?
- What strategy should I use?
- Which power should I choose?
- Should I play it safe or take a risk?

3. Meaningful choices: which? how many?

- To determine the number of meaningful choices you need to figure out **number & types** of things players would like to do

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The Lens of
Meaningful Choices

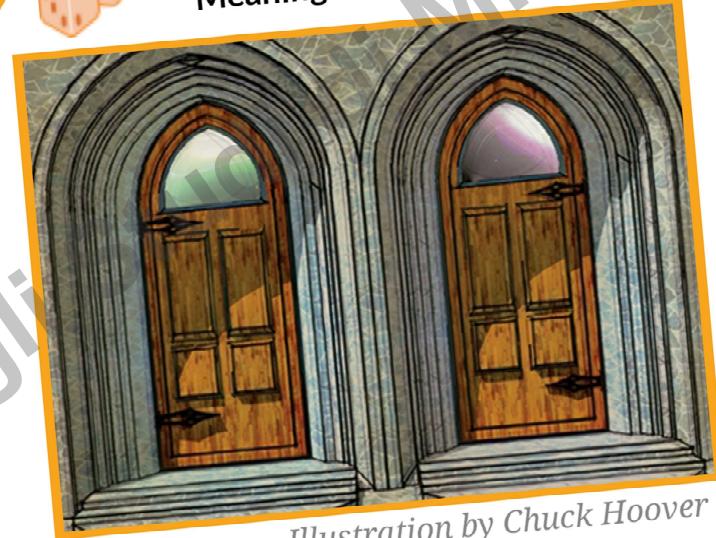


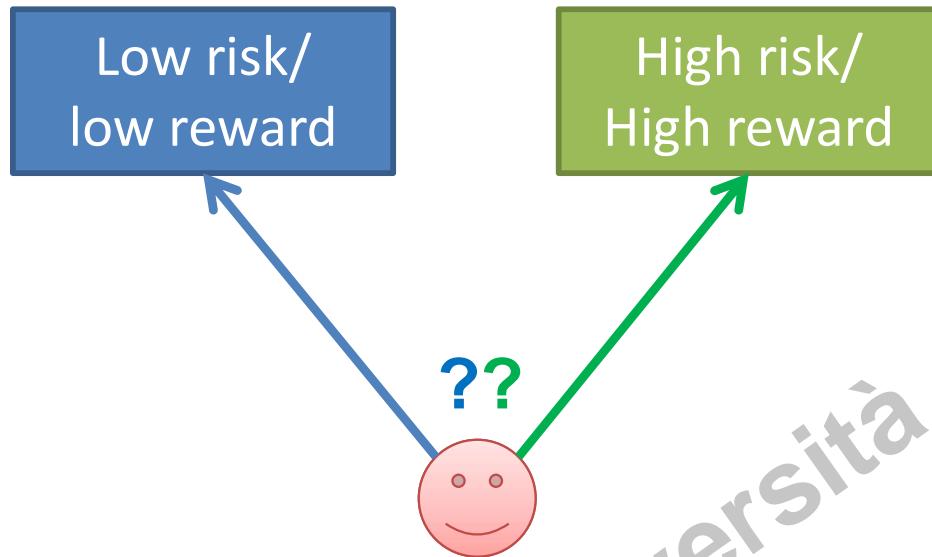
Illustration by Chuck Hoover



When we make meaningful choices, it lets us feel like the things we do matter. To use this lens, ask yourself these questions:

- What choices am I asking the players to make?
- Are they meaningful? How?
- Am I giving the player the right number of choices? Would more make them feel more powerful? Would fewer make the game clearer?
- Are there any dominant strategies in my game?

3. Meaningful choices: triangularity



Once you start looking for triangularity in games, you'll see it everywhere ...

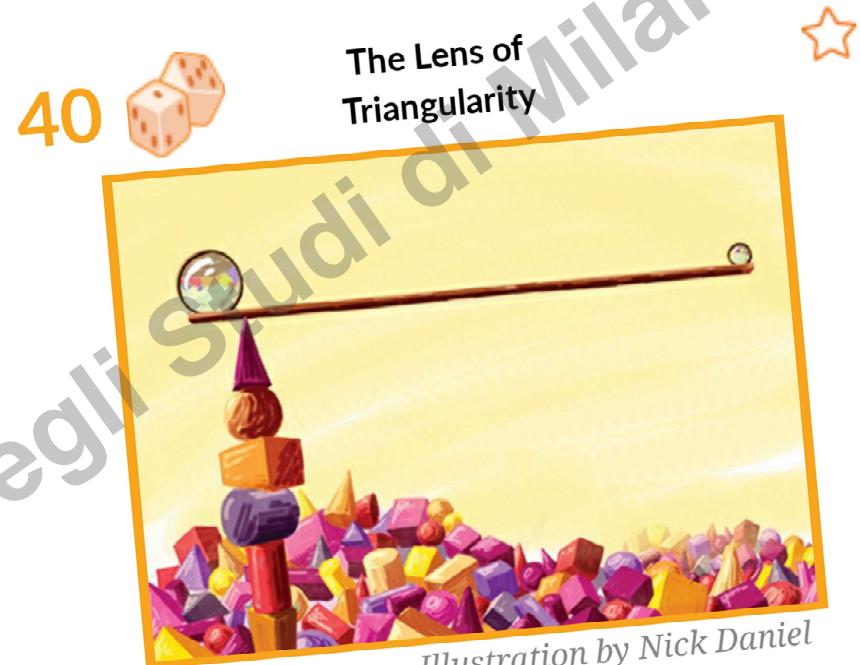


Illustration by Nick Daniel

 Giving a player the choice to play it safe for a low reward, or to take a risk for a big reward is a great way to make your game interesting and exciting. To use this lens, ask yourself these questions:

- Do I have triangularity now? If not, how can I get it?
- Is my attempt at triangularity balanced? That is, are the rewards commensurate with the risks?



3. Meaningful choices: triangularity in Mario Kart

- Manual or automatic?
- Kart or bike?
- Grab power-ups or not?
- Use power-ups or not?
- Keep the current power-up or change?
- Use speed boost pads?
- Left or right in a fork?
- Etc.



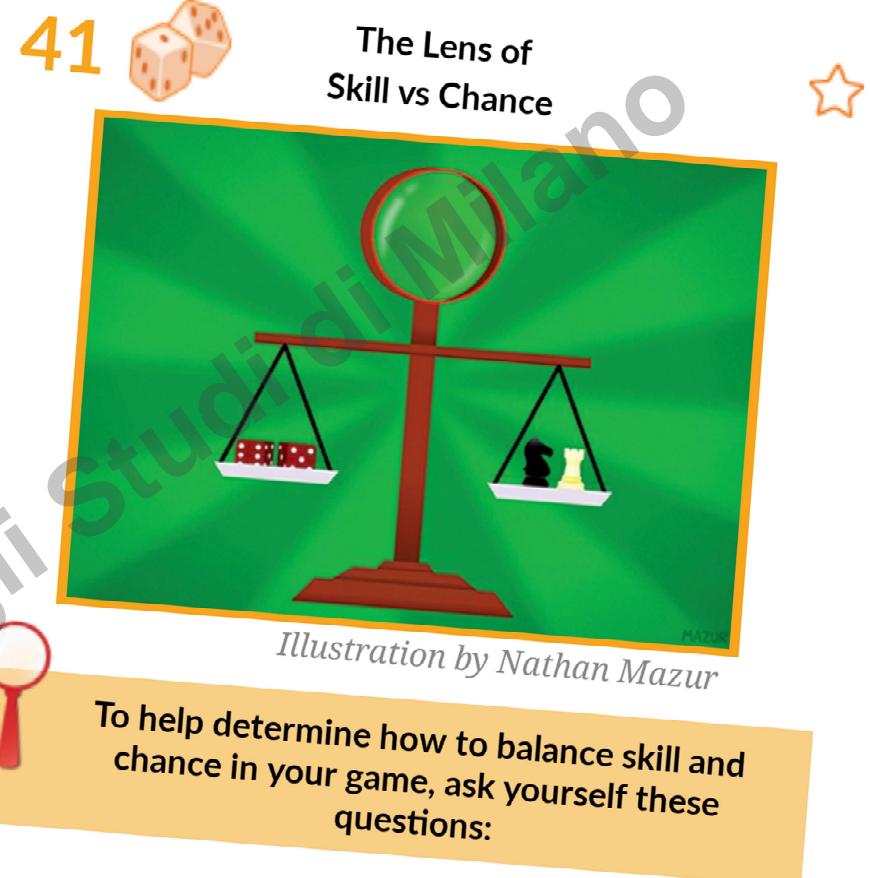
4. Skill vs chance

- Two opposing forces
- Too much chance negates the effect of player skill and vice versa
 - **Skill** games: more competitive
 - **Chance** games: more «relaxed»/casual
- How to balance skill/chance highly **DEPENDS ON YOUR AUDIENCE !!!**
 - E.g. Germans & table-top games



4. Skill vs chance

- Common balancing method:
alternate the use of chance & skill during the game
- Addictive game:
players do 3 things all the time
 - Exercise skill(s)
 - Take risks
 - Work out a strategy



- Are my players here to be judged (skill), or to take risks (chance)?
- Skill tends to be more serious than chance: Is my game serious or casual?
- Are parts of my game tedious? If so, will adding elements of chance enliven them?
- Do parts of my game feel too random? If so, will replacing elements of chance with elements of skill and strategy make the players feel more in control?

5. Head vs hands

- How much of the game should involve doing a challenging physical activity and how much of it should involve thinking?
 - These 2 aspect are NOT separated (e.g. action platformer, final boss, etc.)



- How to balance head/hands highly **DEPENDS ON YOUR AUDIENCE !!!**

— E.g. Pac-Man 2: the new adventures



5. Head vs hands

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The Lens of
Head and Hands

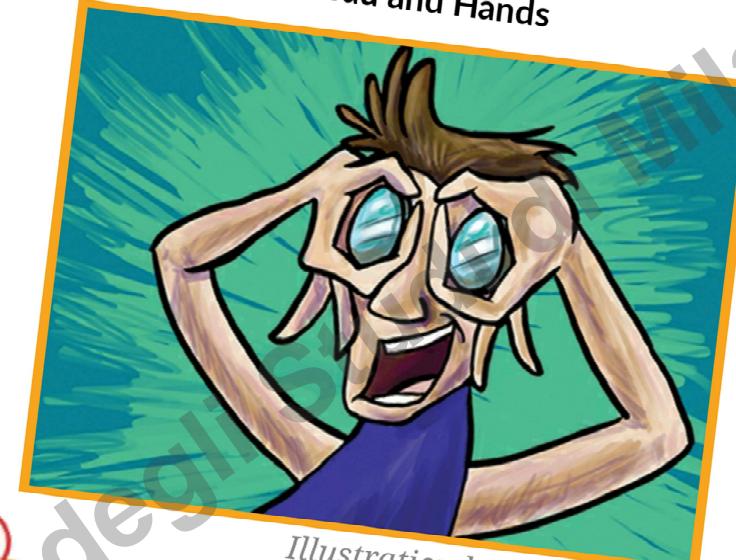


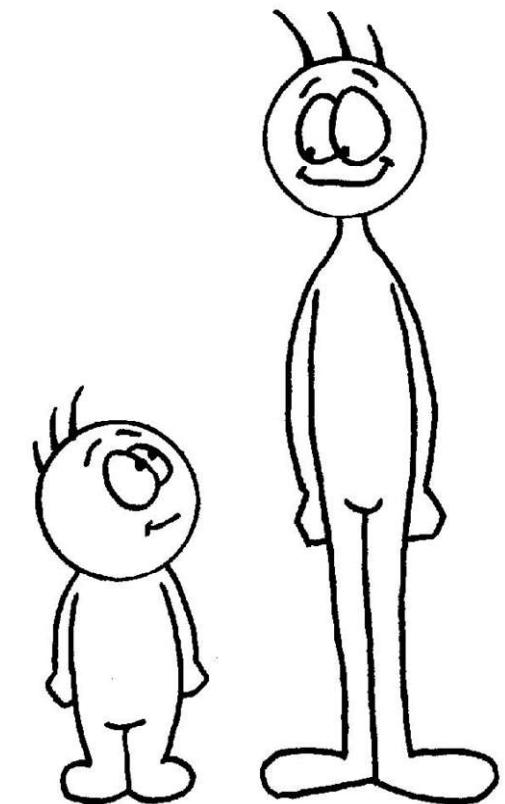
Illustration by Lisa Brown

To make sure your game has a good balance of mental and physical elements, use this lens. Ask yourself these questions:

- Are my players looking for mindless action, or an intellectual challenge?
- Would adding more places that involve puzzle solving in my game make it more interesting?
- Are there places where the player can relax their brain, and just play the game without thinking?
- Can I give the player a choice - either succeed by exercising a high level of dexterity, or by finding a clever strategy that works with a minimum of physical skill?

6. Short vs long

- It is important to balance the **length of the gameplay** ...
 - Too short: no chance to develop meaningful strategies
 - Too long: boring
- **Length is determined by WINNING CONDITIONS**
 - E.g. Monopoly with regular (90') or home rules (270')



6. Short vs long: examples

- Spy Hunter (arcade game 1983)
 - Very challenging game: first 90” unlimited lives
- Minotaur: The Labyrinths of Crete (1992)
 - Multiplayer (4) arena PvP
 - Time limit: a bell rings and it's Armageddon mode ...



Several hints about how to balance a game

1. State your problem clearly
2. Doubling and halving
3. Document your model
4. Tune your model as you tune your game
5. Plan to balance



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Systems Dynamic
Other relevant aspects ...

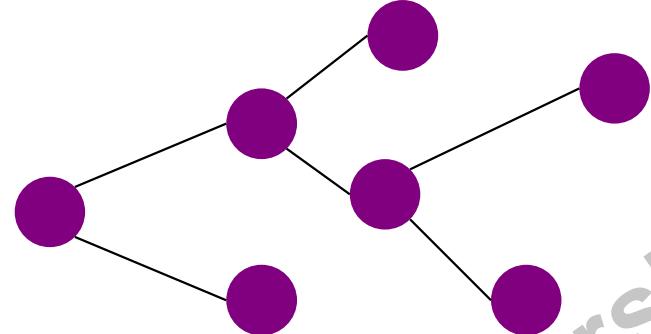


Possibility space: Various game structures

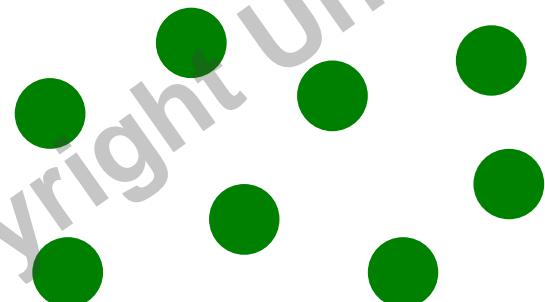


Linear Flow

(Trivial Pursuit, side-scrollers,
etc.)



Network or branching
(adventure games, etc.)



Objects or agents
(The Sims, etc.)

Dynamics involving resources: economies

- The economy is an important structure often found in games: it affects one of the fundamental formal elements (resources)!!
 - NB: in-game economies are generally severely controlled and generally only vaguely resemble real world economies
- To have an economy we need:
 - **Items** to exchange (resources)
 - **Agents** of exchange (players, bank, etc.)
 - **Methods** of exchange (market, bartering, etc.)
 - (a **currency**)
 - **Prices** (free, fixed, etc.)



Dynamics involving resources: economies

- Basic questions to design an in-game economy:
 1. Does the **size of the economy grow** (i.e. resources produced)?
 2. How is the **supply of the currency** (if any) **controlled**?
 3. How are **prices set** (market forces vs game system)?
 4. Are there **any restrictions** on opportunities for trade (turn, cost, etc.)?



Dynamics involving resources: economies

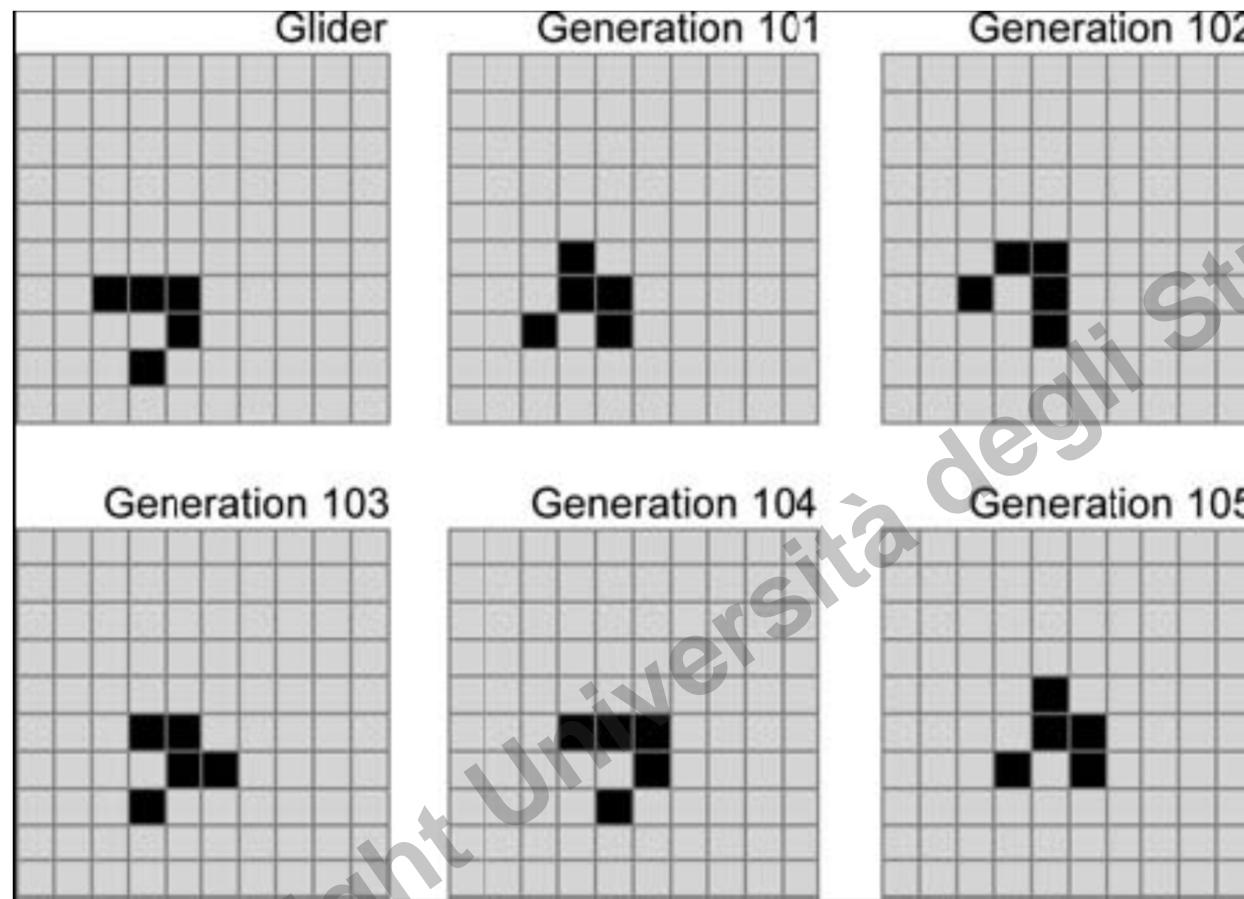
	Amount of product	Money supply	Prices	Trading opport.
<i>Simple bartering</i> (Pit)	fixed	n/a	fixed	Not restricted
<i>Complex bartering</i> (Settlers of Catan)	Controlled growth	n/a	Market value with cap	Restricted by turn
<i>Simple market</i> (Monopoly)	fixed	Controlled growth	Market value	Not restricted
<i>Complex market</i> (Ultima Online, Everquest)	Controlled growth	Controlled growth	Market value with base	Not restricted
<i>Metaeconomy</i> (Magic)	Controlled growth	n/a	Market value	Not restricted

Emergent systems: natural

- “**Emergence**”: natural phenomenon - **very simple rule sets, when put in motion, can produce unpredictable results**
 - 1 ant: lives with a very simple set of rules
 - A colony of ants: a spontaneous intelligence emerges capable of very sophisticated behaviours



Emergent systems: synthetic



Game of life by Conway

Emergent systems: in video games



Emergent systems: in video games

Goal: semirealistic behaviour of NPCs => no pre-written script, but decisions based on the context

- **Halo** - NPCs governed by only 3 rules:
 - Perception of the world (visual, tactile, etc.)
 - State of the world (memories of enemy spotted, of weapons locations, etc.)
 - Emotions (growing scared under attack, etc.)
- **Sims** - rules embedded both in NPCs and in objects:
 - When a Sim gets near to an object interacts (e.g. fridge & hungry Sim)



Interacting with systems

- Games are interactive => design for **interaction**, and consider:
 1. **Information**: how much info do players have about the system state?
 2. **Control**:
 - What aspects of the system do players control?
 - How is that control structured?
 3. **Feedback**:
 - What type of feedback does the system give to the players?
 - How does this affect the gameplay?

Interacting with systems: information

- **Open** information structures: full disclosure of the game state => strategy games
- **Hidden** information structures: game state hidden from players => guessing, bluffing, deceiving games
- **Mixed** info structures
(e.g. Black-Jack)
- **Dynamically changing** info structures: the amount of info vary dynamically during the game (e.g. fog of war)



Interacting with systems: controls

- Games requiring **specific input** types are more successful in some game platforms (e.g. text entry on consoles is quite inefficient)
- Games system can be **in/directly controlled** by players (Rollercoaster Tycoon vs 3D shooter)



- Control system forms the **top-level experience** of the player => **careful design**



Interacting with systems: feedback

- Feedback in systems implies a **direct relationship between output and a change in the system**
- Many games use reinforcing loops to create satisfying risk/reward scenarios
- Balancing relationships are used to keep the game from resolving too quickly

Interacting with systems: feedback

