

Lecture 6

Uncertainty & Risk

Uncertainty and Risk

- **Risk**: outcome of action is uncertain
 - Perhaps action has random results
 - May depend upon opponent's actions
 - Need to know what opponent will do
- Two primary means of risk in a game
 - Chance and randomness
 - Imperfect information

Uncertainty \neq Skill

- Outcomes may depend on player skill
 - Hand-eye coordination challenges
 - Reaction-time/twitch challenges
 - **Knowledge of optimal strategies**
- Varying skill level \rightarrow uncertain outcomes
 - But challenges themselves are predictable
 - Player can train at challenge over time
 - Not the subject of this lecture



Randomness in Games

- Pure randomness is not a good game
 - Remember coin flipping
 - Player has no *meaningful choice*
- But many games **are** random
 - *Candyland, Snakes & Ladders*
 - Poker, other forms of gambling
 - Tetris and other matching, stacking games



Randomness: *Candy Land*



Randomness: Poker



Randomness with Choice

- Tetris pieces are random, but
 - Have a choice in how to position them
 - “Hedge your bets” to prepare for bad drops
- RPG combat is die roll influenced by
 - Armor the defender wears
 - Weapons the attack uses
 - Combat maneuvers employed

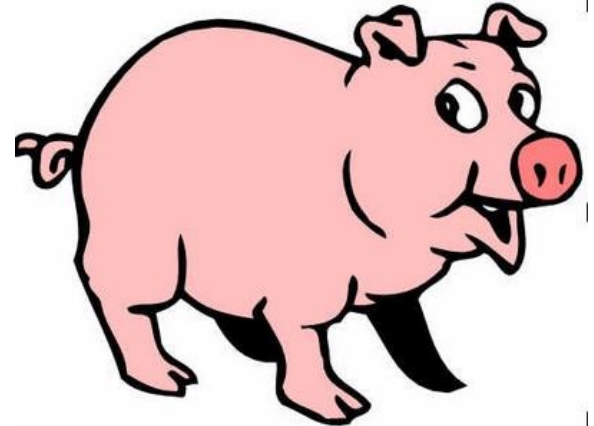


Randomness with Choice



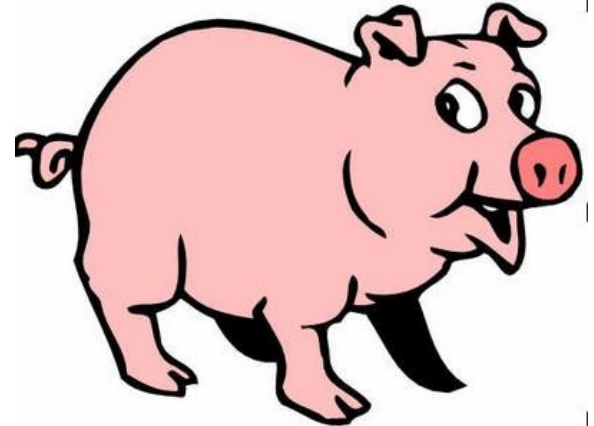
Pig: A Random Game

- Play progresses clockwise
- On your turn, throw the die:
 - If roll 1: lose turn, score zero
 - Anything else: add it to score
 - Can also roll again (and lose)
 - If stop, score is “banked”
- First person to 100 wins.



Strategic Randomness

- Pig has **meaningful choice**
 - Player can choose to bank
 - Risk nothing for a higher score
- How is the choice meaningful?
 - Certain decisions are better than others
 - Certain decisions are more *fun* than others
 - Psychological effect on other players



Expected Value

- Outcome of actions is never the same
 - But the sum averages out over many tries
 - Strategy: compare average outcomes
- **Expected Value** = outcome \times % success
 - If many outcomes, sum them together
 - Example: Average die roll is 3.5
$$1 \times \frac{1}{6} + 2 \times \frac{1}{6} + 3 \times \frac{1}{6} + 4 \times \frac{1}{6} + 5 \times \frac{1}{6} + 6 \times \frac{1}{6} = 3.5$$
- Only applies if can do action *repeatedly*

Expected Value of Pig

# Throws	Survial	Expected Gain	Expected Value
1	83%	3.33	3.33
2	69%	2.78	6.11
3	58%	2.32	8.43
4	48%	1.92	10.35
5	40%	1.61	11.96
6	33%	1.34	13.30
7	28%	1.12	14.42
8	23%	.93	15.35
9	19%	.77	16.12
10	16%	.65	16.77
...
50	0.01%	0.0004	19.998

Expected Value and RTS Games



Psychology of Randomness

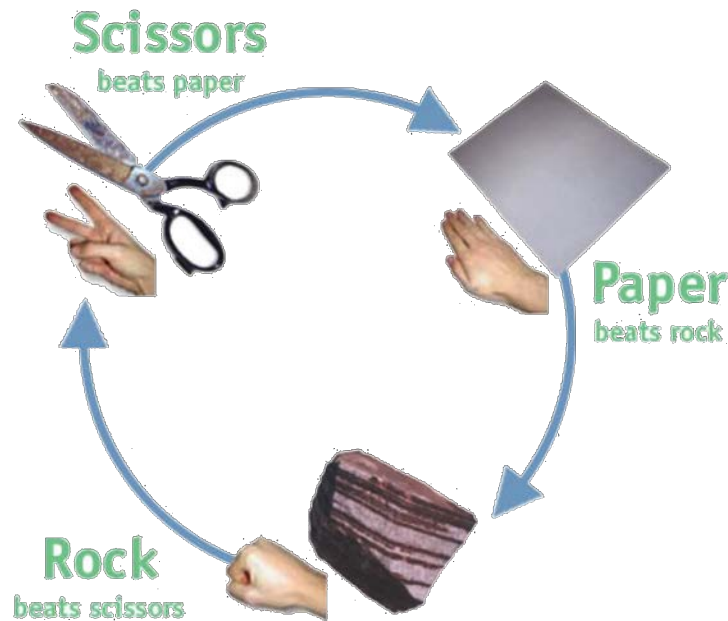
- Players favor **longshots**
 - Rare event that has very high payoff
 - Will work towards it even if not optimal
 - Especially if failure is cheap
- Players have “Monte Carlo syndrome”
 - After a bad run, expect a good result
 - Otherwise, the game is “unfair”

Psychology of Randomness

- **Payoff** influences the perception
 - Players remember events with bigger payoff
 - Will think it is “more likely”
 - Even if two events equally likely
- **Corollary:** Lightning never strikes twice
 - A bad outcome is unlikely to happen again
 - A good outcome will probably happen again

Psychology of Nonrandomness

- Players can view the nonrandom as random
- **Example:** paper-scissors-rock

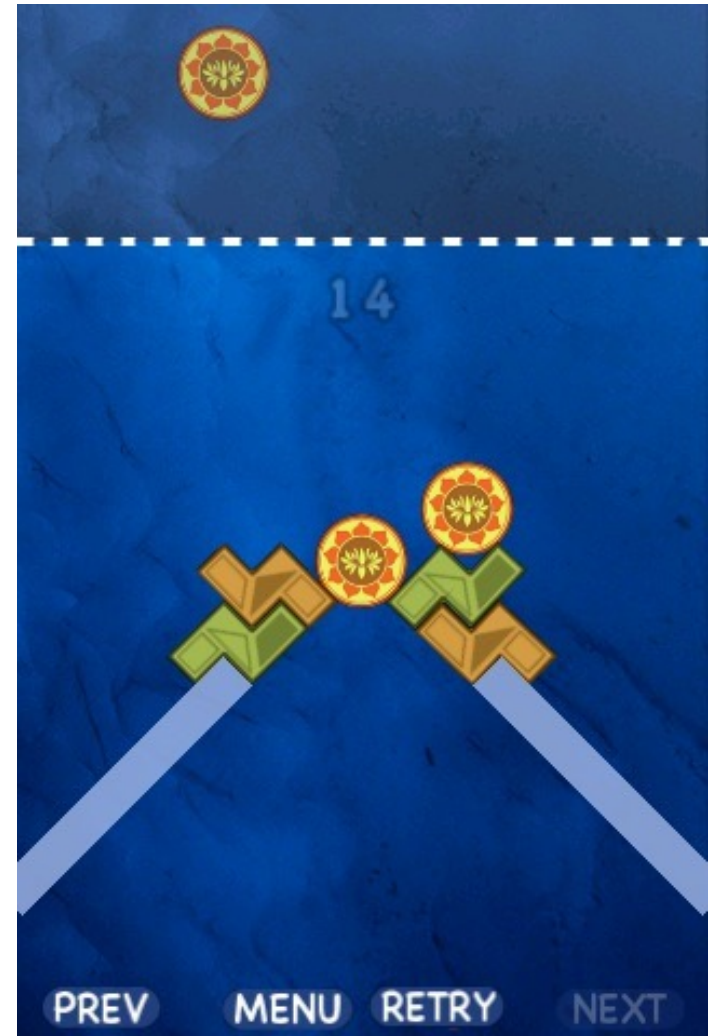


Psychology of Nonrandomness

- Players can view the nonrandom as random
- **Example:** paper-scissors-rock
 - Opponent is *uncertain*, not *random*
 - But there is no choice is better than others
 - How do you choose?
- Any game with heavy negative feedback
- “Random” = lack of meaningful choice

Instability vs. Random

- **Physics** can be sensitive!
 - Small input change = big output change
 - Games can “feel random”
- **Instable challenges**
 - Difficult to repeat success
 - Very difficult to tune
 - But popular trend in modern puzzle games



Benefits of Randomness

- Randomness can improve **replayability**
 - Similar actions \neq similar outcomes
 - Player must adapt if actions fail to pay off
 - Encourages wider exploration of game space
- Basis of modern **RogueLite** movement
 - Content is randomly generated/experienced
 - Each playthrough feels fresh and different
 - But level design is very difficult (**later**)

Should Your Game Have Randomness?

- Do you want to **emphasize strategy**?
 - Common in real-time/turn-based strategies
 - Pay-offs are a strategic cost-benefit decision
 - Randomness keeps strategies from being dominant
- Do you want to **simplify complex systems**?
 - Randomness is often an alternative to **simulation**
 - Makes complete sense in board game setting
 - But computers are good at simulation, so why?

Imperfect Information

- Player may lack information about that game
 - May not know complete game state
 - May not know all of the rules
- Can reason about *likelihood*
 - Rules eliminate certain possibilities
 - Model opponent psychology
 - But less precise than probability



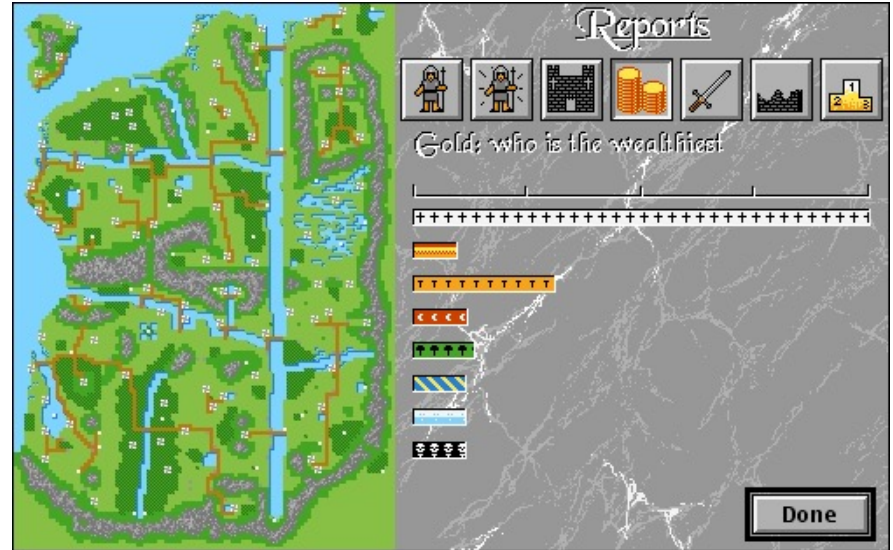
Example: Fog of War



Making Information Imperfect

- **Hide information**

- Fog of war
- Hidden moves
- Hidden die rolls



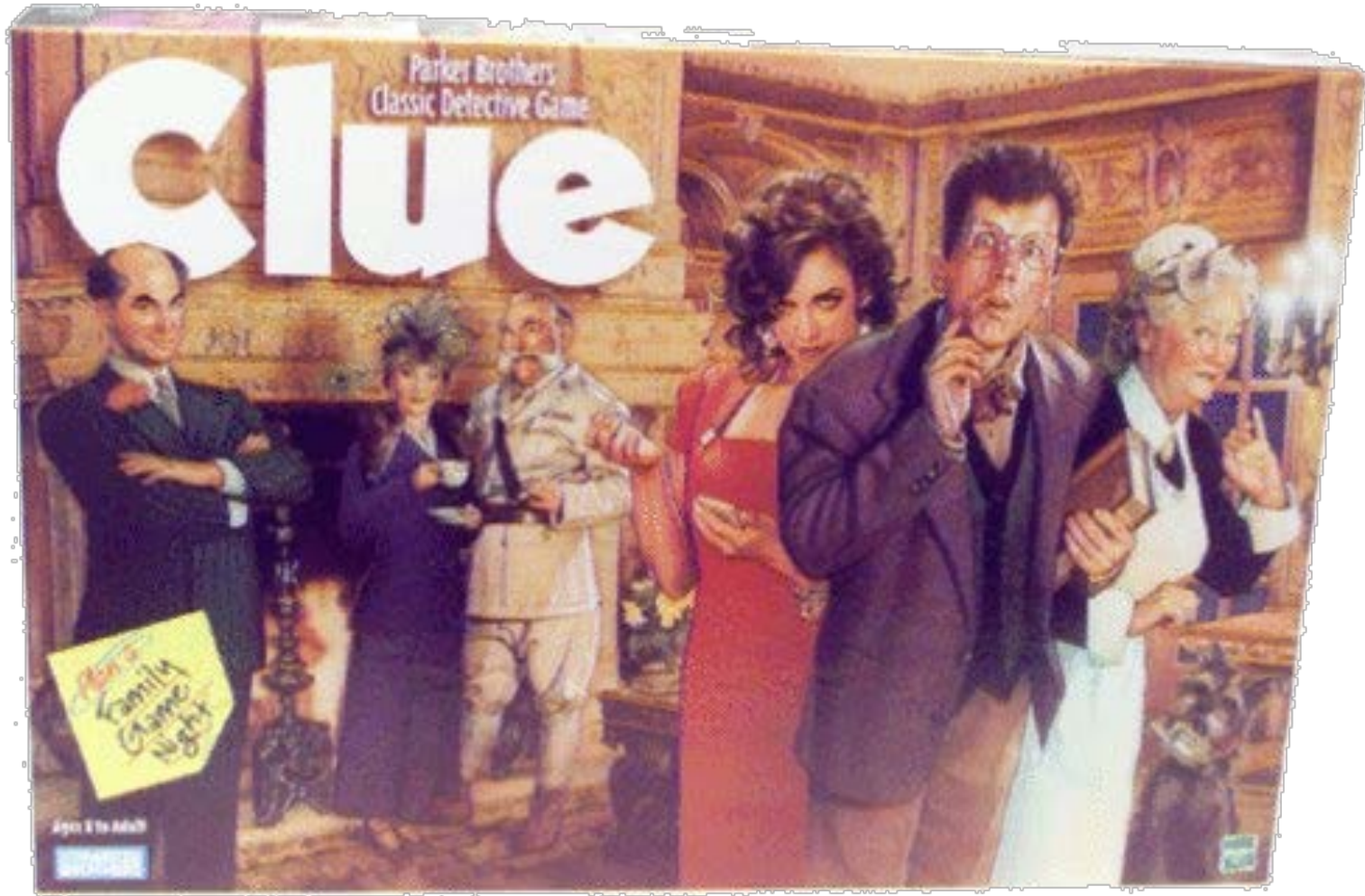
- **Generate random noise**

- (Partial) scanner jamming
- Inaccurate troop measurements

Information Types

- Information known to **all players**
- Information known to **one player**
- Information know only to **the game**
 - **Example**: the next card in a deck
- **Randomly** generated information
 - **Example**: die rolls

Information in Clue



Computers and Information

- Very good at **managing** information
 - Can easily hide information from players
- Can hide very **complex** information
 - Humans have hard time hiding and managing
 - Also, too easy to cheat if hidden
- Particularly good at
 - Information known only to **one player**
 - Information know only to **the game**

Randomness vs Imperfect Information

- Randomness used heavily in board games
 - Nice way to introduce uncertainty/risk
 - Easier to manage than imperfect information
- But not as important for computer games
 - Imperfect information is easy to manage
 - Complex rules (physics) may seem random
- **Deterministic** rules are easier to tune
 - Even board games realize this (*Puerto Rico*)

Digital vs. Nondigital Games

Digital Games

- Advantages
 - Hiding Information
 - Complex mechanics
 - Long-distance play
- Disadvantages
 - Adaptability
 - Product life span

Nondigital Games

- Advantages
 - “House Rules”
 - Portability/life span
 - Multiplayer psychology
- Disadvantages
 - Complex mechanics
 - Hidden information

Digital vs. Nondigital Games

Digital Games

Nondigital Games

- Advantages

- Hiding Information
- Complex
- Long-dis

- Disadvantages

- Adaptability
- Product life span

- Advantages

- “House Rules”
- life span
- psychology

- Disadvantages

- Complex mechanics
- Hidden information

Will return to this
with prototyping

Summary

- Uncertainty and risk are **important**
 - Otherwise player is (eventually) unchallenged
 - No possibility of strategic choice
- Ways of introducing uncertainty/risk
 - Through skill-based challenges
 - Through randomness
 - Through incomplete information
 - Latter is primary strength of computers