the gamedesigninitiative at cornell university

Uncertainty and 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 ≠ Skill

- Outcomes may depend on player skill
  - Hand-eye coordination challenges
  - Reaction-time/twitch challenges
  - **Knowledge of optimal strategies**

- Varying skill level ➔ 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

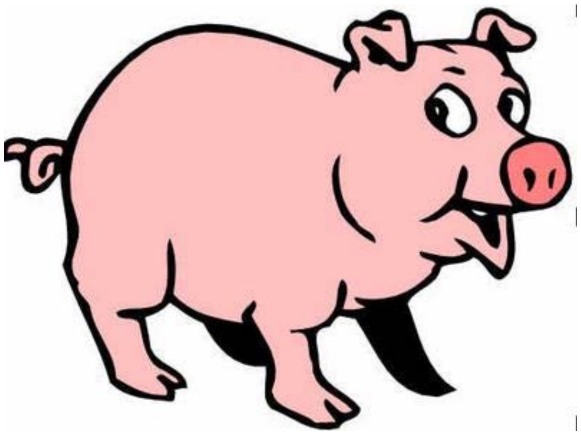
Randomness with Choice

- 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

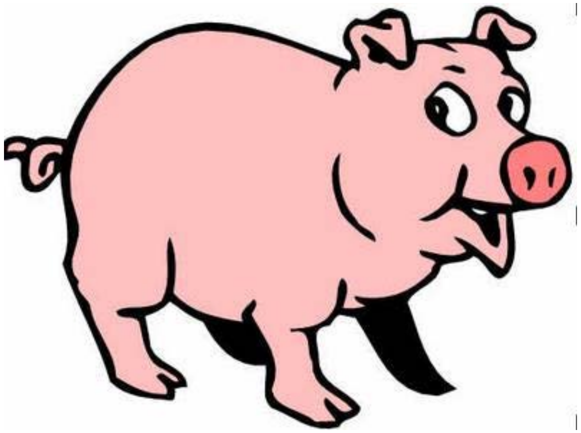
Pig: A Random Game

- 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 × % 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 *Warcraft*

Psychology of Randomness

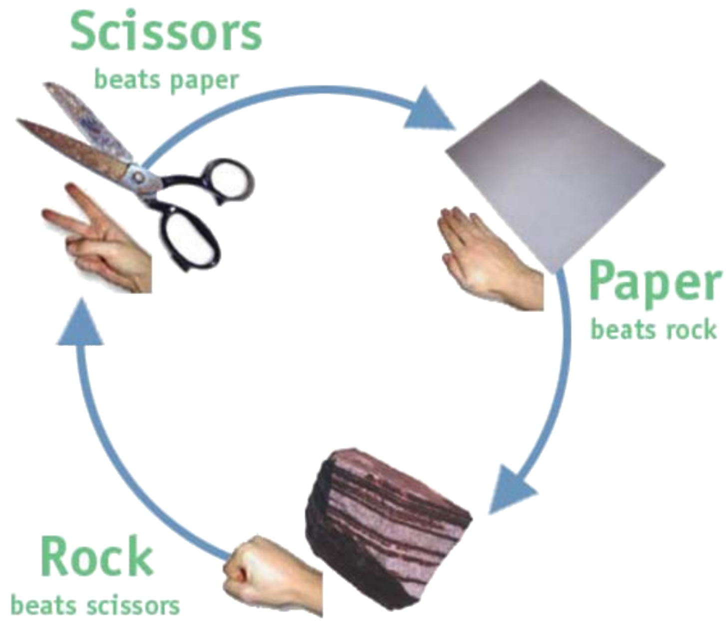
- Players favor longshots
  - Rare event that has very high payoff
  - Will work towards it even if not optimal
  - Especially if failure is cheap
- Players have “Monte Carlo syndrome”
  - After a bad run, expect a good result
  - Otherwise, the game is “unfair”

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

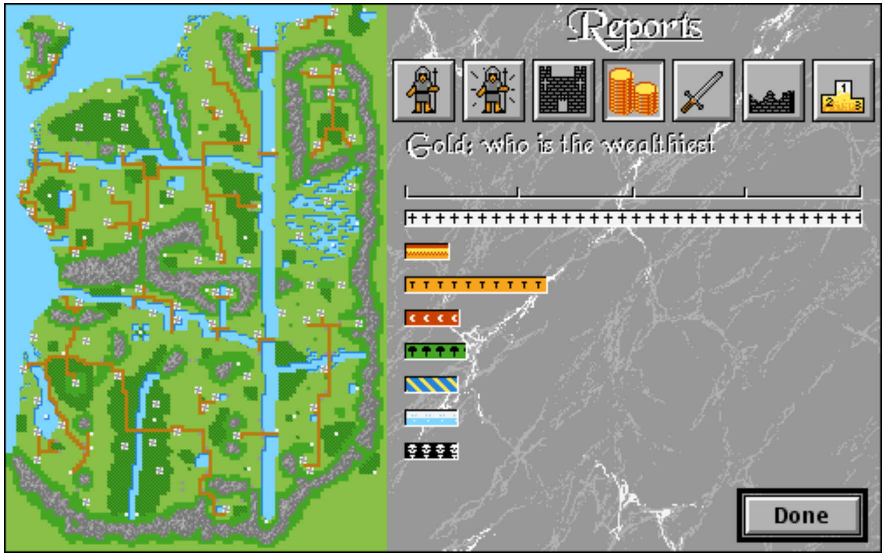
Imperfect Information

- 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

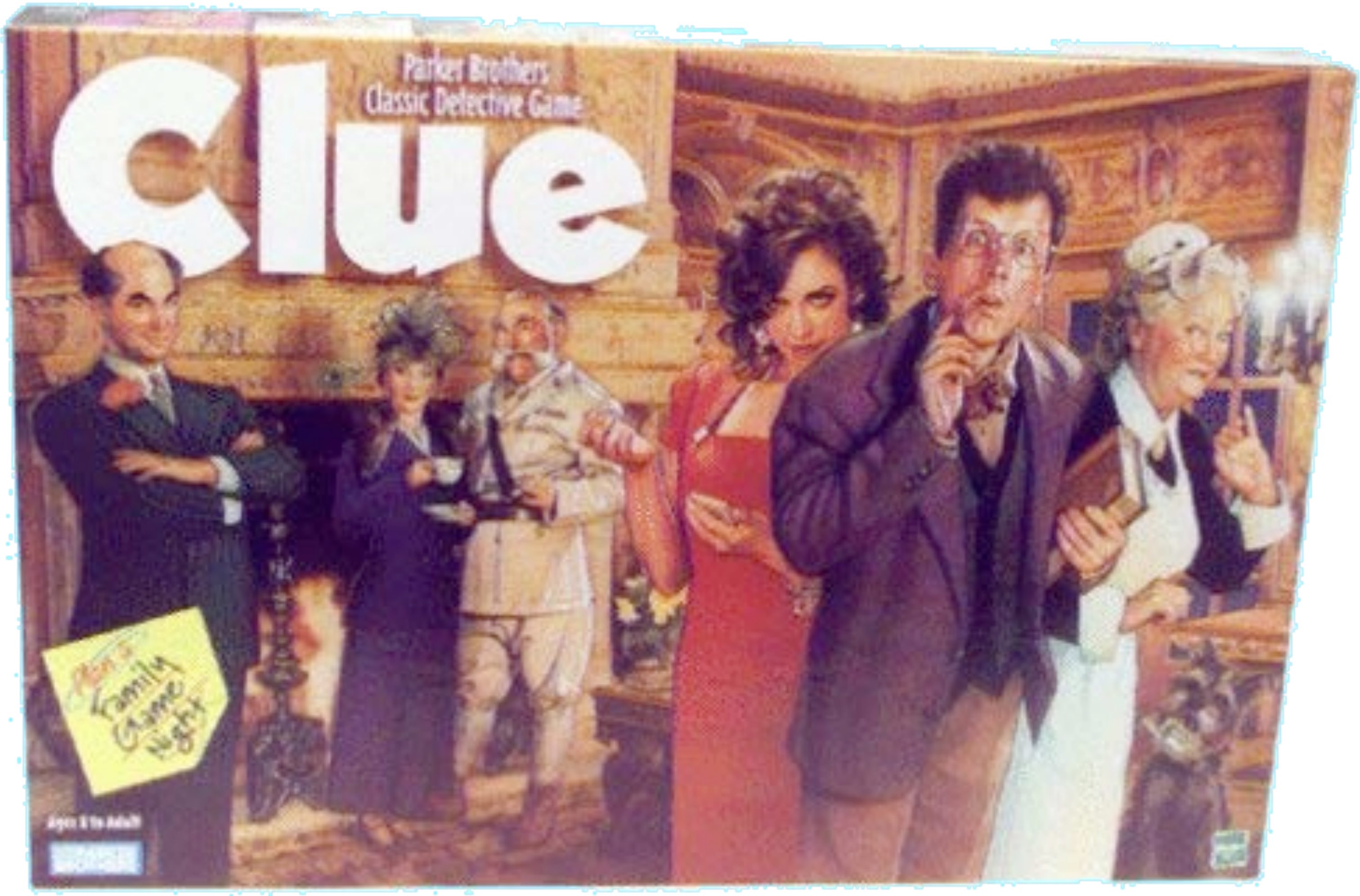


- Generate **random noise**
  - (Partial) scanner jamming
  - Inaccurate troop measurements

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

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