

## Lecture 6

# Uncertainty & Risk

# Brainstorming Activity

# Uncertainty and Risk

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- **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

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- 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

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- 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

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- 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





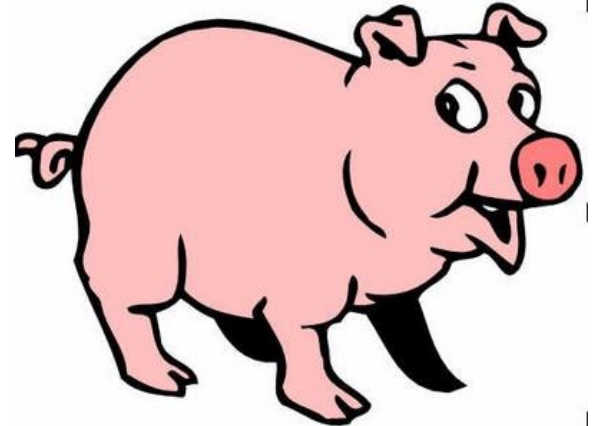
# Randomness with Choice



# Pig: A Random Game

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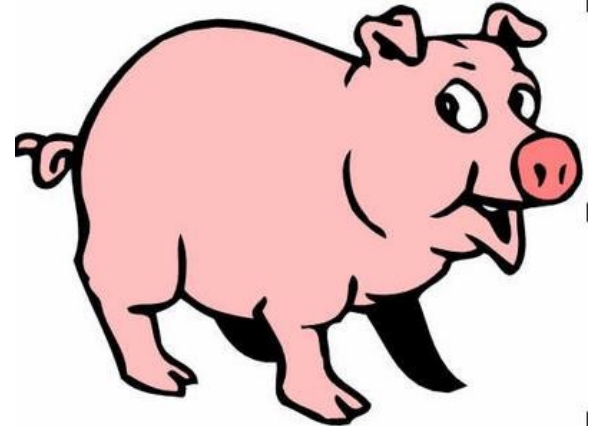
- Play progresses clockwise
- On your turn, throw the die:
  - If roll 1: lose turn, score zero
  - Anything else: add it to score
    - Can also roll again (and lose)
    - If stop, score is “banked”
- First person to 100 wins.



# Strategic Randomness

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- 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

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- 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

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- 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

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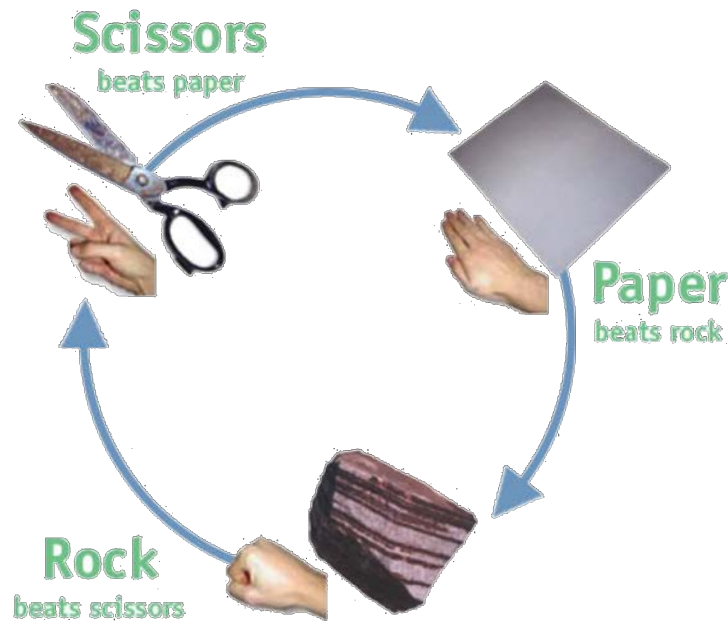
- **Payoff** influences the perception
  - Players remember events with bigger payoff
  - Will think it is “more likely”
  - Even if two events equally likely
- **Corollary:** Lightning never strikes twice
  - A bad outcome is unlikely to happen again
  - A good outcome will probably happen again



# Psychology of Nonrandomness

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



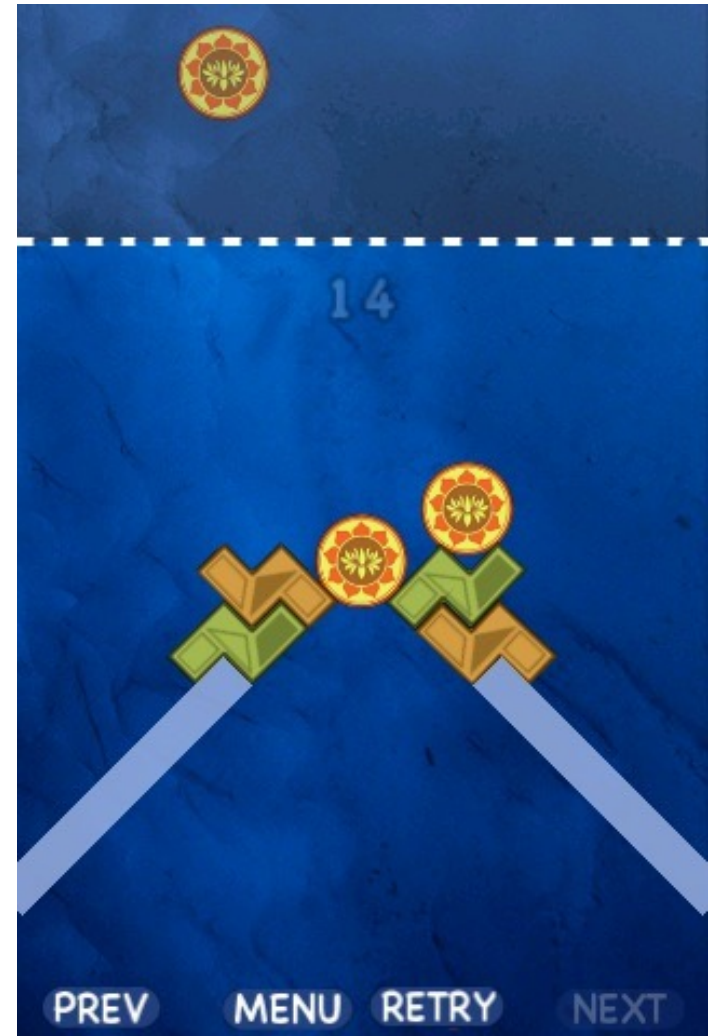
# Psychology of Nonrandomness

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- 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

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- 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?

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- 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

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- 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



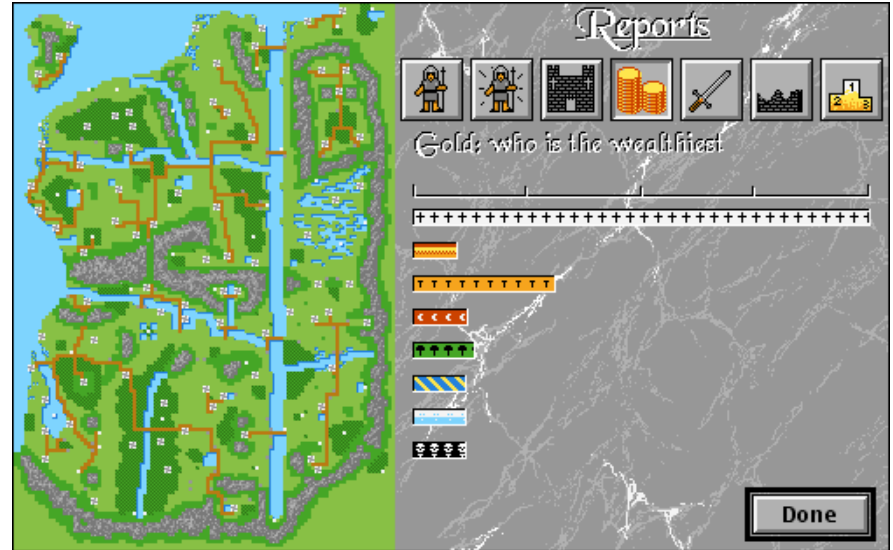
# Example: Fog of War



# Making Information Imperfect

- **Hide information**

- Fog of war
- Hidden moves
- Hidden die rolls



- **Generate random noise**

- (Partial) scanner jamming
- Inaccurate troop measurements



# Information Types

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- 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

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- 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

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- 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

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## Digital Games

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

## Nondigital Games

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- 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

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- 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