Research by Design

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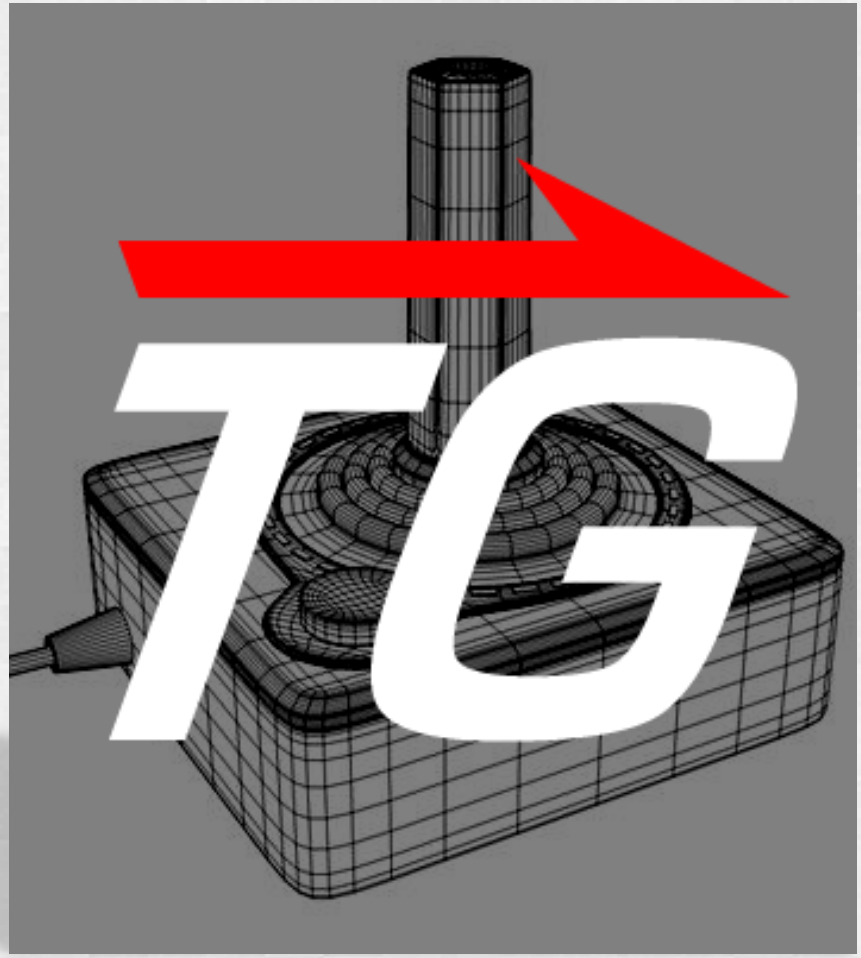
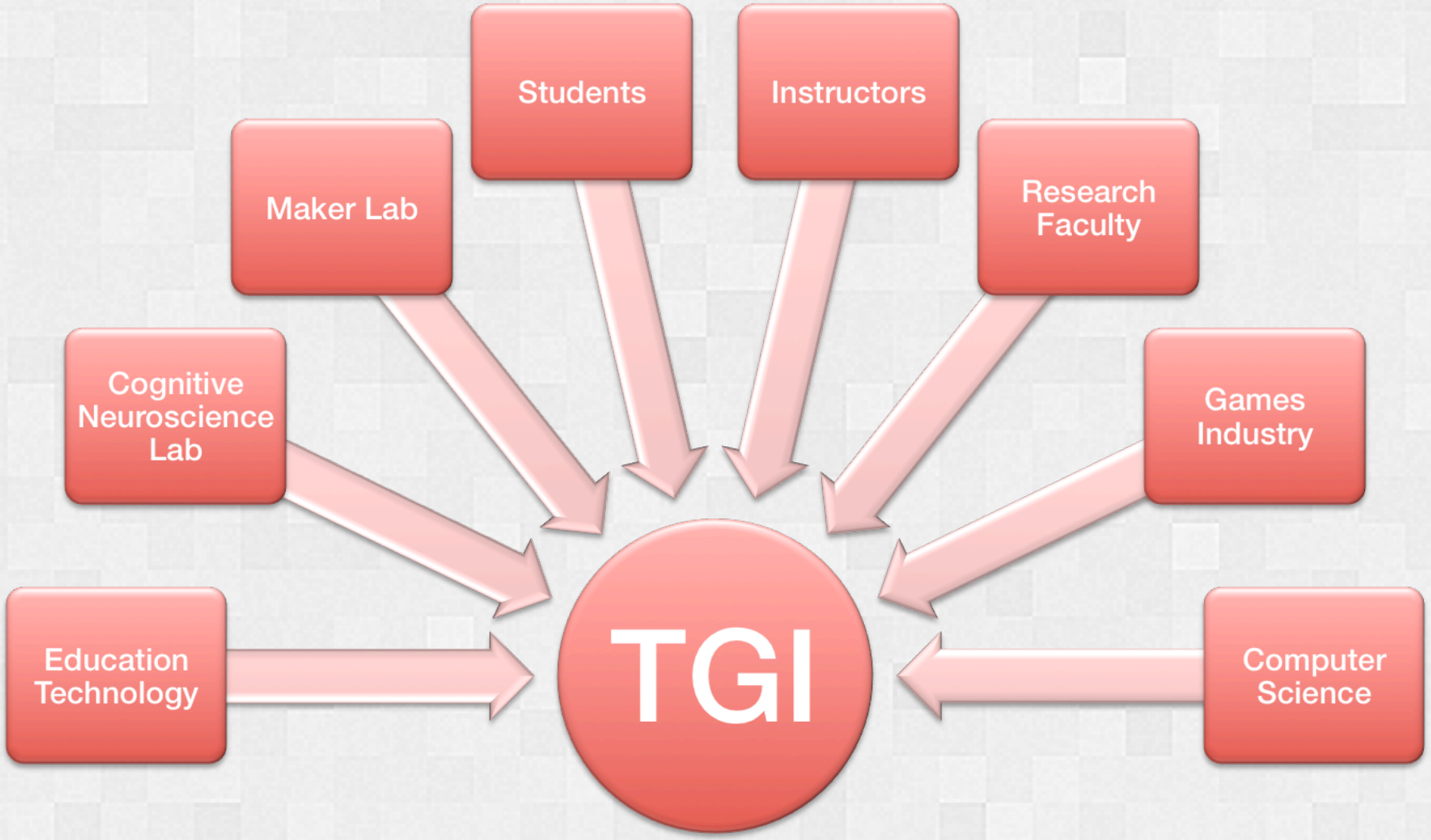
Transformative Games Initiative

- Serve students by providing opportunities for game-based learning
- Promote learning by engaging students in design
- Provide instructors with tools for the classroom
- Facilitate research in pedagogy and game-based learning



“How can **we** help **you**?”

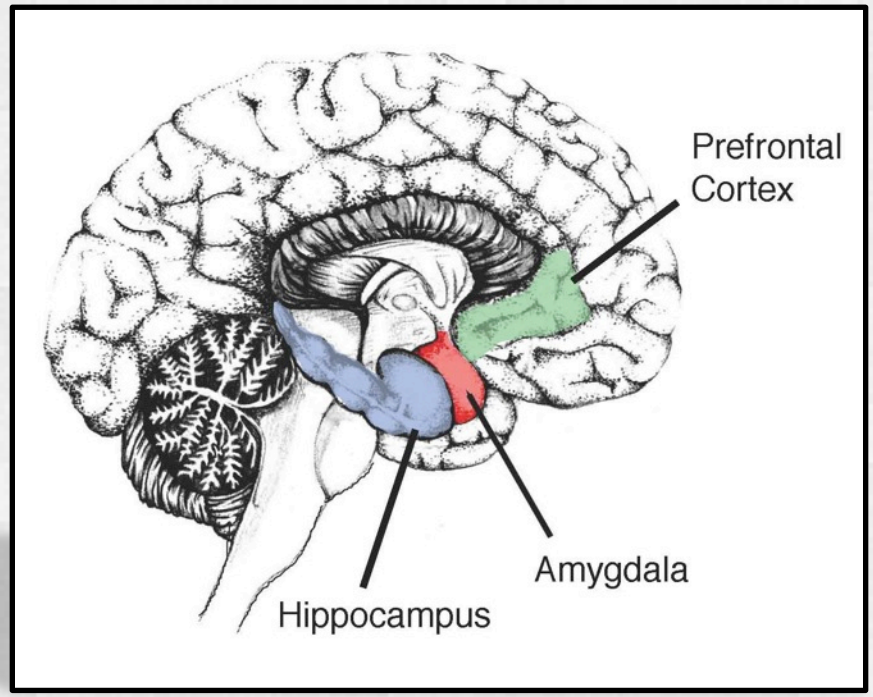


Why Games?

- Improved learning through practice
- Improved learning by applying knowledge to novel situations
- Improved learning through associations with motor memory
  - The brain remembers procedures and events better than facts
- Improved cooperation, brainstorming, and leadership skills

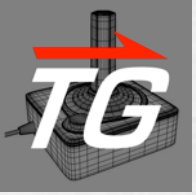
Games = Learning

- Your brain is constantly bombarded with more information than it can process.
- The brain must decide what is important enough to remember
- The hippocampus converts relevant experiences into memories
- The amygdala determines which experiences are worthy of remembering
- pFC predicts the future.
- Art, games, music, learning and LIFE are **fun** when novel experiences pleasantly violate our expectations, which makes them worthy of being remembered.



Fun and Play Defined

- Play is often the practice of survival skills
- A species that plays is more fit for survival
- The importance of play has be deemphasized in school
- Play is practice, not mastery
- Play must be fun to be attractive. But what is "fun?"
- Many types of fun
  - *Nachas* is joy in the success of a mentee
  - *Schadenfreude* is joy in another's misery
  - *Fiero* is triumph over struggle.

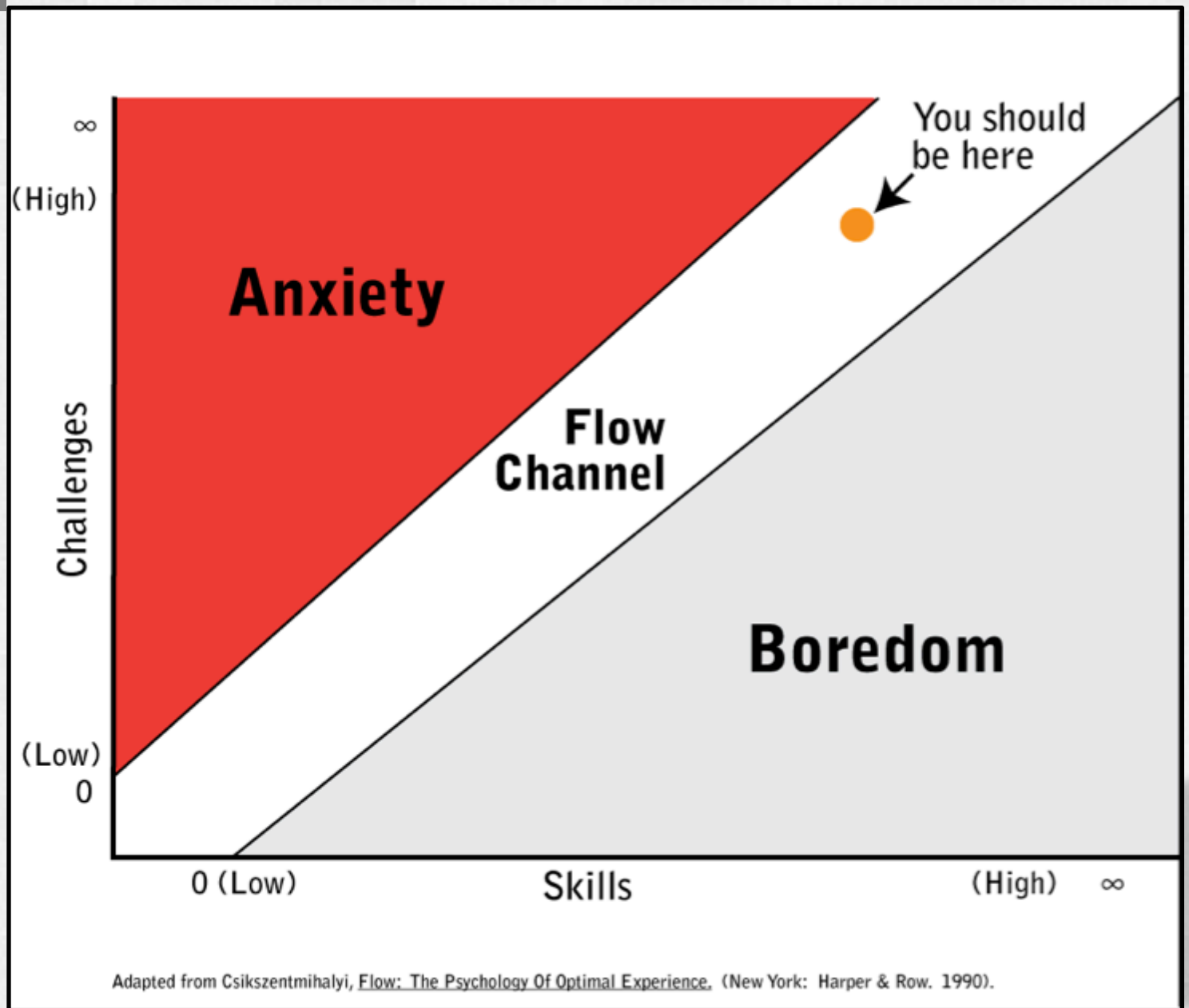


Games Defined

- Unlike pure play, games have a purpose
- "A good game teaches everything it has to offer before the player stops playing."

  – Raph Koster
- Why do we stop playing?
  - Boredom
  - Frustration
- Good games keep the player-learner in a state of flow, where time slips away unnoticed

Flow

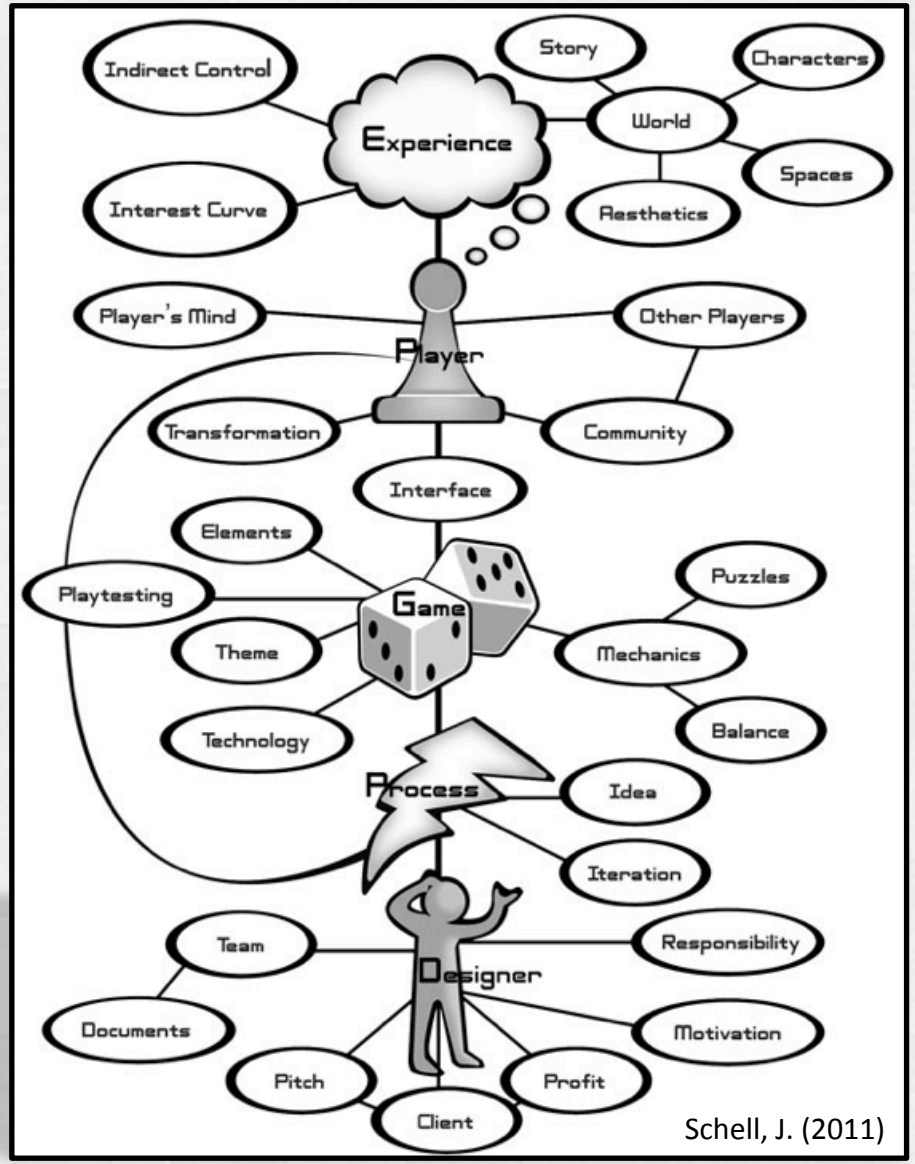


Adapted from Csikszentmihalyi, Flow: The Psychology Of Optimal Experience. (New York: Harper & Row. 1990).

Game Mechanics

- Educational objective
- Game objective
  - Win/lose states
- Resources
- Feedback
- Flow
- Boundaries
- Designer as advocate for the player-student

**The core game mechanic must be wedded to the educational objective.

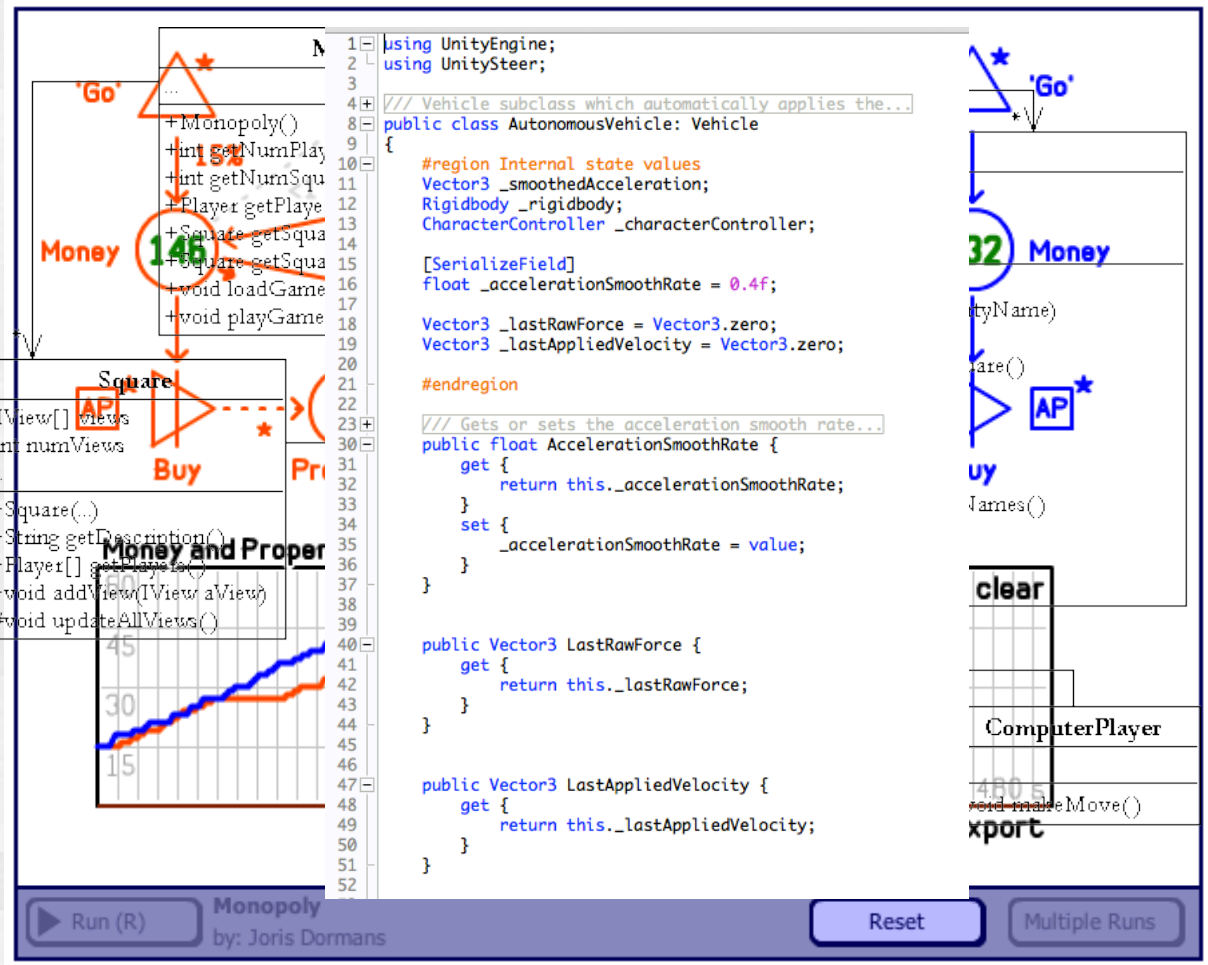


What to Avoid

- "Gamification" - Placing unnecessary emphasis on secondary reinforcers.
  - This devalues the primary reinforcer, the joy of accomplishment.
- Complications
  - Keep it simple and loosely constrained.
  - The more opportunities players have to invent, the more fun they will have.
  - Let them *construct*

Our Current Process

- Iterative Design
  - Brainstorming
  - Paper prototypes
  - Digital prototypes
- Machinations
- UML
- OOP

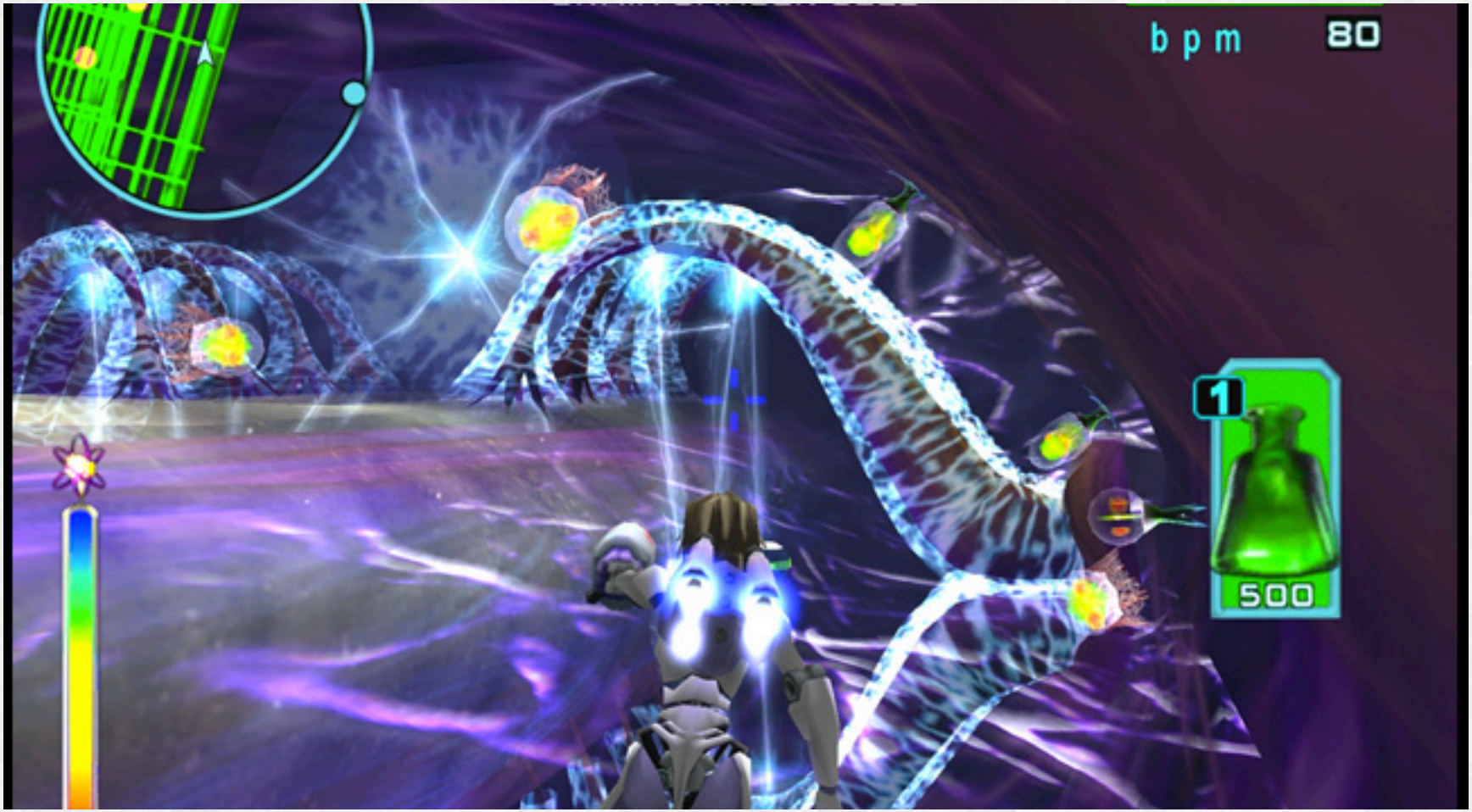


McDonald’s Videogame

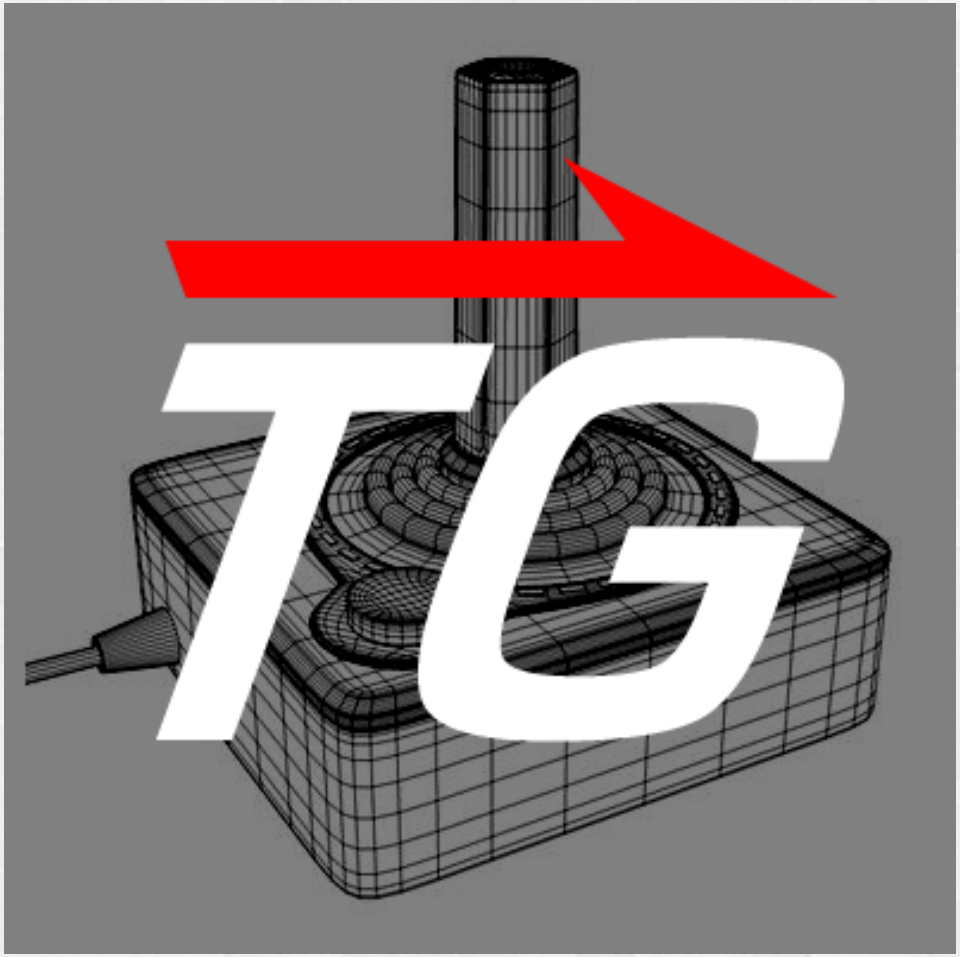
FoldIt


Dr. David Baker
Several sheets are lining up in this protein, but one is out of place. Pull the misaligned sheet back in to form hydrogen bonds! Don't forget you can control-click to lock, and use Shake and Wiggle.
Repeat Introduction
Clear Labels
Progress: 8899 of 10000
Level 4-2: A Sheet Out of Place
Chat
Shake Sidechains
Wiggle Backbone
Clear Locks
Reset Puzzle
Actions
History
File
Pull Tool

Re-Mission



Our First Experiment

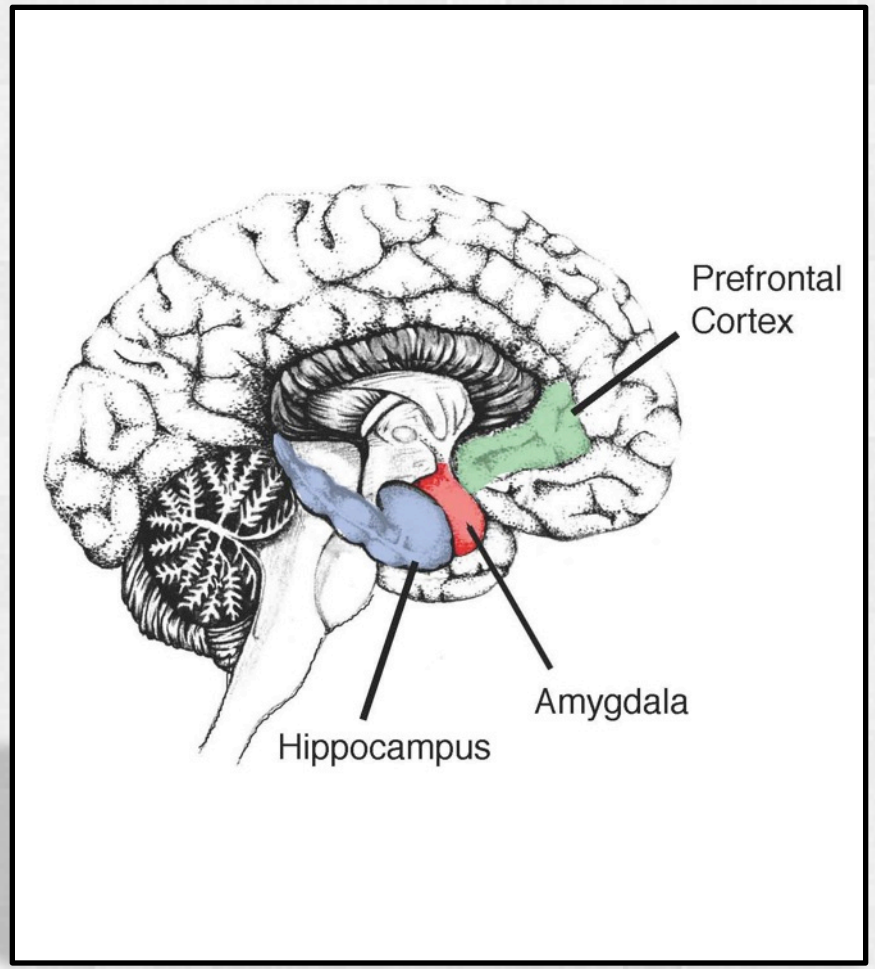


Student Retention

- In 2010, CUNY four-year graduation rates ranged from 3.7 to 33.3%
  - NY Office of Higher Education
- First year retention is 77.1% for the nation and 81.6% for NY.
  - National Center for Higher Education Management Systems
- Thus, at least 1 in 5 students drop out in the first year.

Deliberated Decision Making

- The teenage prefrontal cortex (pFC) is still undergoing development
- The pFC is critical for deliberated decision making
- Deliberated decision making is complicated because it involves judgments of multiple factors
- We suspect the dropout rate could be improved if we understand how teens formulate decisions



Prospect Theory

- A formal model of decision making (Kahneman and Tversky, 1979)
- *Prospects* are choices that are represented by a perceived *utility*
- Utility is composed of a perceived *probability* and perceived *value*.

$$U = p \bullet v$$

- Decisions become complicated when the value or the probability of an outcome is uncertain (e.g., finding happiness)
- Decisions are also complicated when a decision involved multiple attributes (e.g., buying a car, getting married)

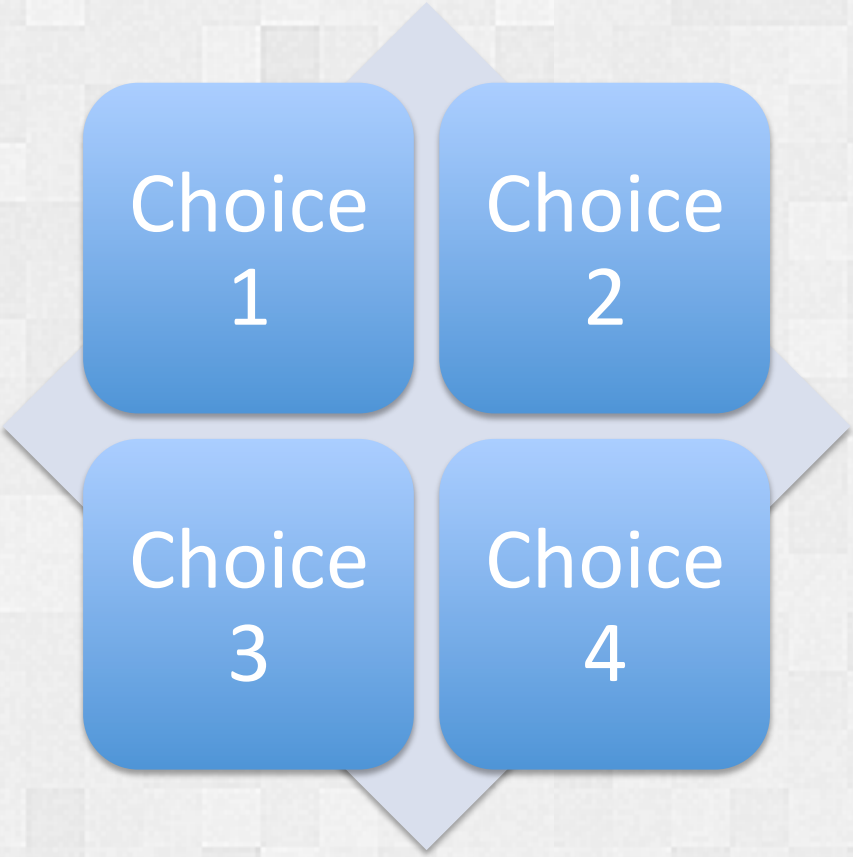
$$\Sigma U_{1\text{-}n} = \{p \bullet v\}_{1\text{-}n}$$

Our Hypothesis

- To study decision making in freshmen, we created a critical thinking game where students could choose between four uncertain prospects.
- We predicted that *practice* would allow the students to create internal representations of probability and value that would correctly guide choices for future prospects.

Methodology

- Subjects
  - 73 students from the York College Research Subjects Pool
  - Subjects were briefed before providing informed consent
  - Randomly assigned to Experimental and Control groups
- Procedure
  - Subjects sat in a quiet computer room
  - 100 Questions from the Reading Comp Section of the LSAT
  - Then, presented with four uncertain prospects
  - One hour
  - Stress accuracy over speed
  - Receive feedback after each answer



Methodology

Q1.Situation: Someone living in a cold climate buys a winter coat that is stylish but not warm in order to appear sophisticated. Analysis: People are sometimes willing to sacrifice sensual comfort or pleasure for the sake of appearances. The analysis provided for the situation above is most appropriate for which one of the following situations?

a. A couple buys a particular wine even though their favorite wine is less expensive and better tasting because they think it will impress their dinner guests.

b. A parent buys a car seat for a young child because it is more colorful and more comfortable for the child than the other car seats on the market, though no safer.

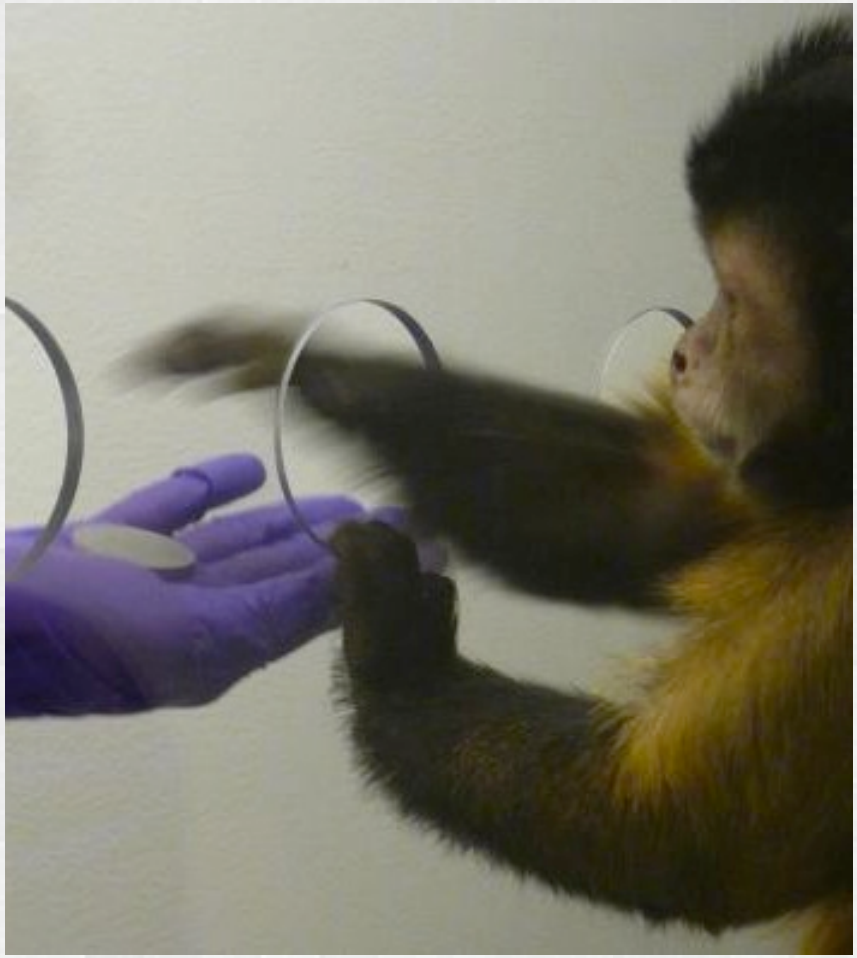
c. A person sets her thermostat at a low temperature during the winter because she is concerned about the environmental damage caused by using fossil fuels to heat her home.

d. An acrobat convinces the circus that employs him to purchase an expensive outfit for him so that he can wear it during his act to impress the audience.

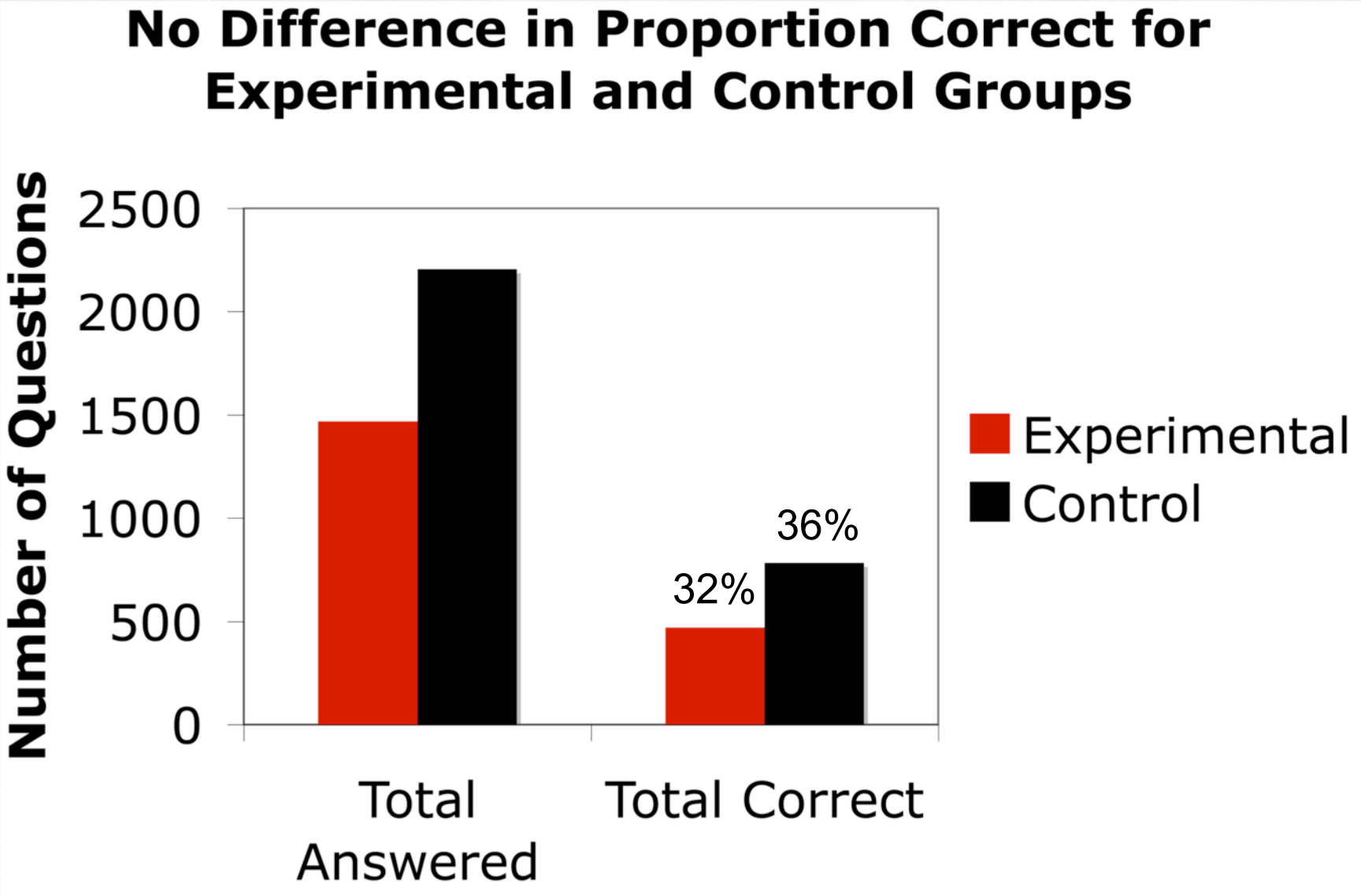
Media source: (A) Peer-reviewed journal (B) Newspaper (C) Website (D) A friend

Methodology

- Proportion of correct responses:
  - Peer-reviewed journal (~50%)
  - Newspaper (~25%)
  - Website (~12.5%)
  - Friend (~12.5%)
- Control group answers were randomly paired with information sources.
- Not to make untoward comparisons, but monkeys learn this sort of thing quickly.



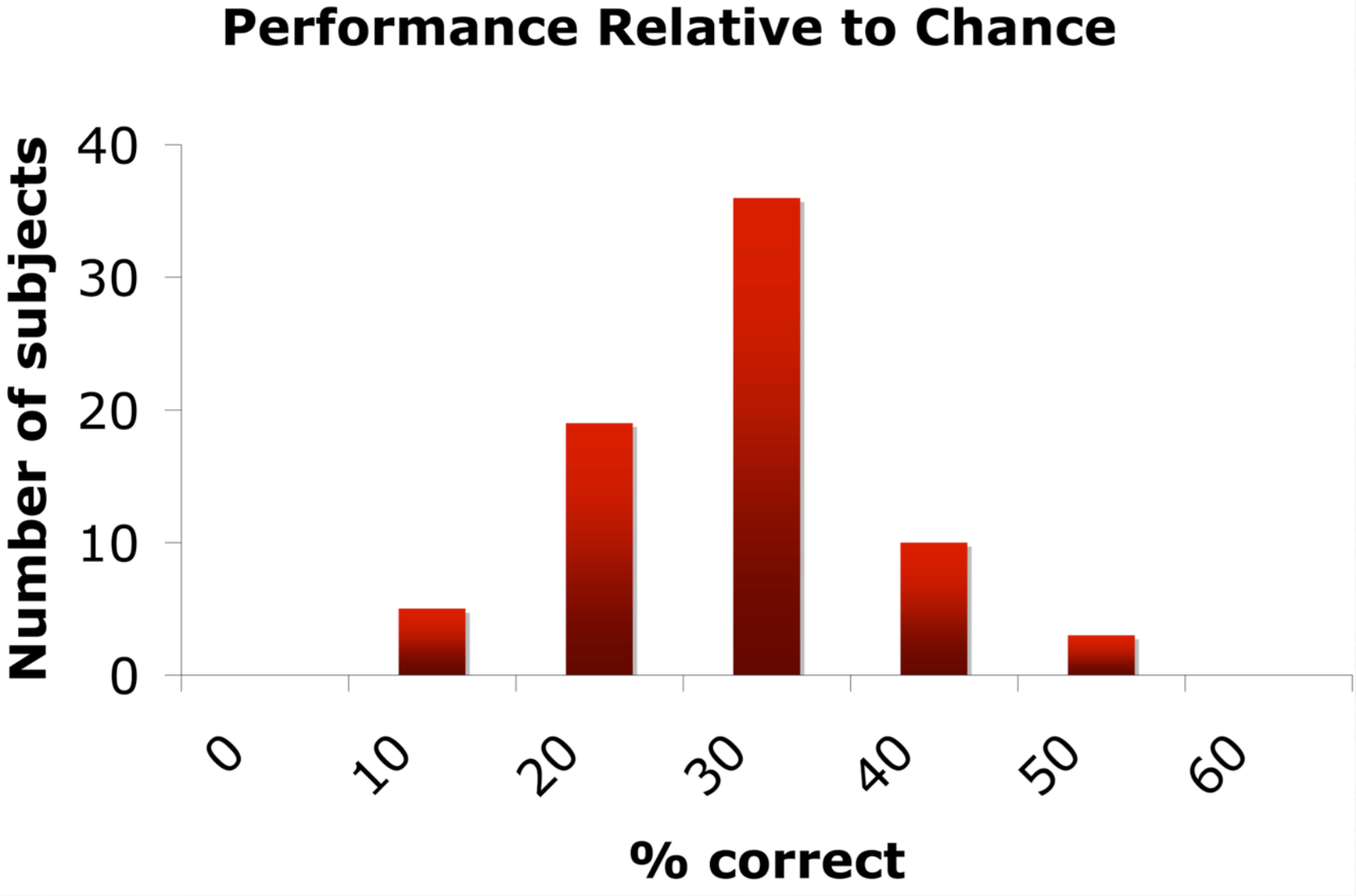
Results


No Difference in Proportion Correct for Experimental and Control Groups
Number of Questions
2500
2000
1500
1000
500
0
32%
36%
Total Answered
Total Correct
Experimental
Control

Results

- A Chi-squared test for goodness-of-fit did not reveal a difference in the proportion of correct answers between the experimental and control groups ($p > 0.10$).
- Surprisingly, subjects did ***not*** make an association between the icons and the correct answer!

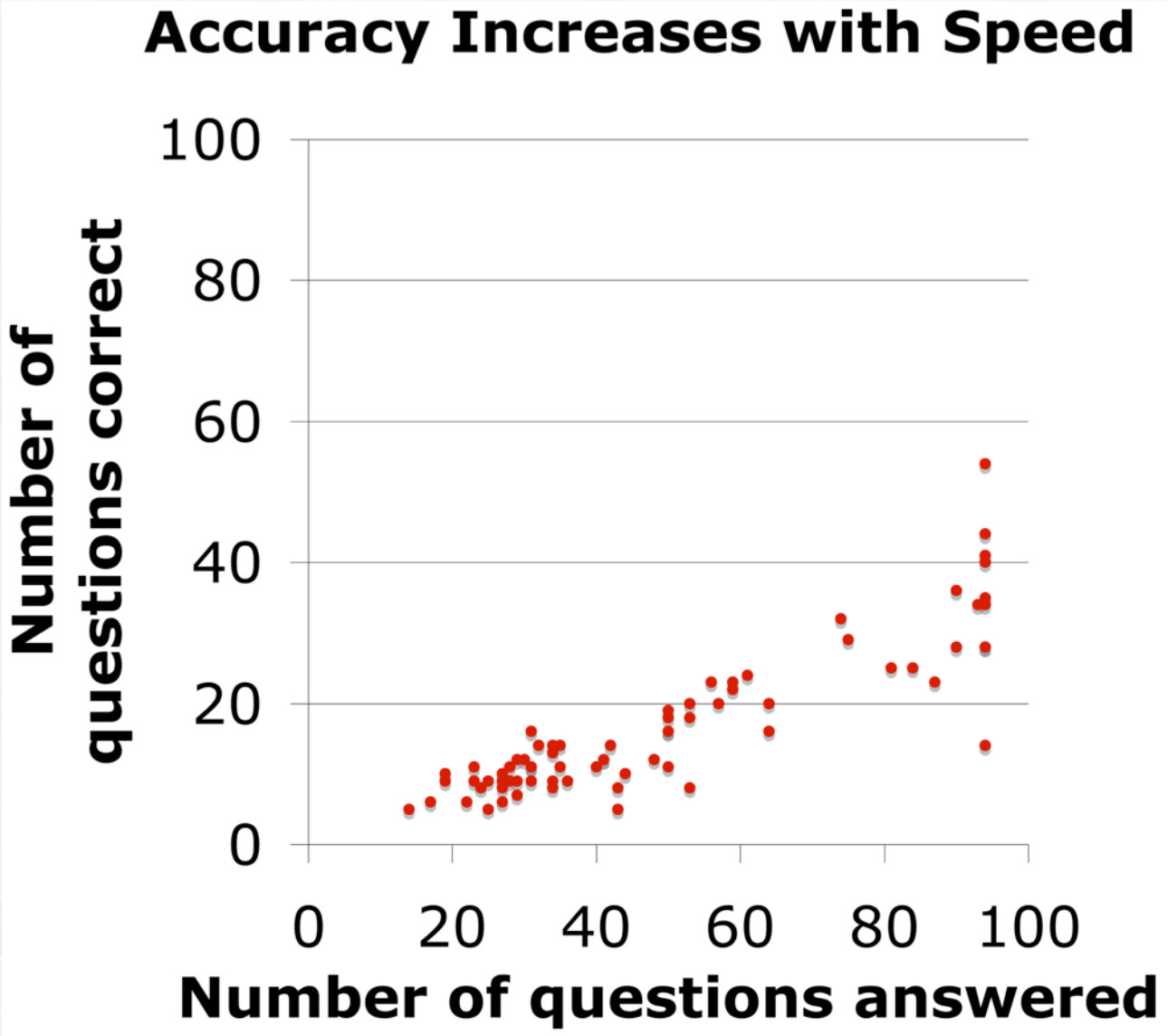
Results


Performance Relative to Chance
Number of subjects
40
30
20
10
0
0
10
20
30
40
50
60
% correct

Results

- Were subjects guessing?
- We compared the distribution of correct responses to what you would expect by chance (i.e., 25% correct)
- The total proportion correct was low (33.8%), but exceeded chance (C^2, $p < 0.05$).
- Subjects were not guessing

Results


Accuracy Increases with Speed
Number of questions correct
100
80
60
40
20
0
0
20
40
60
80
100
Number of questions answered

Results

- We thought students might be rushing
- Usually, speed is inversely correlated with accuracy (i.e., the faster you do something, the worse you perform).
- Despite this poor performance, simple linear regression revealed a positive correlation between the number of questions answered and the number of correct answers (R=0.88, p<0.001)
- Faster students performed better!

Conclusions

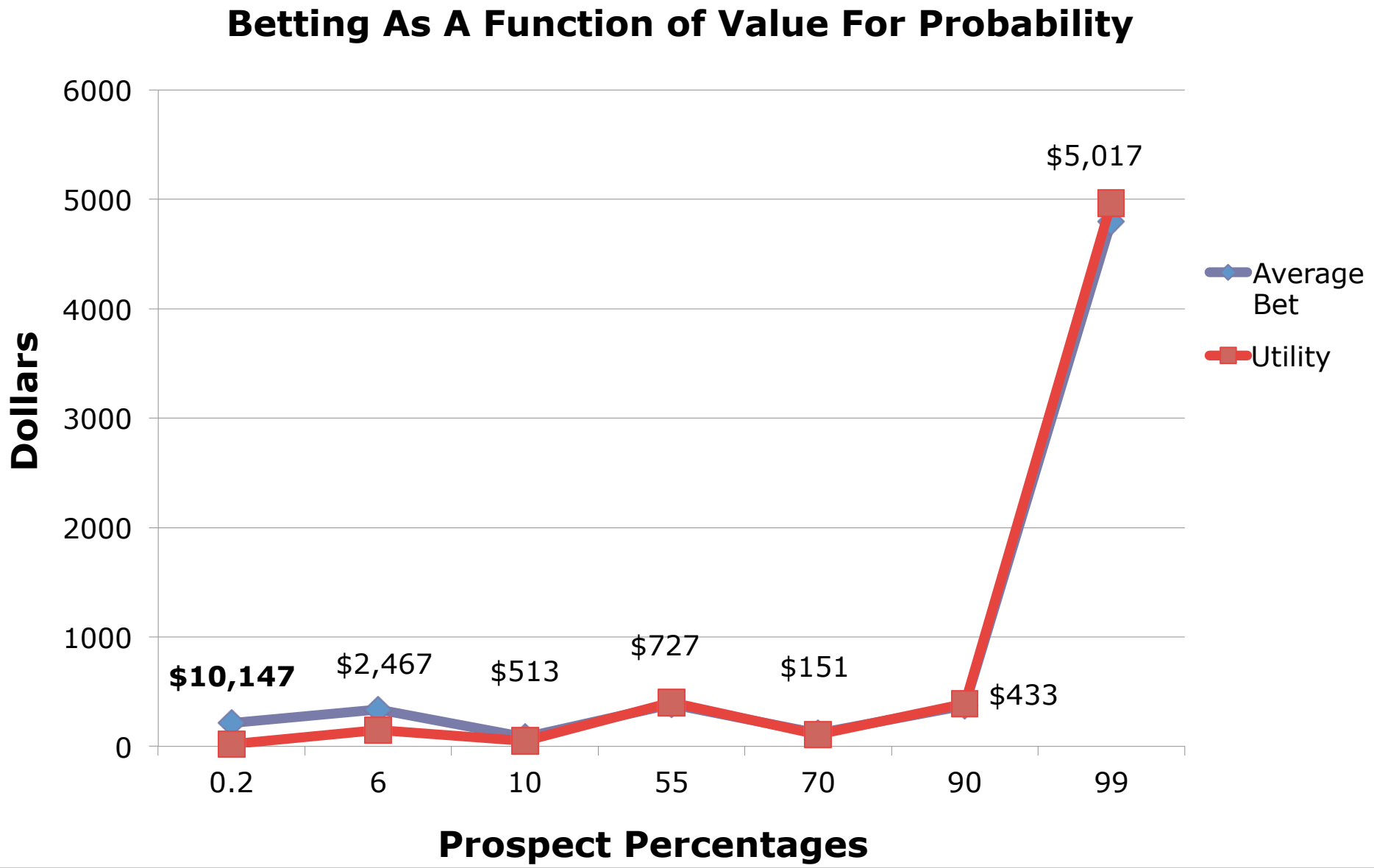
- Students did not link correct information to its source
- Poor overall performance and the speed-accuracy correlation indicate that students:
  1. Found the task very difficult
  2. Were performing to the best of their ability
- When information is very difficult to understand, students tend to ignore where the information comes from!

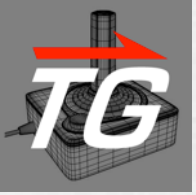
Follow-up Studies

- Problems
  - It was our first study. We were making games like scientists!
  - Questions were too hard
  - The experiment wasn't game-like at all
- Solutions
  - Add game mechanics
  - Start with conditions of certainty

Follow-up Studies

Follow-up Studies

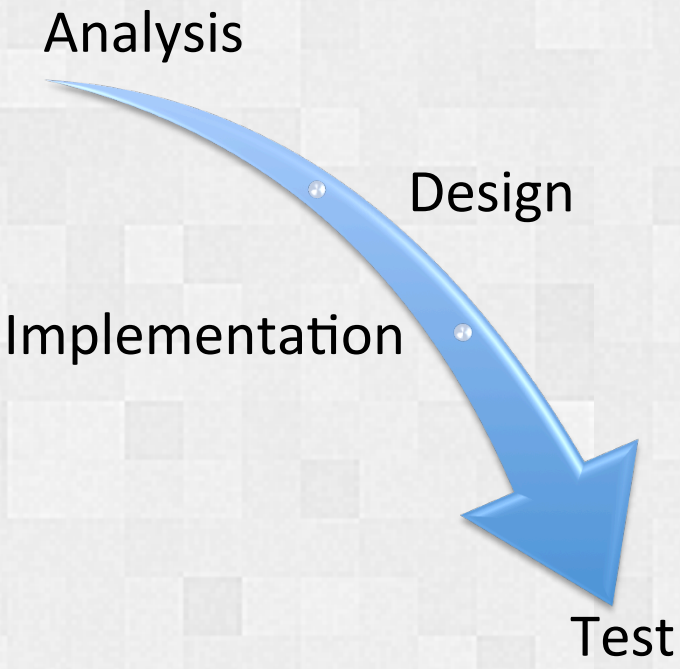




Aligning Game Development, the Scientific Method, and Learning Outcomes

The Problem

- Traditional implementation of the scientific method is slow relative to game development
- Long delays between planning and data analysis
  - Few opportunities to compensate for future problems during execution
  - Few opportunities for students to learn from their mistakes

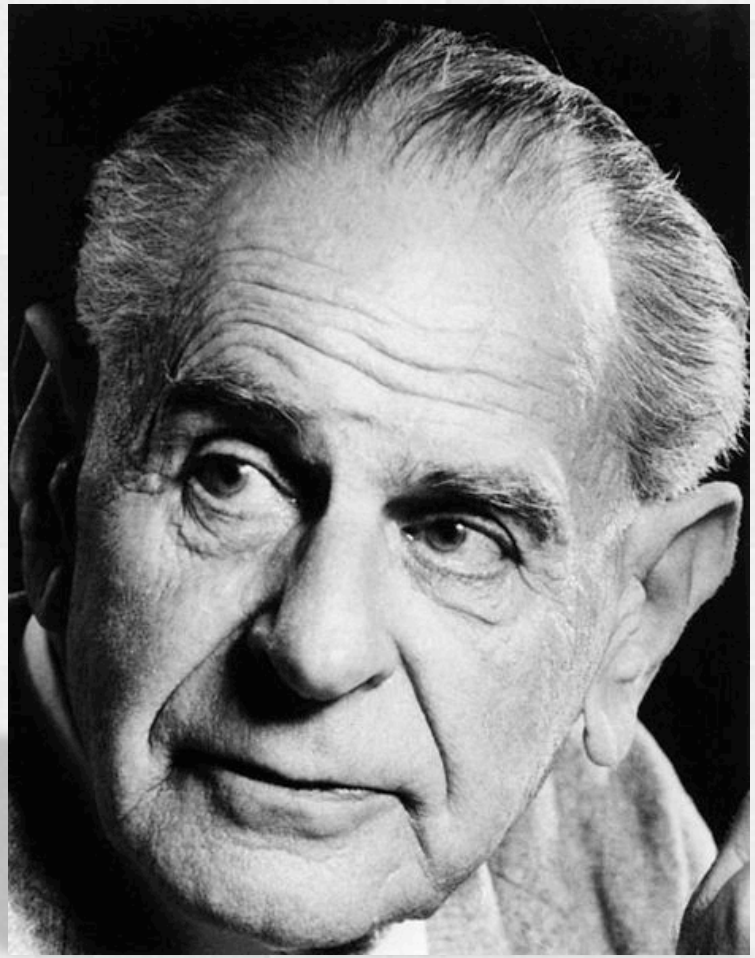


Scrum

- Software developers prefer iterative development over the *waterfall approach*
- Small teams (3-7)
- Sprints: short development cycles (1 day to 1 month)
- Vertical slice: assessment of features
- Unfinished features get placed in a backlog
- Scrum master: prioritizes the backlog for the next sprint

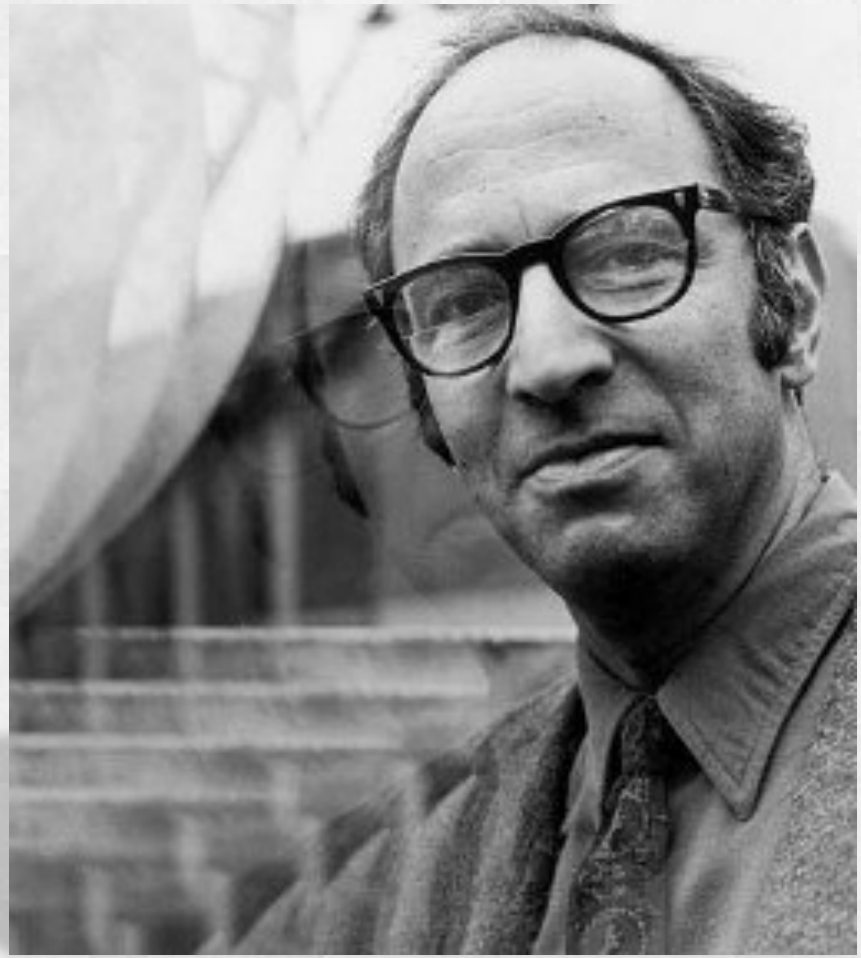
Philosophy of Science

- Karl Popper
  - Falsification: Scientific hypotheses gain little strength from positive data
  - Hypotheses can only be refuted by negative data
  - E.g., One black swan disproves the notion all swans are white.



Philosophy of Science

- Thomas Kuhn
  - Rebuked naïve falsification
  - No data fits a hypothesis exactly
  - All hypotheses would need to be rejected
  - Individual theories are part of a cultural dogma



"Half of what we're teaching you is wrong, but we don't know which half"

-Anon.

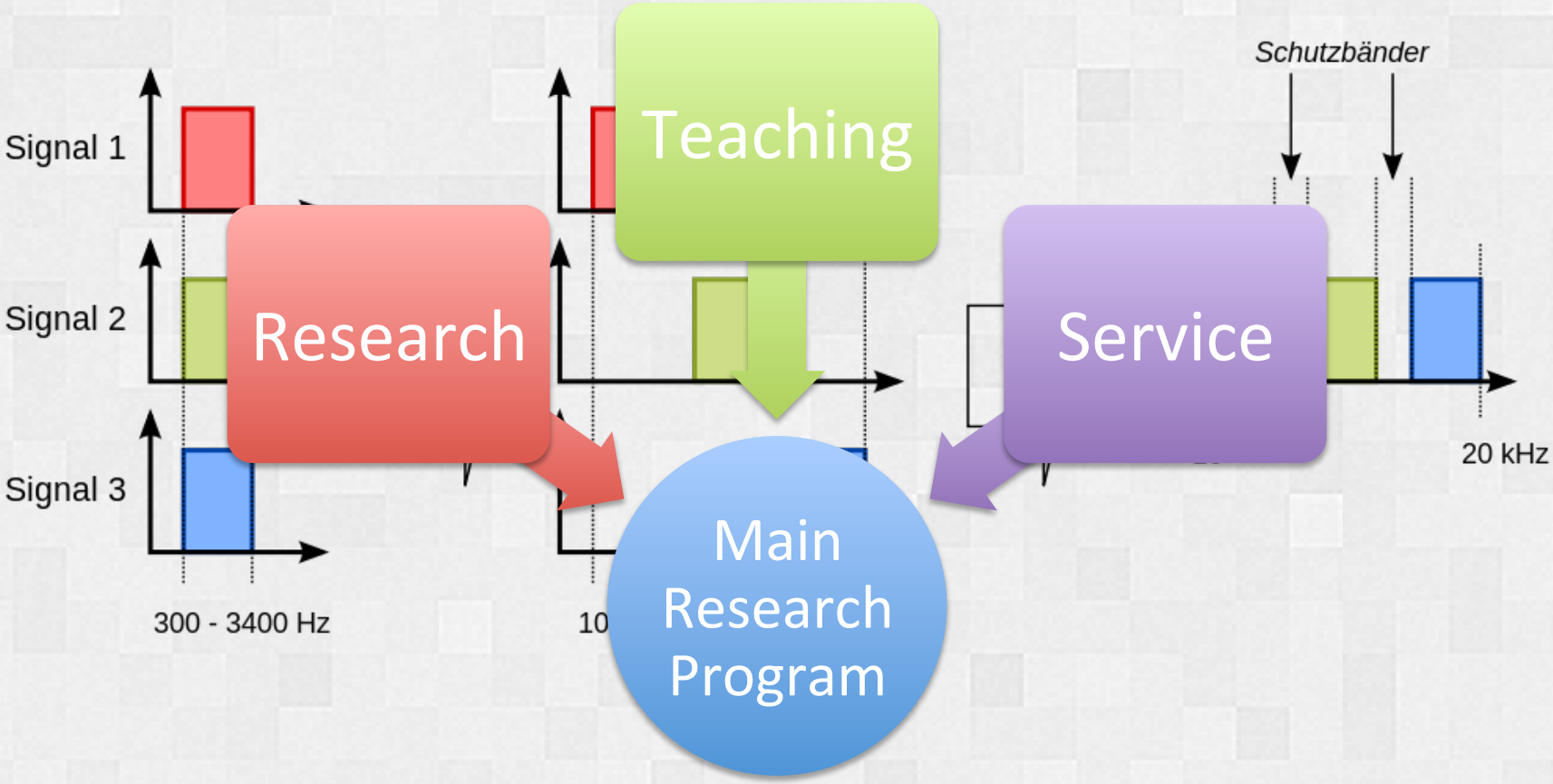
Philosophy of Science

- Imre Lakatos
  - Unlike individual experiments, research programs are not subject to naïve falsification
  - Don't abandon major research programs based on a single result
  - Experiments move fast. Research programs move slow.

Reconciliation

- Paradigm Shifts occur in science
- Novel predictions challenge the *status quo*
- Scrum can be used to quickly generate games that challenge dogmatic educational practices
- Students have several opportunities to learn about a subject during development
- Research programs flourish and strengthen through the years as content is amassed.
- Get students involved in high-risk research for the betterment of your main research program!

Multiplexing
(cooking on three stoves)



What can games do for you?

- Exploring new narratives
- Communication Theory
- Dynamic and interactive art
- Generative art and music
- Interactive music experiences
- Explore sound design
- Math and computational modeling
- Object oriented programming
- Cellular and neuronal modeling
- Behavioral modeling
- Environmental modeling
- Artificial Intelligence
- Physics modeling
- Role play risky or costly situations

"IF YOU USE THE SAME TOOLS AS EVERYONE ELSE, YOU BUILD THE SAME PRODUCTS. IF YOU WRITE YOUR OWN TOOLS, YOU CAN SEE NEW THINGS, DESIGN NEW THINGS."

— SAUL GRIFFITH