Psychology of games

Part 1: Reward-seeking behavior

(computational rationality, behavioral game design, reward design, limits of perception, cognition & action)

Perttu Hämäläinen 2022

Disclaimer: This content is perpetually work-in-progress, updated every year.

Teaser: Curtis et al. 2022

Toward Believable Acting for Autonomous Animated Characters

https://www.youtube.com/watch?v=0RB6DASdUP8

Cassidy Curtis
14 tilaajaa

Tilaa

13 Jaa Lataa Klippi Tallenna

Longer version of the talk with more details

https://www.youtube.com/watch?v=4T-FJ1KI9Lo

Discussion

- Is this a good way to model behavior, motivation, and emotion in animals and/or humans?
- What aspects of the system are realistic?
- What might be missing?

Discussion

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- What aspects of the system are realistic?
- What might be missing?

In the following, I will go deeper into these questions. According to current knowledge, this system gets many things right, although some aspects are overly simplified

Actual lecture begins…

Overview

- Playing games (and other human behavior) as reward-seeking behavior
- Why? Reward-seeking both explains many aspects of player behavior, and can be implemented in software for non-player characters
- What affects our reward seeking (limitations of perception, cognition, and memory)
- How to design game rewards?

Overview

- This lecture: Principles that work independent of the reward type (game score, virtual currency, game objects, satisfaction of beating a challenge…)
- Next lectures: But what is the “human reward function”? What do players really find satisfying/rewarding and care about?
    - This will lead us to deeper topics such as intrinsic motivation, emotion, and transformative games—but those can still benefit from the principles of this first lecture!

Structure

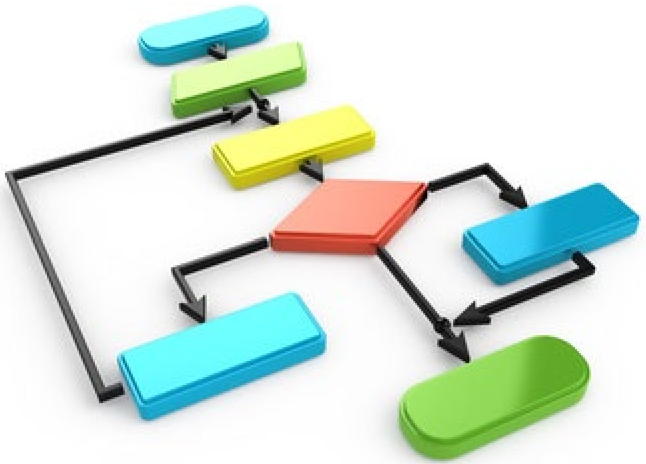
- **Theory: two types of thinking, computational rationality, limits of human cognition, perception, and action**.
- Practice: Game design principles based on the theory.

Computational rationality

- Classical economics: Humans are rational, choosing optimal actions that maximize utility
- Behavioral economics: Humans are not rational. Decision making is plagued by cognitive biases such as sunk cost fallacy
- Computational rationality (a.k.a. bounded rationality, ecological rationality): Humans try to act optimally, but it is hard. In practice, we make errors and are only approximately rational, limited by the capabilities of perception, cognition, and memory. Cognitive biases arise from the limitations.

Two types of thinking

SYSTEM 2: EXPLICIT/CONSCIOUS:
SLOW, ALGORITHMIC, EFFORTFUL



ATTENTION,
PRIMING,
INHIBITION

IDEAS,
ASSOCIATIONS,
IMPULSES,
INTUITIONS

SYSTEM 1: IMPLICIT/UNCONSCIOUS:
FAST, ASSOCIATIVE, EFFORTLESS,
INTUITIVE

ASSOCIATION

And you will read this at the end

You will read this first

And then you will read this

Then this one


Rate Your Experience
X
Enjoying Dungeon Keeper?
5-Star ratings from you help us
provide free updates!
How would you rate
Dungeon Keeper?
1-4 Stars
5 Stars

What limits us?

- Slow speed and high effort of analytical decision making (System 2)
- Inaccuracy and biases of intuition (System 1)
- Inaccuracy of memory
- Limited attention (we time-slice instead of multitasking!)
- Incomplete information
- Relativitity, subjectivity, and adaptivity of perception/evaluation of price, beauty, time…

What limits us?

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- Incomplete information
- Relativitity, subjectivity, and adaptivity of perception/evaluation of price, beauty, time…

This lecture: How to consider these in design, and examples of how the limitations are exploited (“dark patterns”)

What is utility?

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_t \gamma^t r(a_t, o_t)\right]$$

Why is this a good model?

- 3 fundamental forms of behavior:
  - Random
  - Rule-based (stimulus-response)
  - Behavior that tries to achieve some goals
- Human behavior clearly has at least some goals
- Goals and rewards are interchangeable: Rewards for reaching a goal
- Reward-based modeling allows applying AI methods such as Deep Reinforcement Learning to make useful predictions
- A lot of empirical support for humans and animals choosing actions of (approximately) highest perceived utility

Computational rationality

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Computational rationality

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DISCLAIMER: The math is only essential for technical designers who might build game AI or player behavior simulations. Optional material for others.

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_{\boxed{t}} \gamma^{\boxed{t}} r(a_{\boxed{t}}, o_{\boxed{t}})\right]$$

Time, with *t=0* denoting the current time and increasing towards the future

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_t \gamma^t r(\boxed{a_t,}\, o_t)\right]$$

Action at time *t*

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_t \gamma^t r(a_t, \boxed{o_t})\right]$$

Observation of the world at time *t*

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_t \gamma^t \boxed{r}(a_t, o_t)\right]$$

Reward function: What do we perceive as rewarding/satisfying?

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\boxed{\sum_t} \gamma^t r(a_t, o_t)\right]$$

Sum over time: We do not only care about the reward for our next action, but also about all the actions possible after that

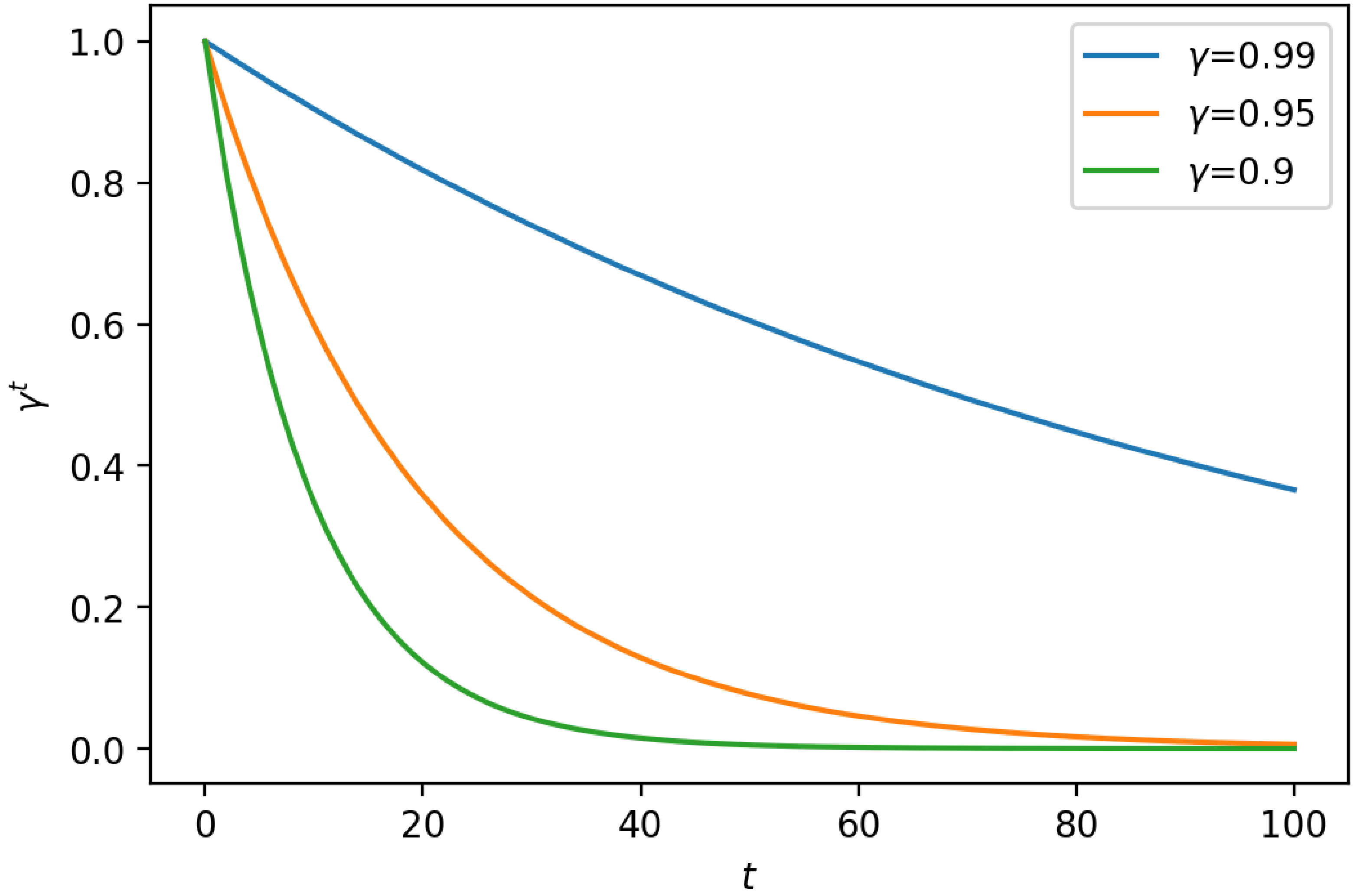
Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\sum_t \boxed{\gamma^t r}(a_t, o_t)\right]$$

Future discounting of rewards: γ is in range 0…1. At t=0, γ^t=1. When t grows, γ^t decreases to zero.

Small discount γ: Immediate rewards matter more



Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\mathbb{E}\left[\boxed{\sum_t \gamma^t r(a_t, o_t)}\right]$$

This sum of discounted future rewards is also called "return", denoted *R*

Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

$$\boxed{\mathbb{E}}\left[\sum_t \gamma^t r(a_t, o_t)\right]$$

Expectation: If the results of our actions are more or less random, we want to take actions yield maximal return, on average.

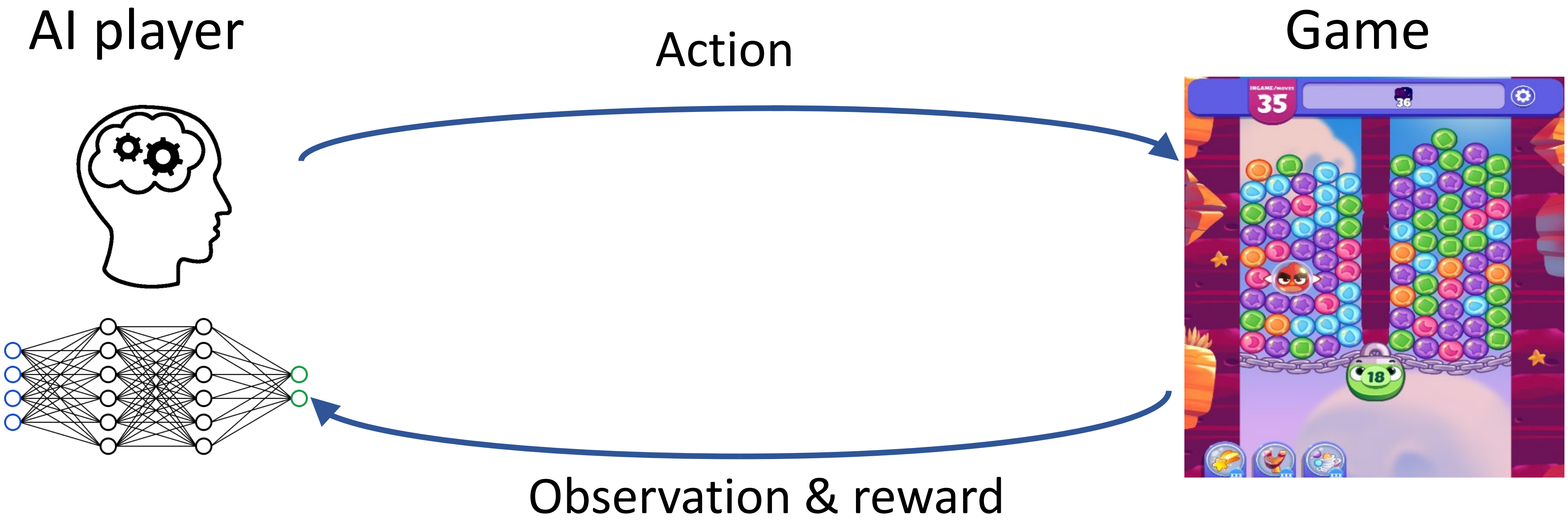
Computational rationality

Behavior emerges from (approximate and limited) optimization of utility: The expected sum of rewards for our future actions

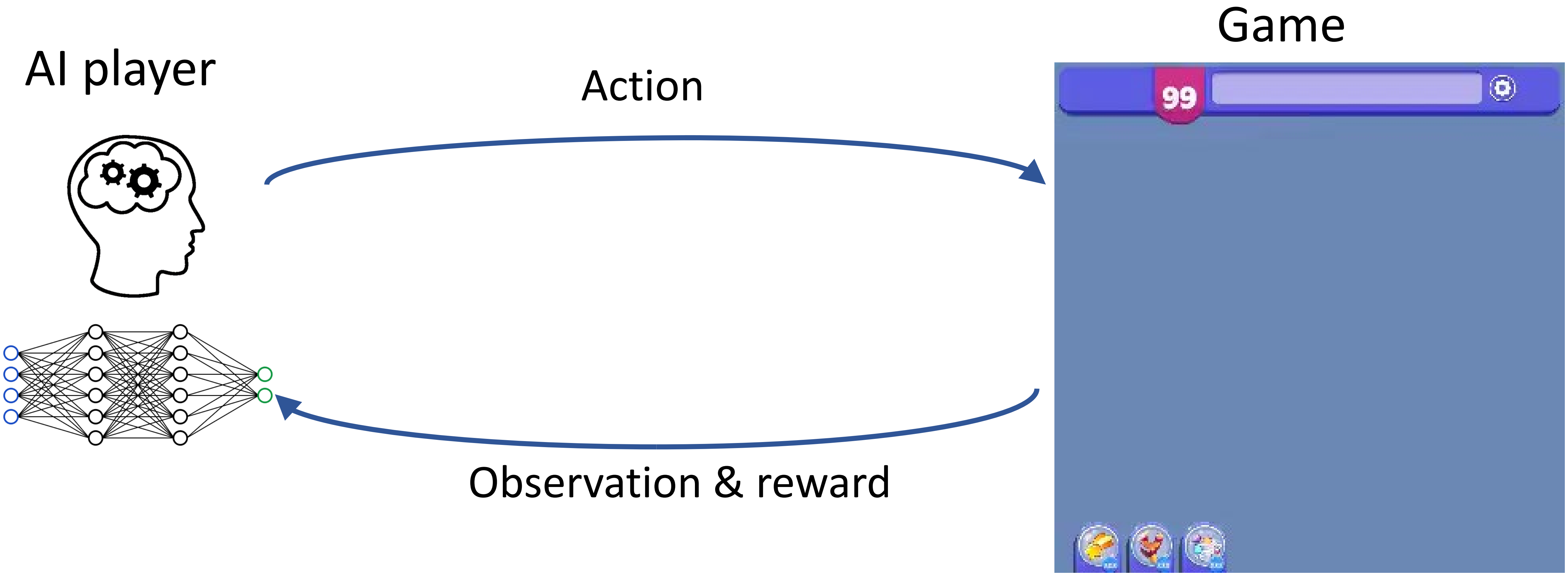
$$\mathbb{E}\left[\sum_t \gamma^t r(a_t, o_t)\right]$$

Optimizing this is at the heart of many AI systems => we can use AI players for playtesting etc.

Game-playing AI



Game-playing AI



We optimize and learn through interaction

Computational Rationality as a Theory of Interaction

Antti Oulasvirta
Aalto University
Finland

Jussi P.P. Jokinen
University of Jyväskylä
Finland

Andrew Howes
University of Birmingham
UK

ABSTRACT

How do people interact with computers? This fundamental question was asked by Card, Moran, and Newell in 1983 with a proposition to frame it as a question about human cognition – in other words, as a matter of how information is processed in the mind. Recently, the question has been reframed as one of adaptation: how do people adapt their interaction to the limits imposed by cognition, device design, and environment? The paper synthesizes advances toward an answer within the theoretical framework of *computational rationality*. The core assumption is that users act in accordance with what is best for them, given the limits imposed by their cognitive architecture and their experience of the task environment. This theory can be expressed in computational models that explain and predict interaction. The paper reviews the theoretical commitments and emerging applications in HCI, and it concludes by outlining a research agenda for future work.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**; **User models**.

KEYWORDS

Cognitive modeling, computational rationality, interaction, reinforcement learning, adaptation, individual differences

menu selection [16], distraction [104], and visual search [67]. Such theories, while abstractions, are central to the practical aims of HCI and have made contributions to computational design [38, 87], human factors [126], design practice [96], and design education [84]. Recently, human–AI cooperation has added another area in which there is a need for theories of cognition [25, 46, 53].

The theory presented in this paper has grown out of difficulties experienced by the authors, cognitive scientists by training, in applying cognitive architectures. We repeatedly faced the issue that each model needs the modeler to hypothesize how the task is completed, and to code this knowledge as production rules. In other words, the modeler must specify a "recipe", a rule set that specifies the user's procedural skill. Writing these rules is challenging, in part because users are clever at generating unexpected strategies that are hard to identify. This difficulty stems from the fact that architectures such as EPIC [66] and ACT-R [3] admit a very large space of possible strategies. They are not sufficiently constrained for ascertaining which strategies users will actually choose. Moreover, rule systems are brittle. They must be updated if the design or environment changes, and a different rule set is needed for each type of user, limiting applications for design and intelligent interfaces.

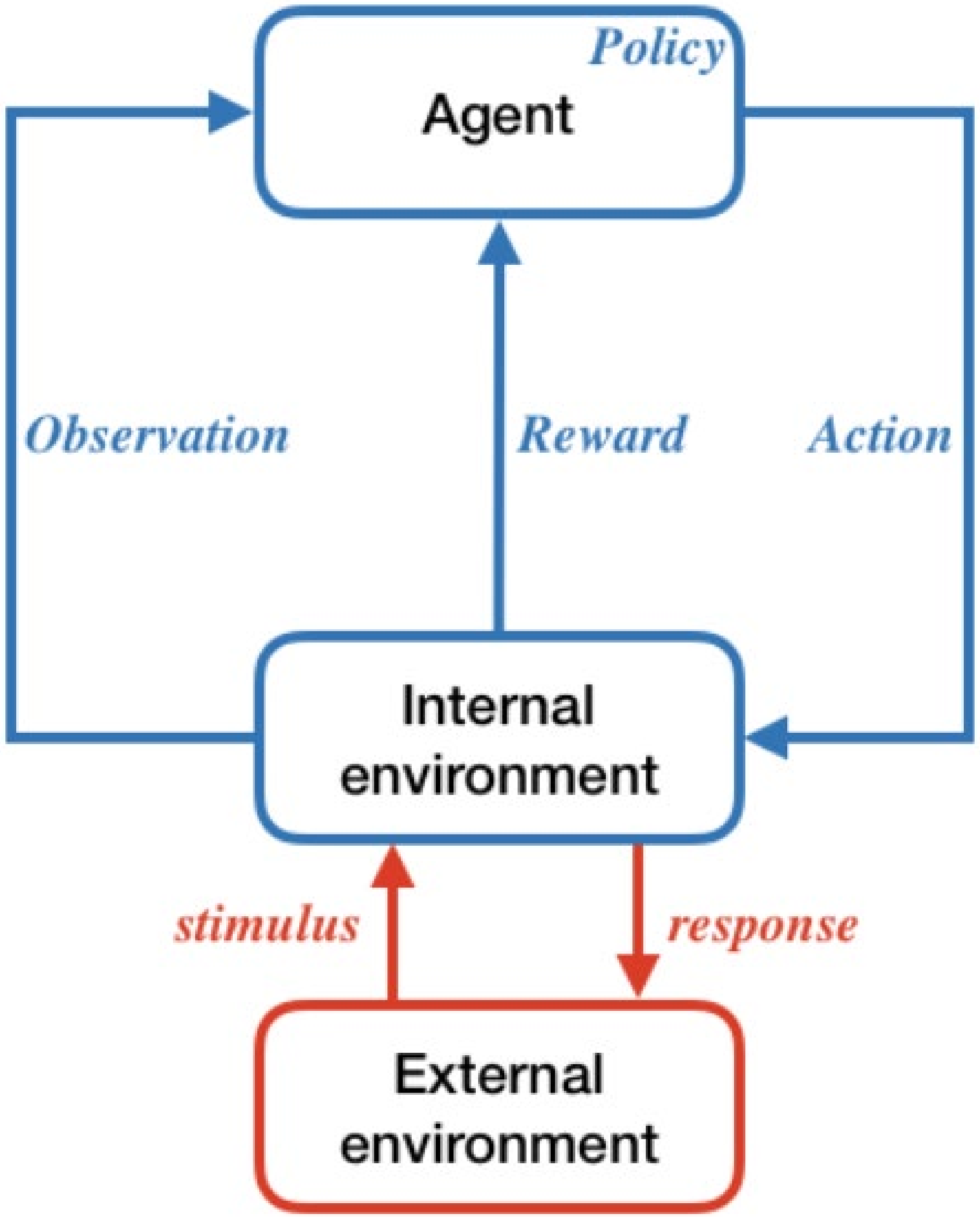
These issues have recently been addressed by a new class of theories in efforts to explain *why* people choose some strategies in interaction and not others [1, 22–24, 56, 59, 61, 63, 91]. Consider, for example, explaining why people make certain text-entry errors

https://dl.acm.org/doi/abs/10.1145/3491102.3517739

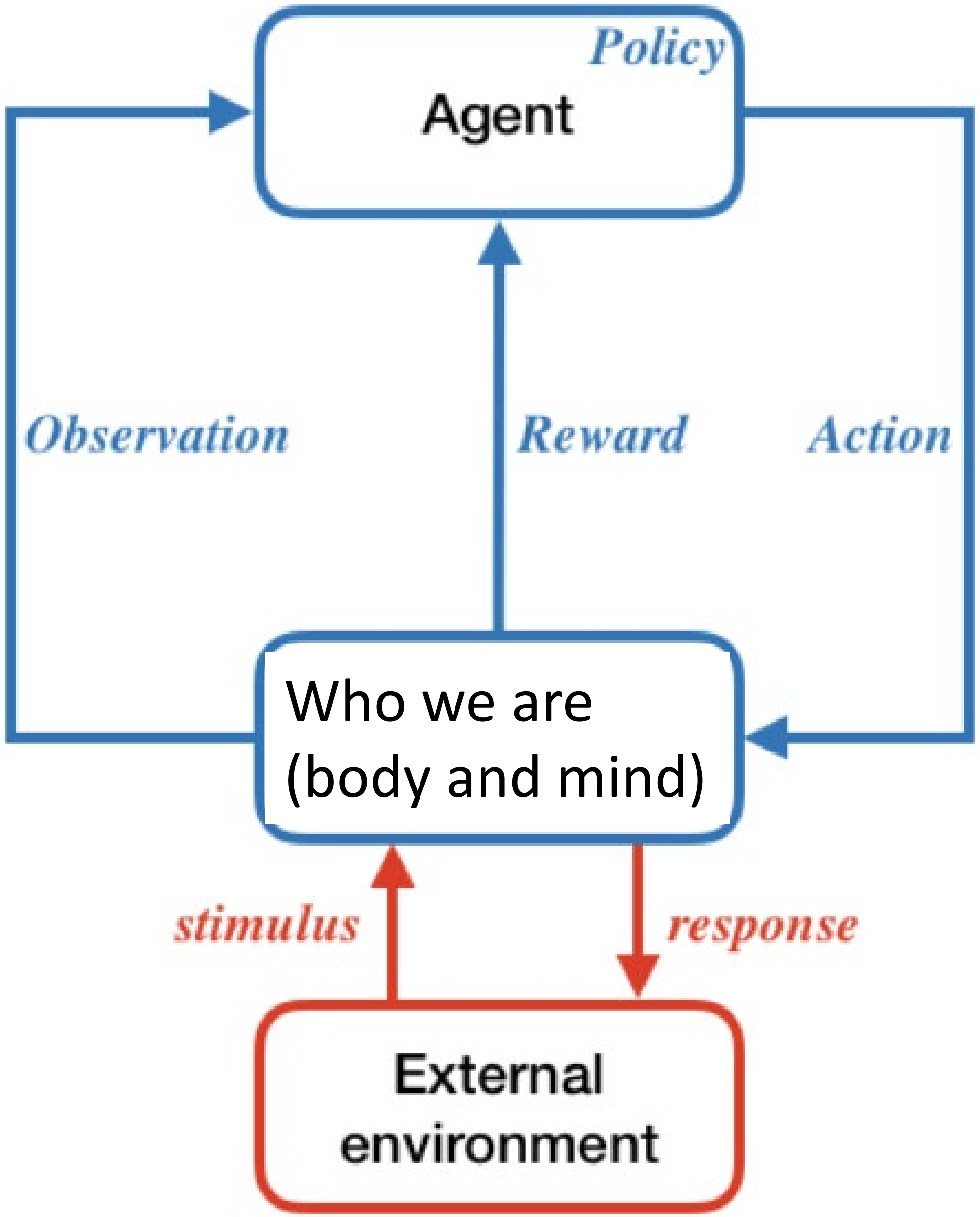
Game playing AI interacting with a game

- First, try random actions
- Gradually start to repeat the actions that yield highest utility
- Fundamentally, learning iteratively through trial and error

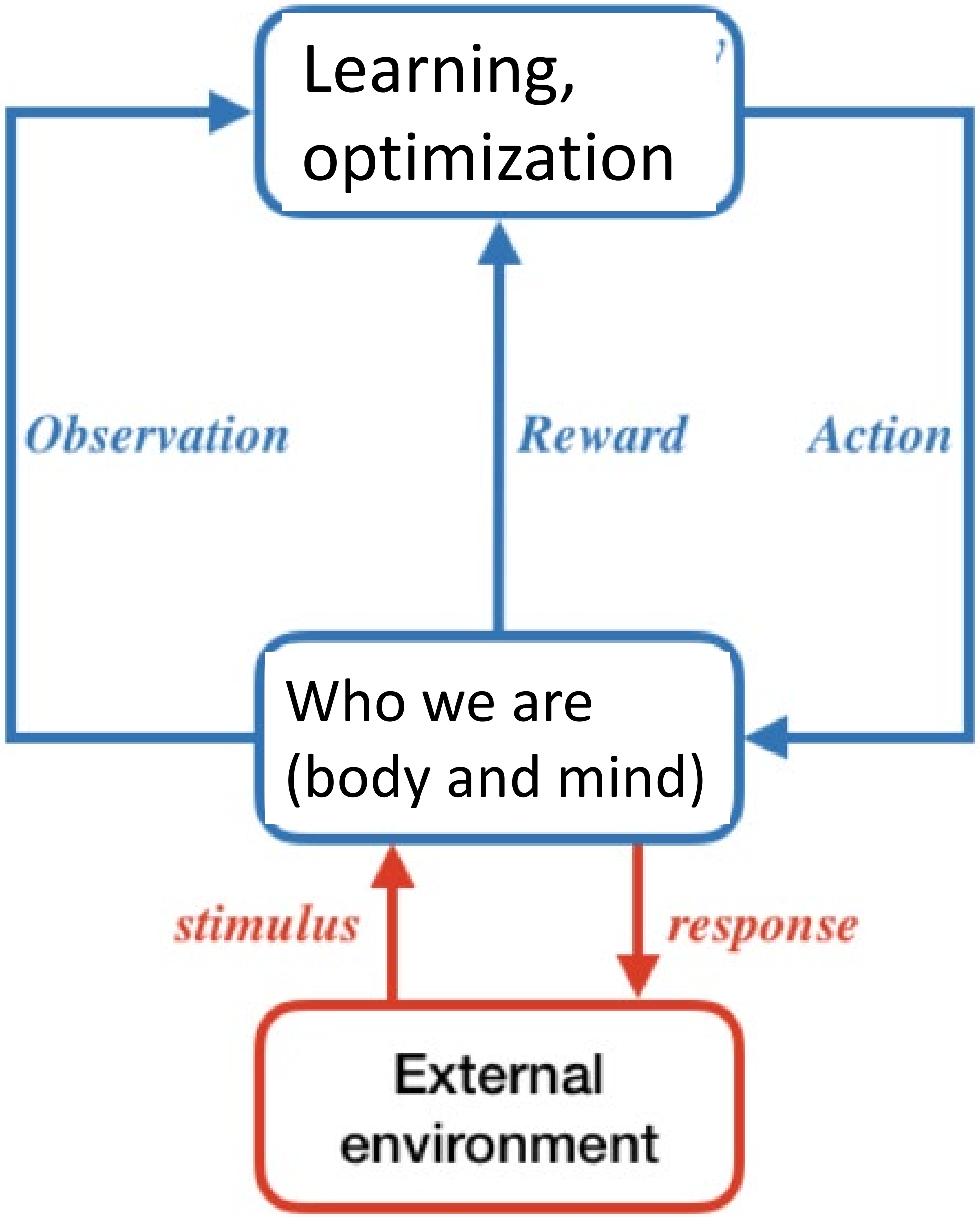
What about humans?



“Internal environment” = who we are



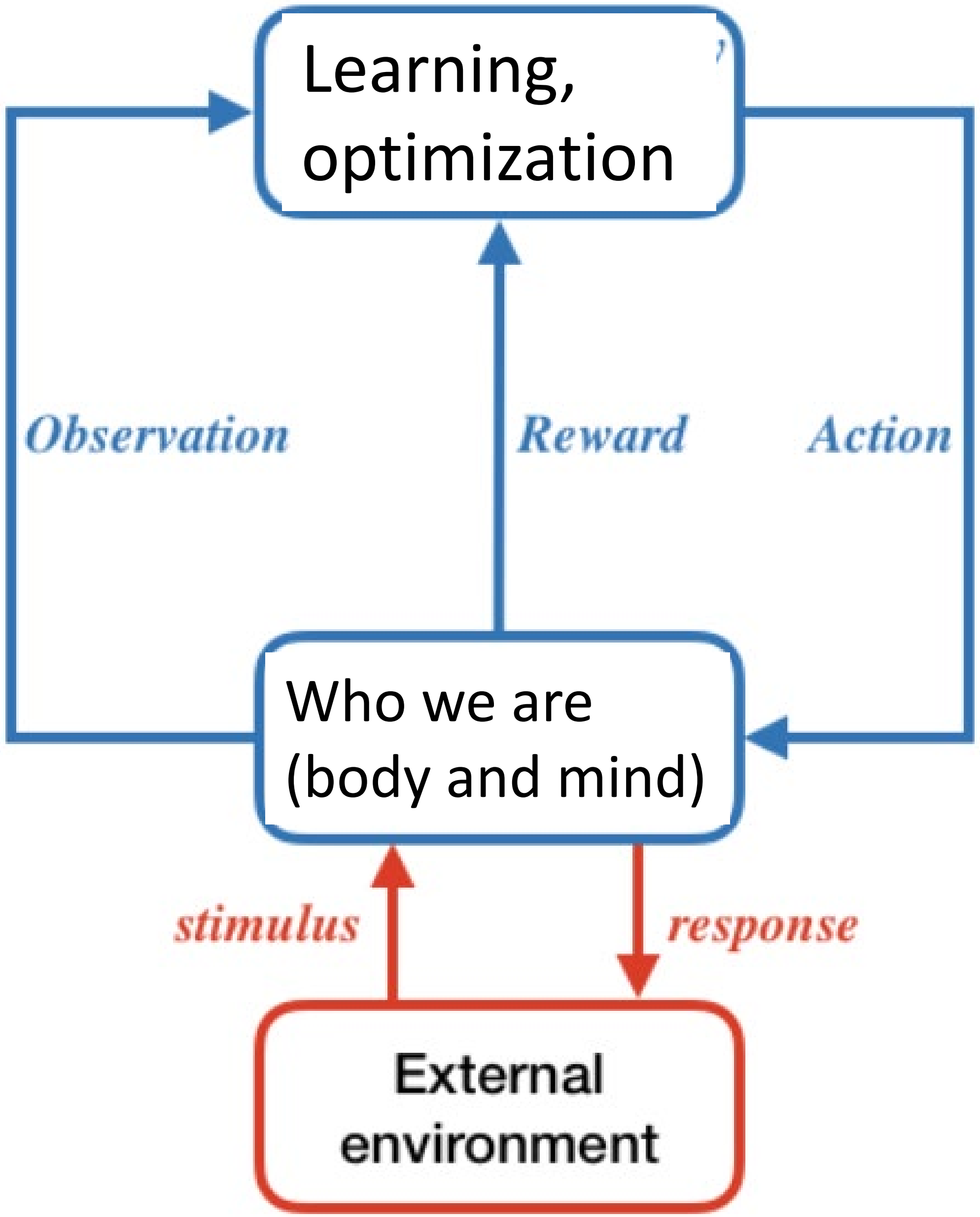
“Agent” = learning & optimization/search



How do we learn and optimize?

System 1: Evaluate and choose actions based on intuition or “what feels right” (intuitive and sometimes irrational predictions of utility)

System 2: Think of every option, e.g., using some mental model that lets us predict the results of actions



System 1 and evolution

- Intuitive/instinctive System 1 preferences are both learned and innate
- During the most of our evolution, energy has been a scarce resource
- High-calorie foods have provided a survival advantage => we're genetically built to seek them and experience them as rewarding, innately and irrationally/suboptimally

JOURNAL ARTICLE

Sweet taste preferences are partly genetically determined: identification of a trait locus on chromosome 16 FREE

Kaisu Keskitalo, Antti Knaapila, Mikko Kallela, Aarno Palotie, Maija Wessman, Sampo Sammalisto, Leena Peltonen, Hely Tuorila ✉, Markus Perola

The American Journal of Clinical Nutrition, Volume 86, Issue 1, July 2007, Pages 55–63, https://doi.org/10.1093/ajcn/86.1.55

Published: 01 July 2007 **Article history** ▾

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ABSTRACT

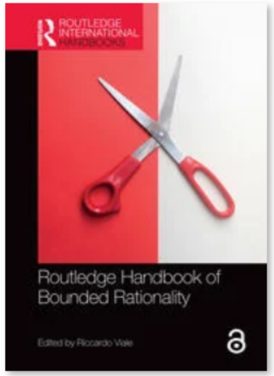
Background: Humans have an innate preference for sweet taste, but the degree of liking for sweet foods varies individually.

Objective: The proportion of inherited sweet taste preference was studied. A genome-wide linkage analysis was performed to locate the underlying genetic elements in the genome.

Design: A total of 146 subjects (32% men, 68% women) aged 18–78 y from 26 Finnish families evaluated the intensity and pleasantness of 3 suprathreshold solutions of sucrose (3.0%, 7.5%, and 18.75%) and plain water and the intensity of filter paper impregnated with 6-*n*-propylthiouracil (PROP). The subjects also reported the pleasantness and the use frequency of 5 sweet foods (chocolate, candy, ice cream, sweet desserts, and sweet pastry) and completed a food-behavior questionnaire that measured their craving for sweet foods.

Results: Of the chemosensory functions, the pleasantness rating of the strongest (18.75%) sucrose solution and the intensity rating of PROP yielded the highest heritability estimates (41% and 66%, respectively). The pleasantness and the use frequency of sweet foods (both variables calculated as a mean of ratings for 5 food items) and the craving for sweet foods showed significant heritability (40%, 50%, and 31%, respectively). A logarithm of odds score of 3.5 (P = 0.00003) was detected for use frequency of sweet foods on chromosome 16p11.2 (marker D16S753).

Conclusions: Sweet taste preferences are partly inherited. Chromosome 16p11.2 may harbor genetic variations that affect the consumption of sweet foods.



Chapter

Ecological rationality

Bounded rationality in an evolutionary light

By Samuel A. Nordli, Peter M. Todd

Book Routledge Handbook of Bounded Rationality

Edition	1st Edition
First Published	2020
Imprint	Routledge
Pages	11
eBook ISBN	9781315658353

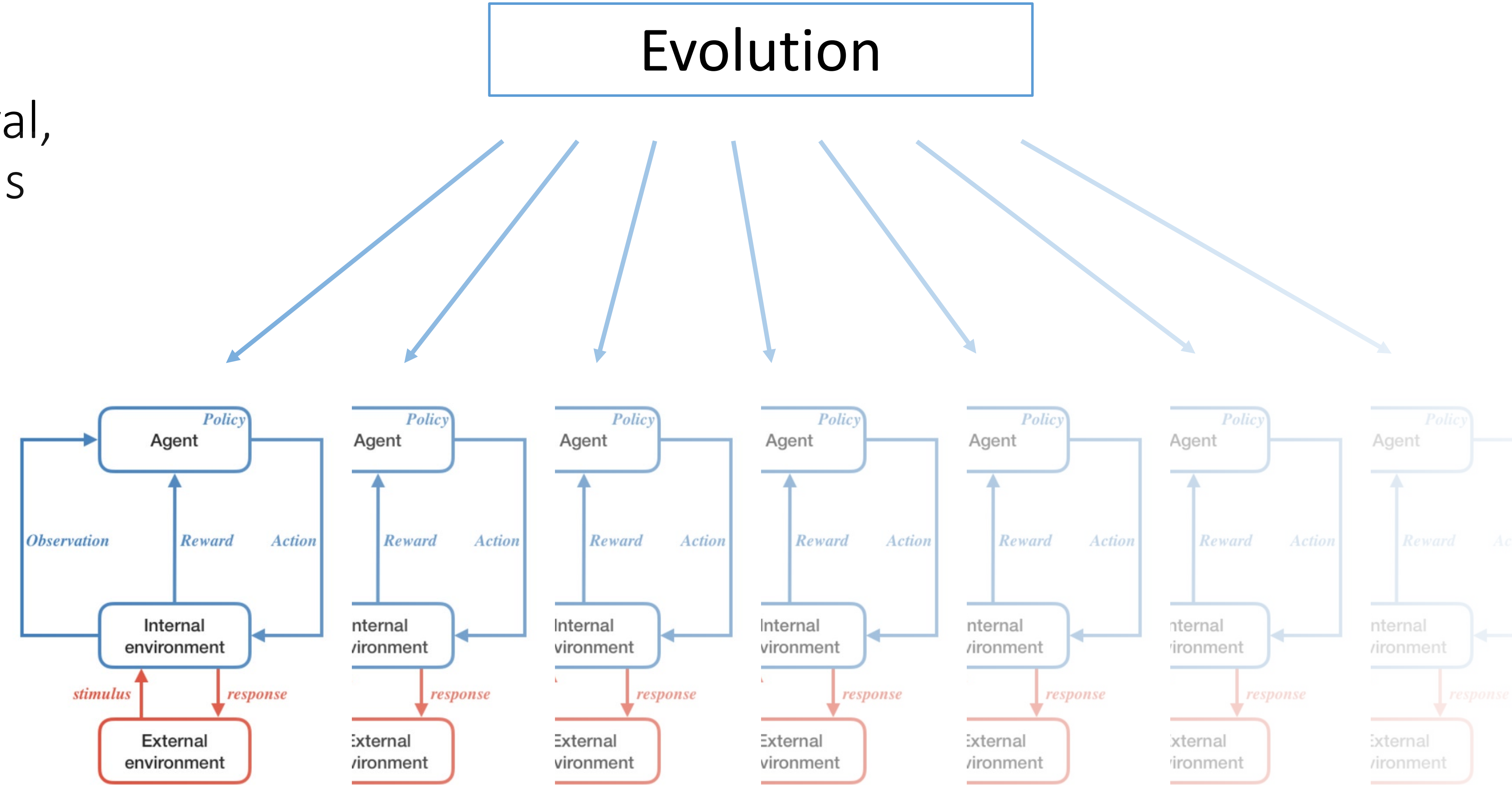
ABSTRACT

The study of ecological rationality situates Simon's notion of bounded rationality within the framework of natural selection, emphasizing that the evolved capacities of decision-making organisms have been shaped by and are adapted to the structure and fitness pressures of ancestral environments. Research in ecological rationality considers the fit between decision mechanisms and the structure of decision environments in order to understand behavioral outcomes in specific decision contexts. This chapter focuses on the importance of goals in decision making, highlighting how decision makers use cues about environment structure to efficiently determine which behaviors or strategies will best serve goal pursuit; research in ecological rationality, behavioral ecology, and neuroscience is used to draw connections between fast and frugal heuristics, fixed action patterns, rules of thumb, and habits, framing each as examples of cue-driven iteration/variation of past behavior used to pursue goals in present contexts. The chapter closes with a review of specific examples from ecological rationality research, an overview of how the ecological rationality perspective can help understand behavior that fails to match classically rational expectations, and finally with a discussion on future directions for research in ecological rationality.

The big picture: Two nested optimization processes

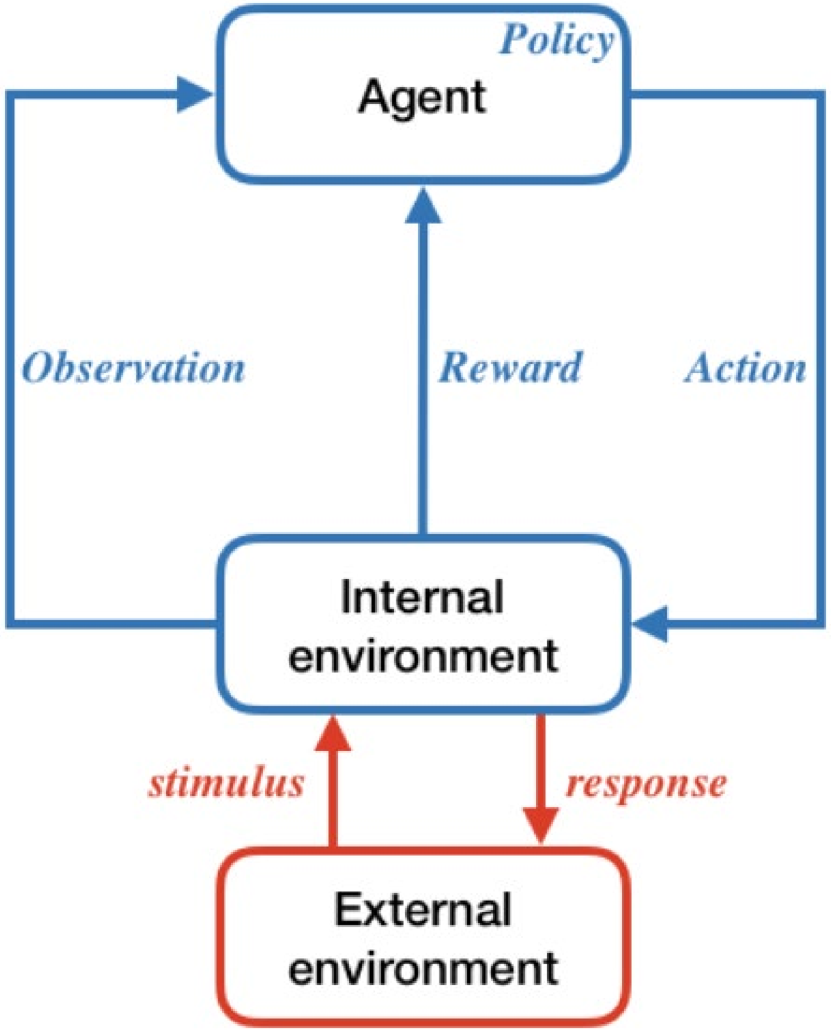
Evolution:
Optimization of genes for survival, over generations

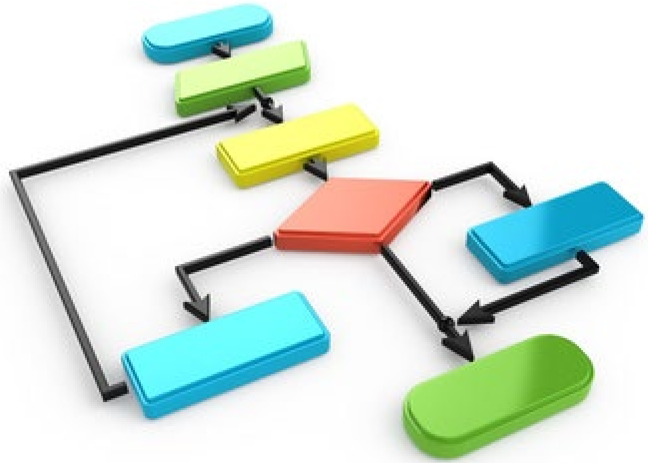
Computational Rationality:
Optimization of behavior during each individual's lifespan



CR limitations defined by evolution: cognitive architecture, innate preferences and other System 1 biases…

CR recap: We optimize utility, but with limitations





ATTENTION,
PRIMING,
INHIBITION

IDEAS,
ASSOCIATIONS,
IMPULSES,
INTUITIONS

ASSOCIATION

Questions? (also: short break)

Structure

- Theory: two types of thinking, computational rationality, limits of human cognition, perception, and action.
- **Practice: Game design principles based on the theory.**

Example games: Walking Dead No Man’s Land´& Clash Royale

- In the following slides, I’ll be using examples from WDNML and Clash Royale.
- I assume you have played both games:
  - WDNML: Complete first two episodes or play until you run out of virtual currency.
  - Clash Royale: Play at least through the tutorial and the first arena so that you get to unlock some cards and start to get an idea of the reward and progress mechanics

Design principles and implications

- **Core reward design principles (anticipation and discounting of rewards)**
- Avoiding thinking (System 1 vs. System 2, cognitive biases affecting reward evaluation)
- Perception and attention (contrast, Halo effect, confirmation bias)
- Memory (storing and retrieving information)
- Social (effect of other people)

Behavioral game design

https://www.gamedeveloper.com/design/10-years-of-behavioral-game-design-with-bungie-s-research-boss

10 Years of Behavioral Game Design with Bungie's Research Boss

Bungie's head of user research takes another look at his decade-plus old article, which has become both influential and infamous for its suggestion that games can be better when developers take the psychology of players into account.

John Hopson
Blogger

June 15, 2012

[*Bungie's head of user research takes another look at his decade-plus old article, which has become both influential and infamous for its suggestion that games can be better when developers take the psychology of players into account.*]

A lone scientist labors late into the night in his lab, assembling his creation piece by piece, and then releases it to rampage across an unsuspecting world! Muwhahahaha!

No, not *Frankenstein*. Behavioral Game Design!

When I wrote that article a decade ago, I was a psychology graduate student and amateur game designer who had never worked in the games industry. Since then, the article has run amok, living an almost completely independent existence in the wilds of the internet.

It's been translated into multiple languages and assigned as homework. It's been cited by academics, pilloried by the Huffington Post, and even lampooned by my childhood favorite, Cracked magazine.

[Footnote: This actually makes me the second of Bungie's employees to be called out by Cracked. Their treatment of our security chief was much more complimentary.]

And as anniversaries tend to do, the 10 year anniversary of this article has spurred a lot of reflection on my part. The industry has changed almost beyond recognition since 2001, and I'd like to take the opportunity to ruminate publicly about where this topic has gone in the past decade.

Reinforcement learning has been acknowledged as a

powerful force in game design.

The biggest change is that it's hard to find a game today that doesn't take its reward structure seriously. At the time of the article, it was a radical idea to say that games contained rewards and that the way those rewards were allotted could affect how people played. Now it's simply a given.

The clearest example of the acceptance of reinforcements in game design is the widespread use of achievements. Achievements are a really interesting case for study because there often isn't any

Rewards only motivate us if we anticipate/predict them

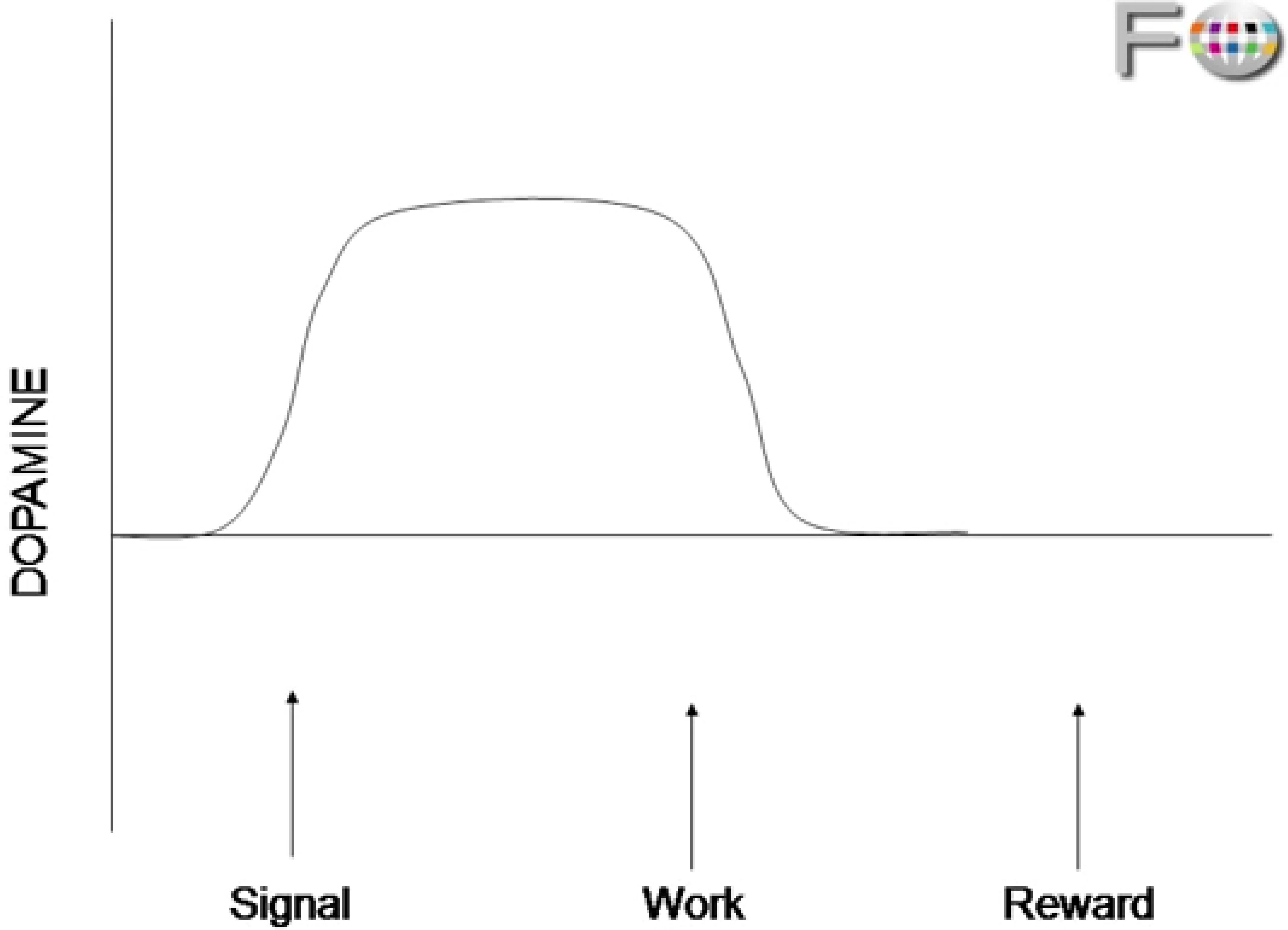
- Computational Rationality: players choose actions that yield highest expected utility (sum of future rewards)

$$\mathbb{E}\left[\sum_t \gamma^t r(a_t, o_t)\right]$$

- However, players' information, search capabilities and mental models are limited => they might not anticipate the rewards

Anticipating rewards and the brain

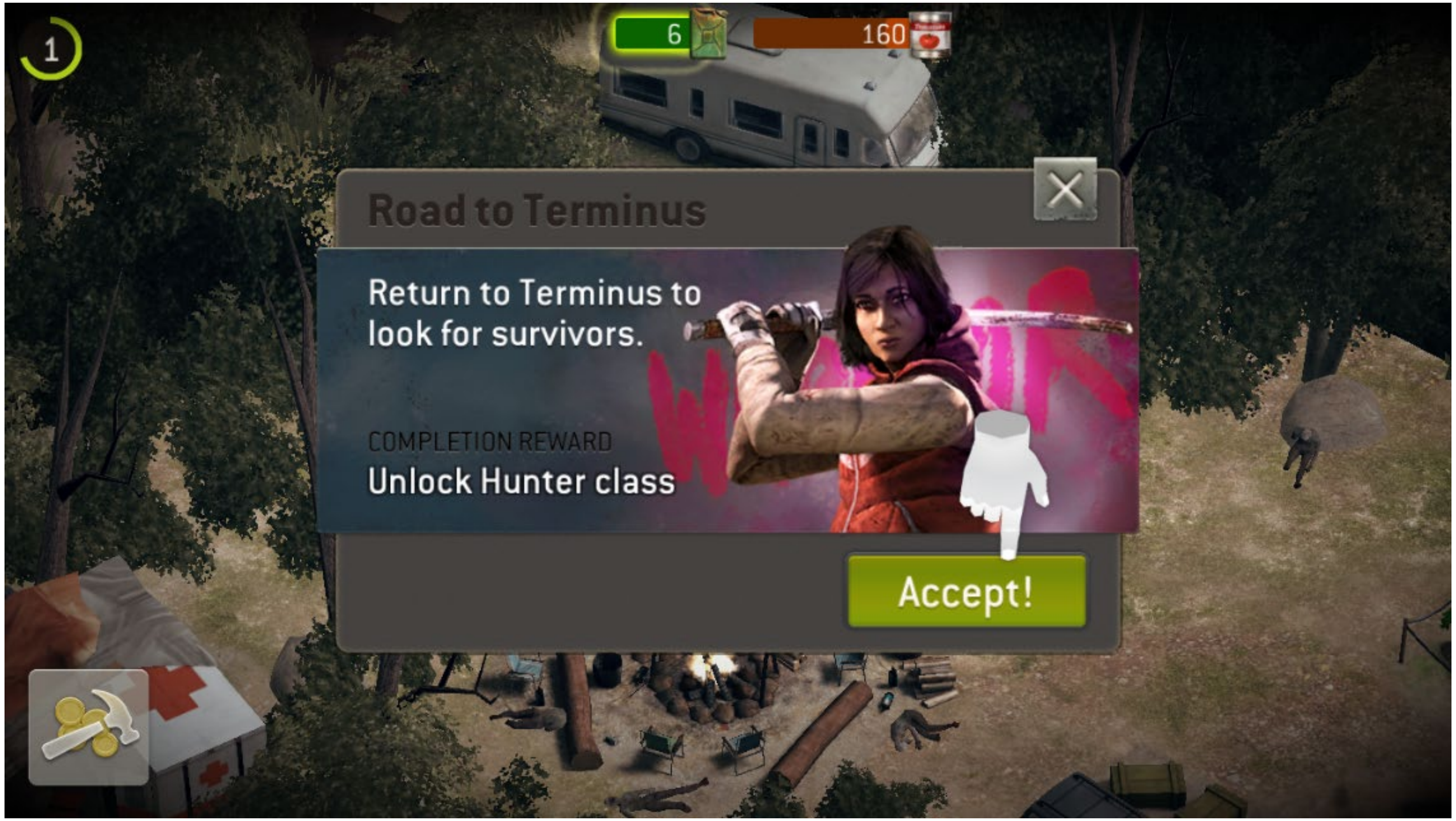
- Dopamine is the key neurotransmitter, linked to seeking reward and pleasure in games, gambling, work, sex...
- Dopamine peaks when anticipating reward (based on previous experience or some mental model), not when getting the reward. The rise of dopamine drives us to action.


DOPAMINE
Signal
Work
Reward

Design principle: Build anticipation

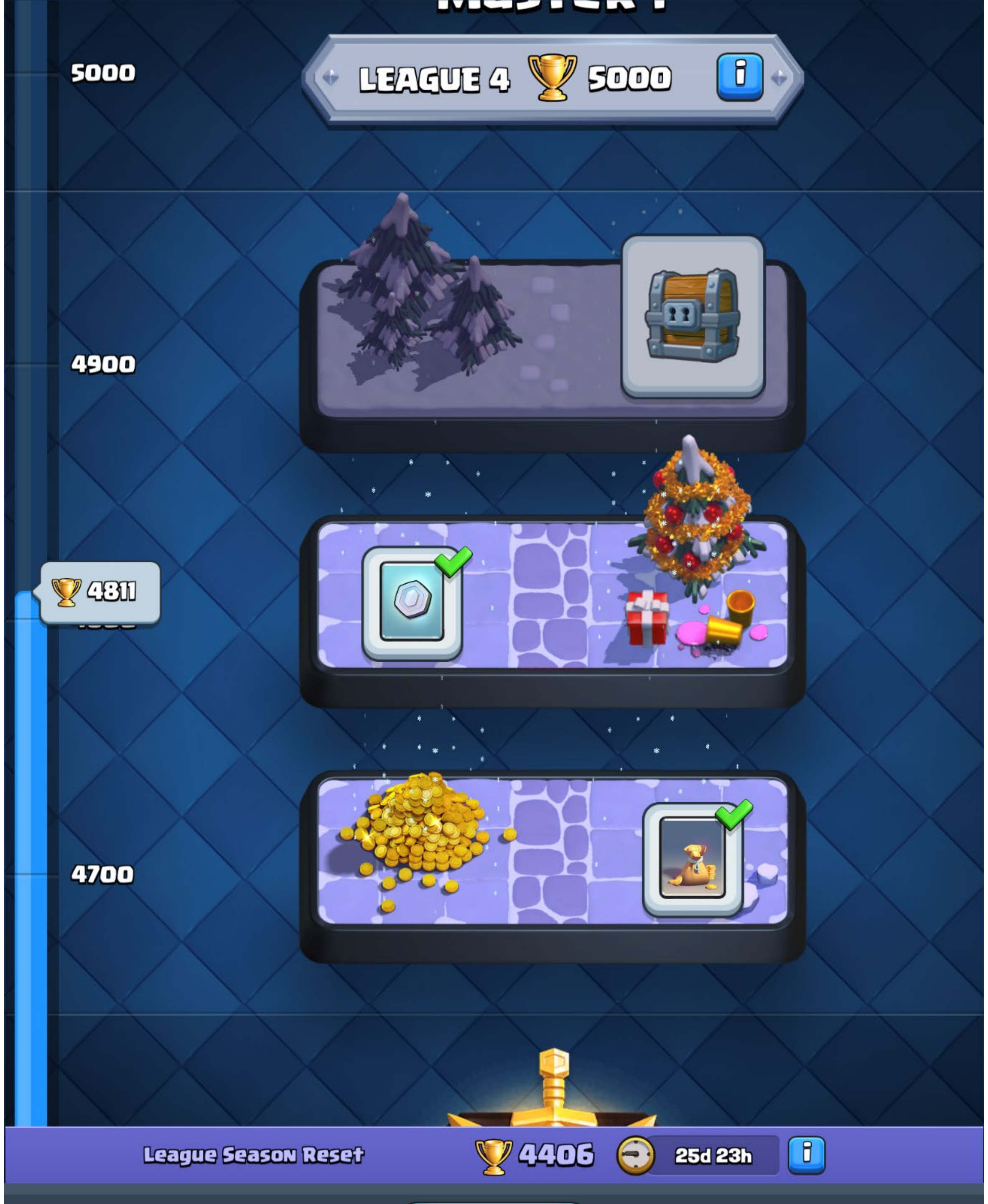
- The player's information, search capabilities and mental models are limited => they might not anticipate the rewards
- Design implications:
  - Communicate/advertise future rewards to increase motivation!
  - Often: Communicate next reward already before previous one reached.

Communicate future rewards



WDNML: Clearly state the reward that the player will get, e.g., after completing an episode


12
56543/80000
50 203
108
tuHOV
hulluhan se on
4811
1
1
0/10
9
PASS ROYALE
NEXT REWARD
Battle
Party!
New Mode!
Queue
3H
OPEN
ARENA 13
Chest Slot
Special Offer Available
1
2
10
Battle

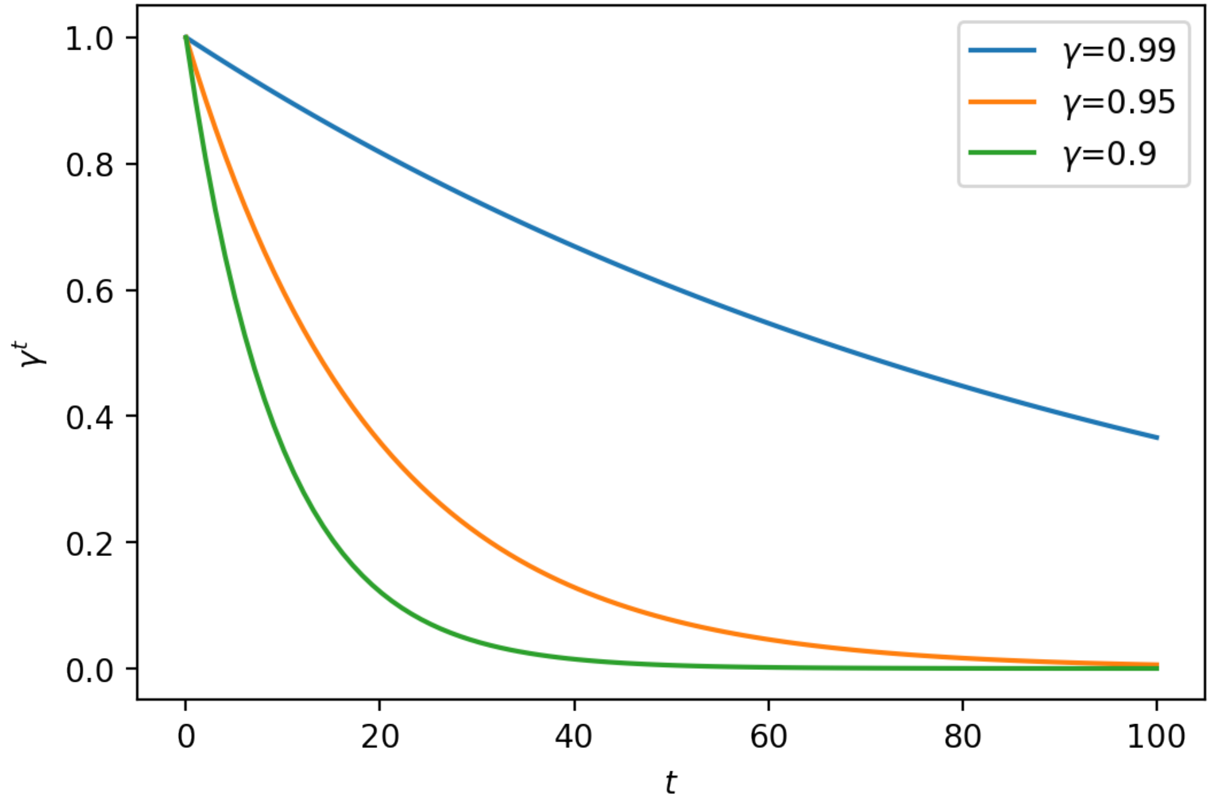

5000
LEAGUE 4
5000
4900
4811
4700
League Season Reset
4406
25d 23h

Design pattern: Rewards that unlock later

WDNML: Cascaded rewards. Many rewards cannot be used immediately, player has to first reach some other goal(s).

Motivation increases when the reward or goal is near

- Computational Rationality model: future discounting through the gamma parameter
- Design principles:
  - Breadcrumbing
  - Break tasks into subtasks that have rewards.
  - Rewards at multiple time scales (e.g., core loop and daily login rewards)




Horizon Zero Dawn - Cauldron RHO Walkthrough
550 / 550
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N
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35
CAULDRON RHO
Find the Cauldron Core
Breadcrumbing using small rewards
1/16
9:39 / 14:19

Breadcrumbing in Level Design: Guiding your player from A to B

https://www.youtube.com/watch?v=IyKgZ56IGzw

timdoesleveldesign
3,24 t. tilaajaa
Tilaa

149 Jaa Lataa Klippi Tallenna ···

Daily Quests or Daily Pests? The Benefits and Pitfalls of Engagement Rewards in Games

JULIAN FROMMEL, Utrecht University, Netherlands and University of Saskatchewan, Canada
REGAN L. MANDRYK, University of Saskatchewan, Canada

Many games use engagement rewards as incentives for players to engage, e.g., daily login rewards, repeatable challenges, or seasonal rewards like holiday skins. These rewards may serve players by facilitating enjoyment or motivation; however, they may also be considered differently by skeptical players, e.g., as dark patterns that do not benefit players, and may detract from—or even harm—player experiences. As they are widely prevalent in a variety of games, it is important to understand how such rewards are experienced by players to inform potential pitfalls, such as when they are negative for gaming experience or lead to unhealthy gaming behaviours. 178 participants completed a mixed-methods survey and described such rewards in games they play, the tasks required to acquire them, and their experience qualitatively and with validated scales of motivation regulation and passion orientation. We found that players perceived these rewards as beneficial (e.g., as motivation), as negative (e.g., by promoting fear of missing out), or even as an obligation or chore. Quantitative results further support the dualistic experience of such rewards. We contribute findings and design recommendations that are useful for understanding and designing widely used but potentially detrimental reward mechanics.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; • **Applied computing → Computer games**; • **Software and its engineering → Interactive games**.

Additional Key Words and Phrases: games, reward, daily, quests, engagement, motivation, passion, lootbox

ACM Reference Format:
Julian Frommel and Regan L. Mandryk. 2022. Daily Quests or Daily Pests? The Benefits and Pitfalls of Engagement Rewards in Games. *Proc. ACM Hum.-Comput. Interact.* 6, CHI PLAY, Article 226 (October 2022), 23 pages. https://doi.org/10.1145/3549489

https://dl.acm.org/doi/abs/10.1145/3549489

Reward design checklist

- Rewards are a key tool for motivating players => Reward all desired behavior
- Reward for failing and trying again (WDNML: XP from killed walkers, timers that complete while playing)
- Reward for reaching goals (WDNML: loot boxes)
- Reward for coming back the next day (WDNML: upgrade timers, XP & can producers, random walkers)
- Reward long-term retention (WDNML: episodic structure and episode rewards, character leveling, episodes too long to be completed in a single session. Also: achievements/trophies)


4
6
1095
810
83
4
Map


4
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1311
810
83
219
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Map


4
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1314
908
83
109
4
Map


4
6
1314
919
XP
83
4
Map

Clash Royale rewards?

- Battle (core loop) win?
- Battle fail?
- Login rewards?
- Daily retention rewards?
- Weekly?
- Longer term?

Clash Royale rewards

- Battle win: chests, xp
- Battle fail: crowns for crown chest, xp
- Login: chest timers have expired, you can open. Free cards in shop.
- Daily: get 10 crowns for crown chest, the 2-day structure of clan wars (collection day + war day, very bad socially to miss either – you might get kicked out from the clan)
- Weekly: Epic Sunday (can request and donate epics with clan, free epic in shop, more epics and legendaries to buy in shop)
- Longer term: Getting to new arenas, clan war season rewards, challenger season rewards

Design principles and implications

- Core reward design principles (anticipation and discounting of rewards)
- **Avoiding thinking (System 1 vs. System 2, cognitive biases affecting reward evaluation)**
- Perception and attention (contrast, Halo effect, confirmation bias)
- Memory (storing and retrieving information)
- Social (effect of other people)

Avoiding thinking, going with the default

- Analytic System 2 thinking requires mental effort, which people tend to avoid
- Implication: people often go with the default, intuitive/automatic response, especially when tired or intoxicated
- Game design principle: Frame the desired player behavior as the default
- Game monetization: Many games frame paying as the default

The power of the default

- In many countries, getting a driver's license includes indicating whether you are a willing organ donor in case of accidental death
- Even in such an important decision, people go with the default, avoiding thinking.
- Checking a box to opt out: nearly 100% of people become donors
- Checking a box to opt in: donor rate drops near or below 10%
- Example 2: parole judges deny more parole requests (the default and safe choice) when hungry and tired

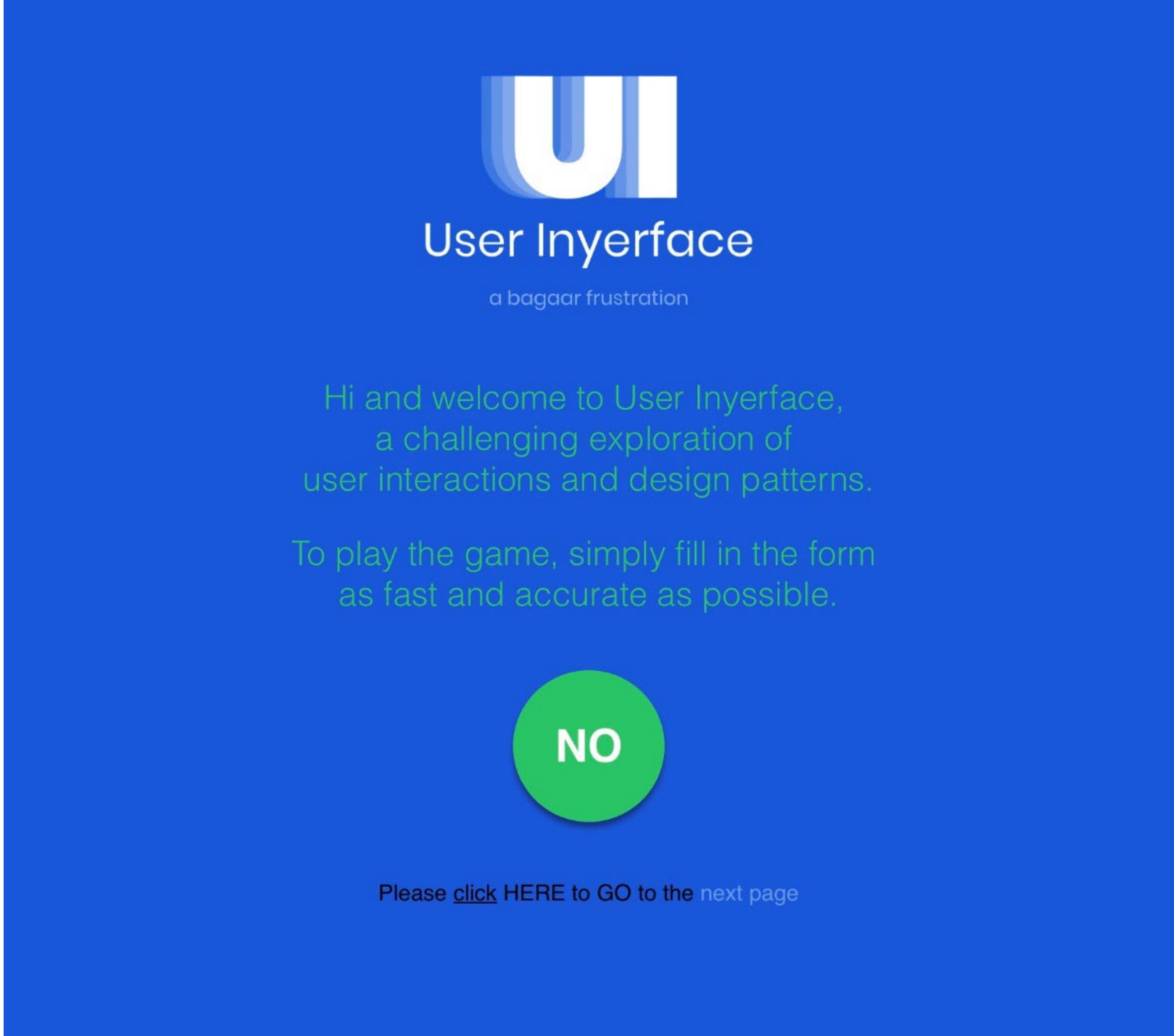

6
1087
690
94
EPISODE 1
ROAD TO TERMINUS
TERMINUS
Hello there!
Are you enjoying The Walking Dead: No Man's Land so far? Would you like to recommend us in the App Store?
Write a review
No, thanks
World map
Camp
3


Rate Your Experience
X
Enjoying Dungeon Keeper?
5-Star ratings from you help us provide free updates!
How would you rate Dungeon Keeper?
1-4 Stars
5 Stars

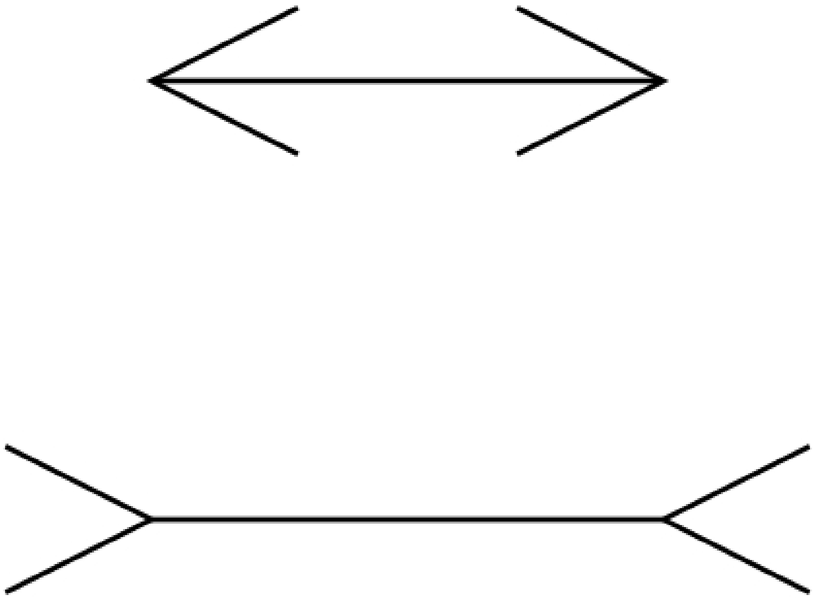
Common ”default designs” in games?

- Menu flow that gets you into the game if you don’t want to think and just keep pressing ’X’
- When the game starts or a saved game is loaded, the player’s initial facing direction is towards the next goal
- Clear landmarks that intuitively guide navigation

https://userinyerface.com/



Cognitive biases affecting reward evaluation



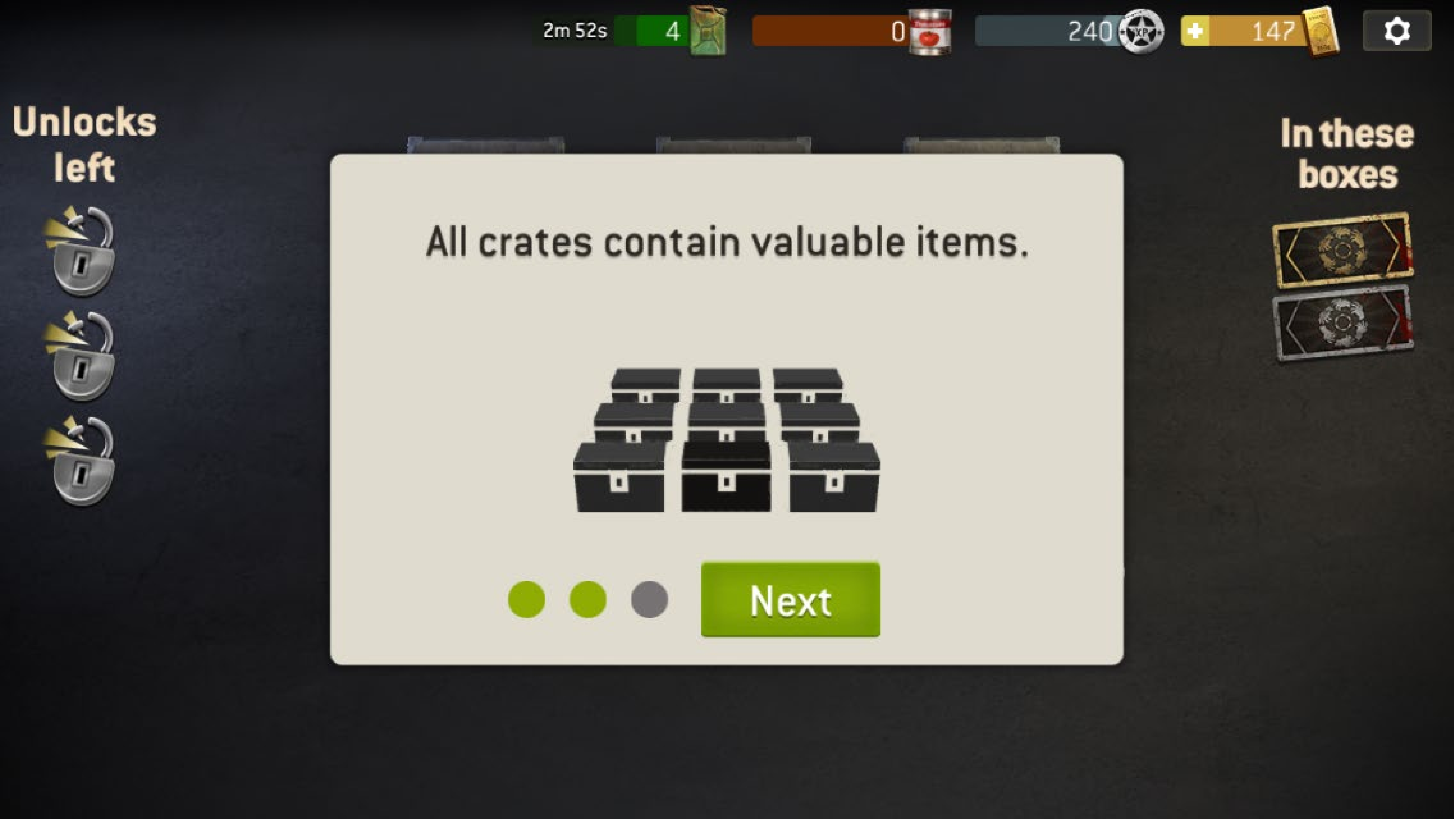
Cognitive biases affecting reward evaluation

- The biases may be suboptimal for a given individual and situation, but optimal on average, from an evolutionary perspective
- Often exploited in game reward design and monetization
- Biases covered in the next slides: desirability of random rewards, loss aversion, artificial scarcity, sunk cost fallacy

Desirability of random rewards

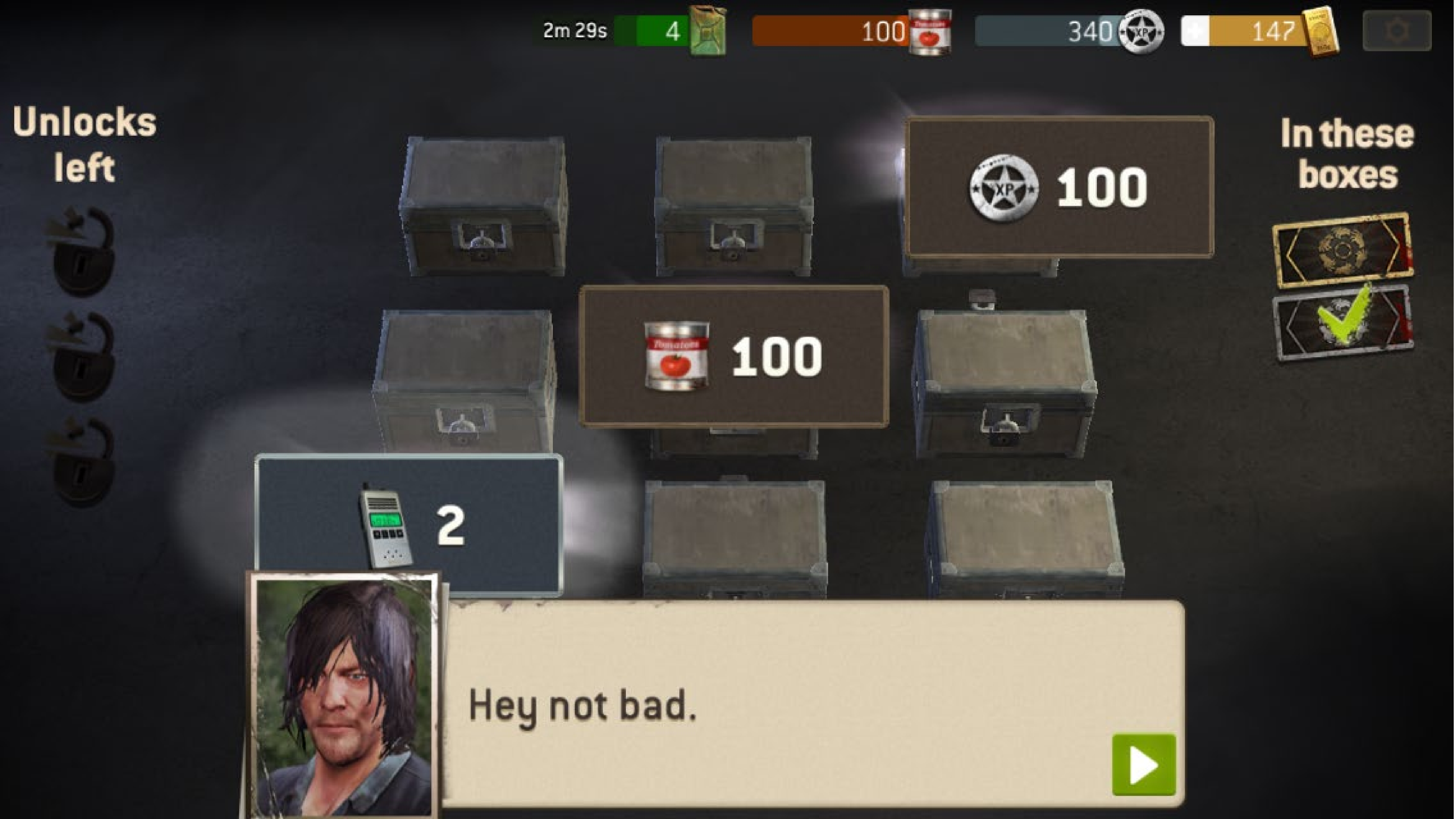
- Random rewards (e.g., loot boxes) are more desirable and motivating than fully predictable rewards.
- Computational rationality: Increased perceived value of rewards => actions that produce random rewards appear more optimal
- Behavioral psychology term: Variable ratio reinforcement
- Design implication: Good to have both randomness and skill-based play
- Randomness is also a game balancing technique: Reach a wider target group of various skill levels (perceived fairness, competence)


2m 56s
4
0
240
147
Unlocks left
In these boxes
After a mission you get 3 free unlocks.
Next

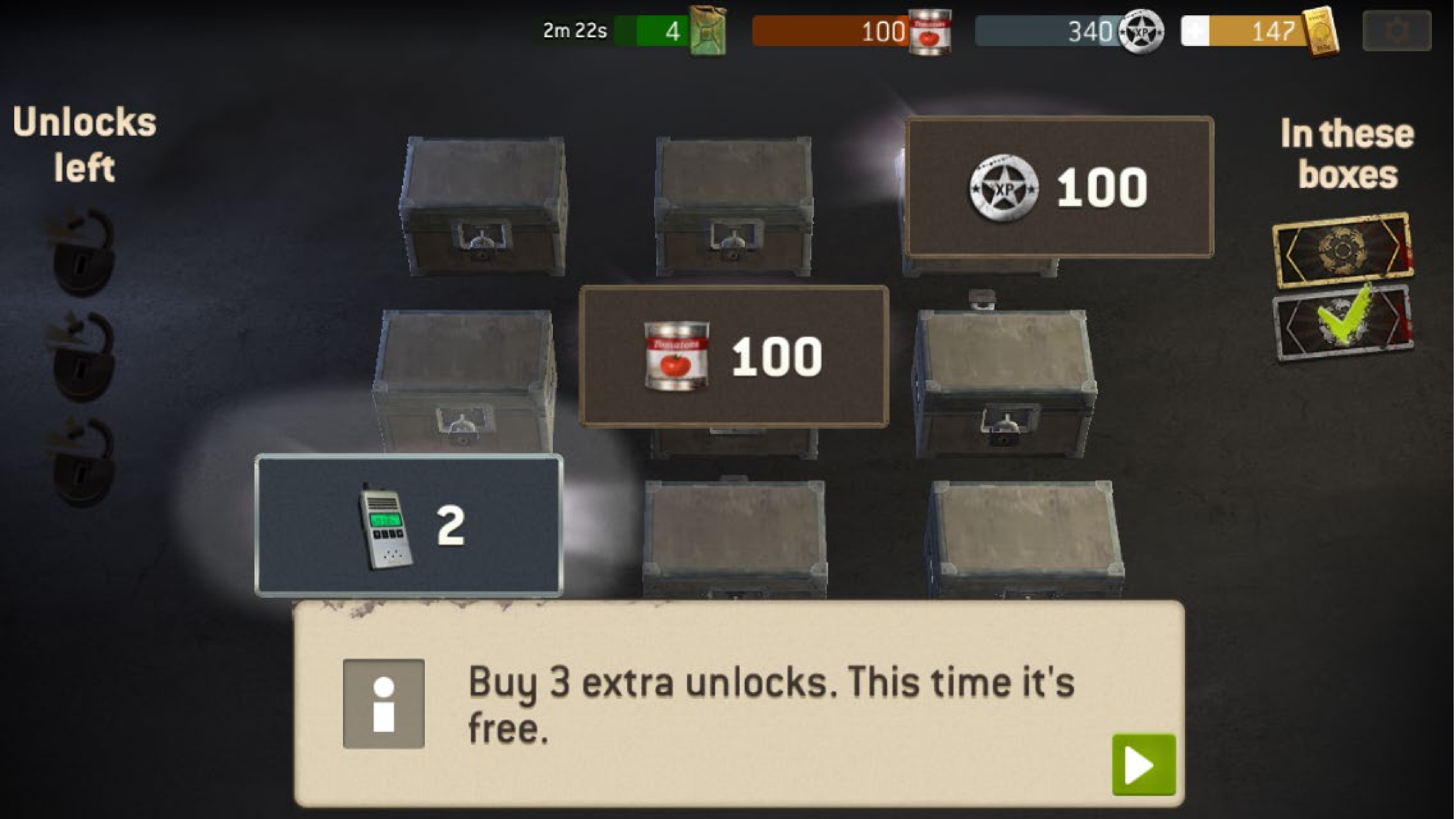

2m 52s
4
0
240
147
Unlocks left
In these boxes
All crates contain valuable items.
Next


2m 39s
4
0
240
147
Unlocks left
In these boxes

2m 33s
4
56
34
147
Unlocks left
In these boxes
100
100
100
100
2


2m 29s
4
100
340
147
Unlocks left
In these boxes
100
100
2
Hey not bad.


2m 25s
4
100
340
147
Unlocks left
In these boxes
100
100
2
The golden crate is still out there.


2m 22s
4
100
340
147
Unlocks left
In these boxes
100
100
2
Buy 3 extra unlocks. This time it's free.


2m 16s
4
100
340
147
Get 3 more
Free
100
100
2
In these boxes


2m 12s
4
100
340
147
Unlocks left
In these boxes
100
100
2
Alright, open 3 more!


2m 3s
4
110
340
147
Unlocks left
100
In these boxes
100
2


2m
4
200
440
147
Unlocks left
100
100
2
16
2
100
100
In these boxes
Continue

Problems?

Clash Royale and randomness

- Explicit randomness of lootbox/cheast contents
- Implicit unpredictability of battles due to matchmaking.

Computational rationality and random rewards

- We didn't evolve in the presence of slot machines and other forms of artificial randomness!
- Optimism/overconfidence bias
- Gambler's fallacy

https://www.cell.com/current-biology/pdf/S0960-9822(11)01191-2.pdf

Primer

The optimism bias

Tali Sharot

The ability to anticipate is a hallmark of cognition. Inferences about what will occur in the future are critical to decision making, enabling us to prepare our actions so as to avoid harm and gain reward. Given the importance of these future projections, one might expect the brain to possess accurate, unbiased foresight. Humans, however, exhibit a pervasive and surprising bias: when it comes to predicting what will happen to us tomorrow, next week, or fifty years from now, we overestimate the likelihood of positive events, and underestimate the likelihood of negative events. For example, we underrate our chances of getting divorced, being in a car accident, or suffering from cancer. We also expect to live longer than objective measures would warrant, overestimate our success in the job market, and believe that our children will be especially talented. This phenomenon is known as the optimism bias, and it is one of the most consistent, prevalent, and robust biases documented in psychology and behavioral economics.

The optimism bias is defined as the difference between a person's expectation and the outcome that follows. If expectations are better than reality, the bias is optimistic; if reality is better than expected, the bias is pessimistic. The extent of the optimism bias is thus measured empirically by recording an individual's expectations before an event unfolds and contrasting those with the outcomes that transpire. This methodology reveals, for instance, that students expect to receive higher starting salaries and more job offers than they end up getting. People tend to underestimate how long a project will take to complete and how much it will cost. Most of us predict deriving greater pleasure from a vacation than we subsequently do, and we anticipate encountering more positive events in an upcoming month (such as receiving a gift or enjoying a movie) than we end up experiencing (Figure 1A). Across many different

Sharot, Tali. "The optimism bias." *Current biology* 21.23 (2011): R941-R945.

doi:10.1038/nature10384

The evolution of overconfidence

Dominic D. P. Johnson[1] & James H. Fowler[2]

https://www.nature.com/articles/nature10384

Confidence is an essential ingredient of success in a wide range of domains ranging from job performance and mental health to sports, business and combat[1–4]. Some authors have suggested that not just confidence but overconfidence—believing you are better than you are in reality—is advantageous because it serves to increase ambition, morale, resolve, persistence or the credibility of bluffing, generating a self-fulfilling prophecy in which exaggerated confidence actually increases the probability of success[3–8]. However, overconfidence also leads to faulty assessments, unrealistic expectations and hazardous decisions, so it remains a puzzle how such a false belief could evolve or remain stable in a population of competing strategies that include accurate, unbiased beliefs. Here we present an evolutionary model showing that, counterintuitively, overconfidence maximizes individual fitness and populations tend to become overconfident, as long as benefits from contested resources are sufficiently large compared with the cost of competition. In contrast, unbiased strategies are only stable under limited conditions. The fact that overconfident populations are evolutionarily stable in a wide range of environments may help to explain why overconfidence remains prevalent today, even if it contributes to hubris, market bubbles, financial collapses, policy failures, disasters and costly wars[9–13].

Humans show many psychological biases, but one of the most consistent, powerful and widespread is overconfidence. Most people show a bias towards exaggerated personal qualities and capabilities, an illusion of control over events, and invulnerability to risk (three phenomena collectively known as 'positive illusions')[2–4,14]. Overconfidence amounts to an 'error' of judgement or decision-making, because it leads to overestimating one's capabilities and/or underestimating an opponent, the difficulty of a task, or possible risks. It is therefore no surprise that overconfidence has been blamed throughout history for high-profile disasters such as the First World War, the Vietnam war, the war in Iraq, the 2008 financial crisis and the ill-preparedness for environmental phenomena such as Hurricane Katrina and climate change[9,12,13,15,16].

maximizing benefits over costs, especially under conditions of competition, uncertainty and asymmetric costs of different types of error[8,18–21]. Whereas economists tend to posit the notion of human brains as general-purpose utility maximizing machines that evaluate the costs, benefits and probabilities of different options on a case-by-case basis, natural selection may have favoured the development of simple heuristic biases (such as overconfidence) in a given domain because they were more economical, available or faster.

Here we present a model showing that, under plausible conditions for the value of rewards, the cost of conflict, and uncertainty about the capability of competitors, there can be material rewards for holding incorrect beliefs about one's own capability. These adaptive advantages of overconfidence may explain its emergence and spread in humans, other animals or indeed any interacting entities, whether by a process of trial and error, imitation, learning or selection. The situation we model—a competition for resources—is simple but general, thereby capturing the essence of a broad range of competitive interactions including animal conflict, strategic decision-making, market competition, litigation, finance and war.

Suppose a resource r is available to an individual that claims it, and there are two individuals, i and j. These individuals each have initial 'capability' θ_i and θ_j that determine whether or not they would win a conflict over the resource. Without loss of generality, we assume that θ is distributed in the population according to a symmetric stable probability density[22] with cumulative distribution Φ, a mean of 0, and a variance of 0.5. The initial advantage to individual i is $a = \theta_i - \theta_j$, and assumptions about the distribution of θ imply that the probability density of a has a cumulative distribution Φ, a mean of 0, and unit variance (see Supplementary Information for the full model).

If neither individual claims the resource, no fitness is gained. If only one makes a claim, then the claimant acquires the resource and gains fitness r and the other individual gains nothing. If both claim the resource, then both pay a cost c as a result of the conflict between them, but the individual with the higher initial capability will win the conflict, acquiring the resource and obtaining fitness r. This means there are only

Computational rationality and random rewards

- Probability neglect: We tend to over/underestimate very small probabilities
- Affect-rich choices: Perceived value of rare win (highly emotional, exciting!) might be much higher than the perceived cost of playing one more time (no emotion)

JOURNAL OF
BEHAVIORAL DECISION MAKING

Research Article | Full Access

How Affect Shapes Risky Choice: Distorted Probability Weighting Versus Probability Neglect

Renata S. Suter, Thorsten Pachur, Ralph Hertwig

First published: 01 July 2015 | https://doi.org/10.1002/bdm.1888 | Citations: 41

Abstract

People's choices between prospects with relatively affect-rich outcomes (e.g., medical side effects) can diverge markedly from their choices between prospects with relatively affect-poor outcomes (e.g., monetary losses). We investigate the cognitive mechanisms underlying this "affect gap" in risky choice. One possibility is that affect-rich prospects give rise to more distortion in probability weighting. Another is that they lead to the neglect of probabilities. To pit these two possibilities against each other, we fitted cumulative prospect theory (CPT) to the choices of individual participants, separately for choices between options with affect-rich outcomes (adverse medical side effects) and options with affect-poor outcomes (monetary losses); additionally, we tested a simple model of probability neglect, the minimax rule. The results indicated a qualitative difference in cognitive mechanisms between the affect-rich and affect-poor problems. Specifically, in affect-poor problems, the large majority of participants were best described by CPT; in affect-rich problems, the proportion of participants best described by the minimax rule was substantially higher. The affect gap persisted even when affect-rich outcomes were supplemented by numerical information, thus providing no support for the thesis that choices in affect-rich and affect-poor problems diverge because the information provided in the former is nonnumerical. Our findings suggest that the traditional expectation-based framework for modeling risky decision making may not readily generalize to affect-rich choices.

https://pure.mpg.de/rest/items/item_2350314/component/file_2350905/content

Loss aversion (Prospect Theory): losses loom larger than gains in our decision making

Problem 1: You have been given $1000. You are now asked to choose one of:

50% chance to win $1000 OR get $500 for sure.

Problem 2: You have been given $2000. You are now asked to choose one of:

50% chance to lose $1000 OR lose $500 for sure.

Loss aversion (Prospect Theory): losses loom larger than gains in our decision making

Problem 1: You have been given $1000. You are now asked to choose one of:

50% chance to win $1000 OR get $500 for sure.

Problem 2: You have been given $2000. You are now asked to choose one of:

50% chance to lose $1000 OR lose $500 for sure.

Problems are equal in terms of outcomes, on average, but people choose the sure thing in 1 and gamble in 2.

Related: Endowment effect

- Perceived value of object is higher if we already own it
- Dark pattern: Frame paying as avoiding losing something. E.g., instead of getting loot as level completion reward, the player wins loot already during a level, and if they die, they have to either lose the loot or pay to keep it.


4m 45s
5
160
20
Unlocks left
You found several loot crates during the mission. Open them.


2m 25s
4
100
340
147
Unlocks left
In these boxes
100
100
2
The golden crate is still out there.


6
1087
690
94
Get 3 more
FREE!
Watch video
25
2
90
90
In these boxes
Continue

Computational rationality and loss aversion

- Evolutionary explanations exist
- Some view it as compensating for optimism bias

On the Evolutionary Origin of Prospect Theory Preferences

Rose McDermott University of California, Santa Barbara
James H. Fowler University of California, San Diego
Oleg Smirnov State University of New York at Stony Brook

Prospect theory scholars have identified important human decision-making biases, but they have been conspicuously silent on the question of the origin of these biases. Here we create a model that shows preferences consistent with prospect theory may have an origin in evolutionary psychology. Specifically, we derive a model from risk-sensitive optimal foraging theory to generate an explanation for the origin and function of context-dependent risk aversion and risk-seeking behavior. Although this model suggests that human cognitive architecture evolved to solve particular adaptive problems related to finding sufficient food resources to survive, we argue that this same architecture persists and is utilized in other survival-related decisions that are critical to understanding political outcomes. In particular, we identify important departures from standard results when we incorporate prospect theory into theories of spatial voting and legislator behavior, international bargaining and conflict, and economic development and reform.

Prospect theory has become one of the most influential behavioral theories of choice in the wider social sciences, particularly in psychology and economics (Kahneman, Slovic, and Tversky 1982; Kahneman and Tversky 1979). It has also been applied to issues in political science (Druckman 2001; Lau and Redlawsk 2001; McDermott 2004; Mercer, 2005; Quattrone and Tversky 1988); in particular, in the areas of international relations (Berejikian 1997, 2002; Faber 1990; Jervis 1994, 2004; Levy 1994, 1997; McDermott 1998), international political economy (Elms 2004), comparative politics (Weyland 1996, 1998), American politics (Patty 2006), and public policy (McDaniel and Sistrunk 1991). As a model explaining decision making under conditions of risk, prospect theory provides an elegant description of the relationship between environmental contingency in the form of gains and losses and individual risk propensity. In short, those faced with gains tend to be risk averse, while those confronting losses become much more risk seeking. Prospect theory developed in explicit opposition to more normative models of rational choice, such as subjective expected utility theory.

Historically, prospect theory also evolved in reaction to earlier behavioral models exemplified by figures such as B.F. Skinner (1952) who wholly disregarded the importance of cognitive processing in human action. As such, prospect theory can be understood as representing the apex of the cognitive revolution in psychology and social sciences in general (Simon 1985). This historical development of prospect theory as a significant departure from behavioral into cognitive explanations for decision making is interesting because, as Mercer notes; "The dominant explanation for political scientists' tepid response focuses on the theoretical problems with extending a theory devised in the lab to explain political decisions in the field. . . . .It suggests that prospect theory's failure to ignite the imagination of more political scientists probably results from their aversion to behavioral assumptions and not from problems unique to prospect theory" (2005, 1). And, indeed, more recent work in decision making within cognitive neuroscience has also begun to incorporate emotion and motivation into cognitively oriented theories of choice. Similar research trends can be observed in economics as well (Andreoni 1990; Bolton and Ockenfels 2000; Dawes et al. 2007; Fehr and Schmidt 1999; Rabin 1993, 2002).

Models derived from risk-sensitive optimal foraging theory offer an opportunity to generate an

The Journal of Politics, Vol. 70, No. 2, April 2008, Pp. 335–350 doi:10.1017/S0022381608080341

ISSN 0022-3816

ELSEVIER

Journal of Economic Dynamics and Control
Volume 37, Issue 1, January 2013, Pages 18-31

Bounded rationality as a source of loss aversion and optimism: A study of psychological adaptation under incomplete information

Jing Yao [a], Duan Li [b]

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https://doi.org/10.1016/j.jedc.2012.07.002

Abstract

We develop a formal model to investigate the implications of bounded rationality for the origin and structure of loss aversion and optimism in marketplaces. Based on Simon's original description, we explicitly model bounded rationality as a decision mechanism that captures incomplete information, psychological adaptation, and rational behavior. We find that the endogenous loss aversion and optimism emerge when the degree of information incompleteness reaches a certain threshold, and both grow to be more prominent when information becomes sparser. Our results highlight that the psychological biases could be expected to take advantage of perceived information incompleteness in terms of value creation.

ELSEVIER

Evolution and Human Behavior
Volume 41, Issue 1, January 2020, Pages 87-95

The evolution of the endowment effect

Justin Bruner [a], Frank Calegari [b], Toby Handfield [c]

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https://doi.org/10.1016/j.evolhumbehav.2019.10.004 Get rights and content

Abstract

People often value an item more when they own it than when it is available for purchase, and consequently are relatively reluctant to trade. This is the "endowment effect", which has been widely documented in human populations and also in some non-human species. This paper develops a simple model in which it is adaptive to have a bias against trade, potentially explaining the basis of the endowment effect. The bias against trade arises from the strategic nature of trade in a moderately competitive environment: the interest of a potential trading partner in making the exchange is evidence that the decision maker already has the more valuable object. The model predicts that an endowment effect is promoted by large uncertainty about the fitness value of items, and also by conditions in which there are on average small gains to be had from trade. Because the model employs a simple bounded rationality heuristic for trade, it explains how the endowment effect could arise in species that lack theory of mind and related strategic reasoning abilities. The model also suggests an explanation for why endowment effects are so rarely observed in biological markets that exist between species. Because the trading classes have very different fitness functions, there is negligible competition across those classes. Consequently, there are substantial mutual gains to trade, so our model predicts there is unlikely to be adaptive pressure for an endowment effect.

Wishful Thinking, Prudent Behavior: The Evolutionary Origin of Optimism, Loss Aversion and Disappointment Aversion

26 Pages • Posted: 31 Jan 2018

Chris Dawson
University of Bath

David de Meza
London School of Economics Department of Management

Date Written: January 24, 2018

Abstract

Optimism, the tendency to overestimate the likelihood of positive events, is one of the most established psychological "biases". So too are the apparently counteracting phenomena of loss and disappointment aversion. We propose an evolutionary based reconciliation of these seemingly conflicting biases and test it by looking at gender differences in their prevalence. The starting point is the theory advanced by Robert Trivers that optimism has evolved to more effectively persuade or deceive others. A side effect of optimism is mistaken own decisions and excessively rash behavior. Loss aversion does not affect optimistic beliefs but curtails the inclination to act on them. Disappointment aversion also induces prudence, partly through lowering optimism, a characteristic less useful to women. We find that men are more optimistic than women, both sexes are equally loss averse and women are more disappointment averse than men. This is consistent with gender-specific evolutionary adaptations.

Keywords: Gender; Optimism; Loss Aversion; Disappointment Aversion; Dread Aversion

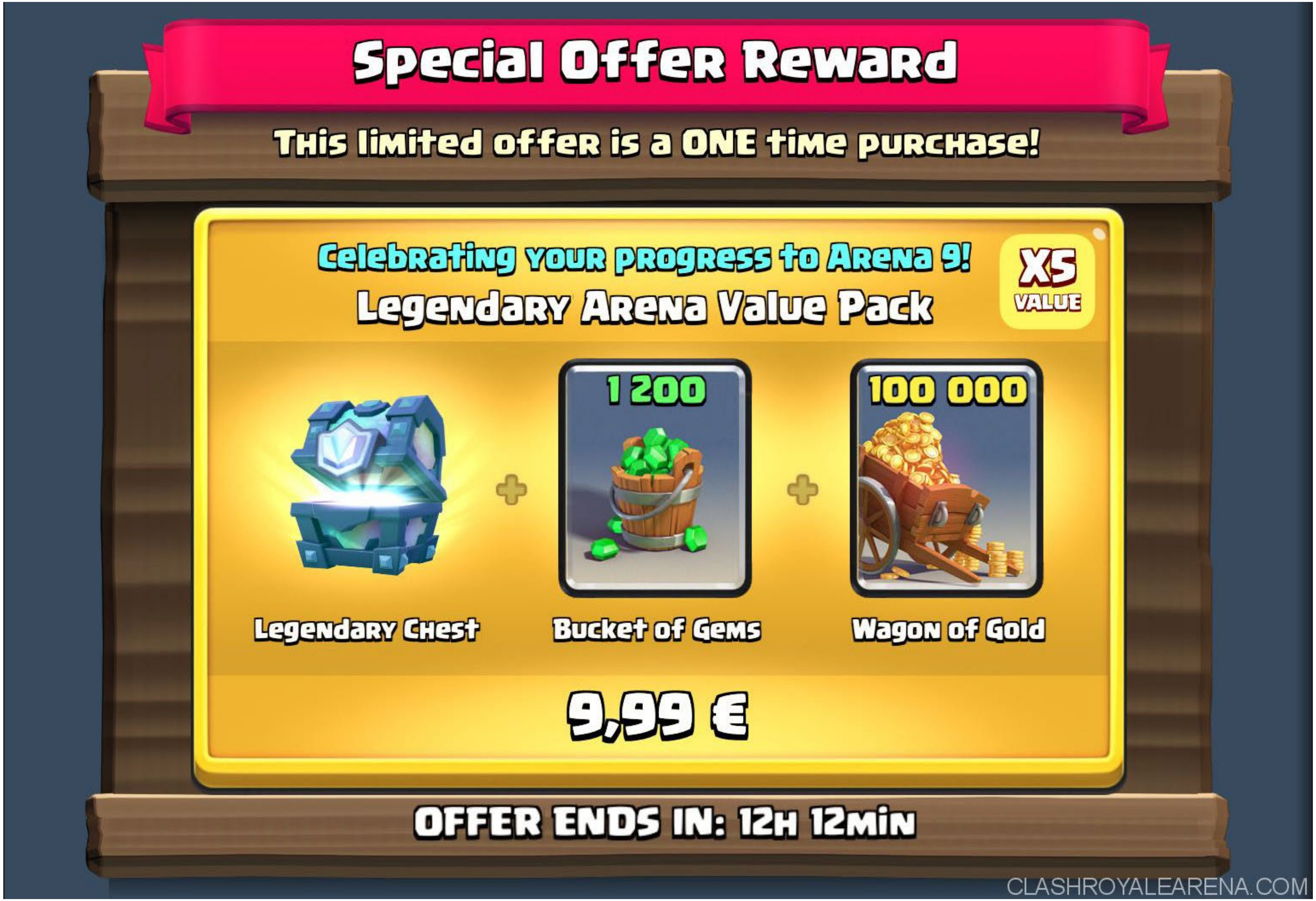
JEL Classification: D03

Suggested Citation:

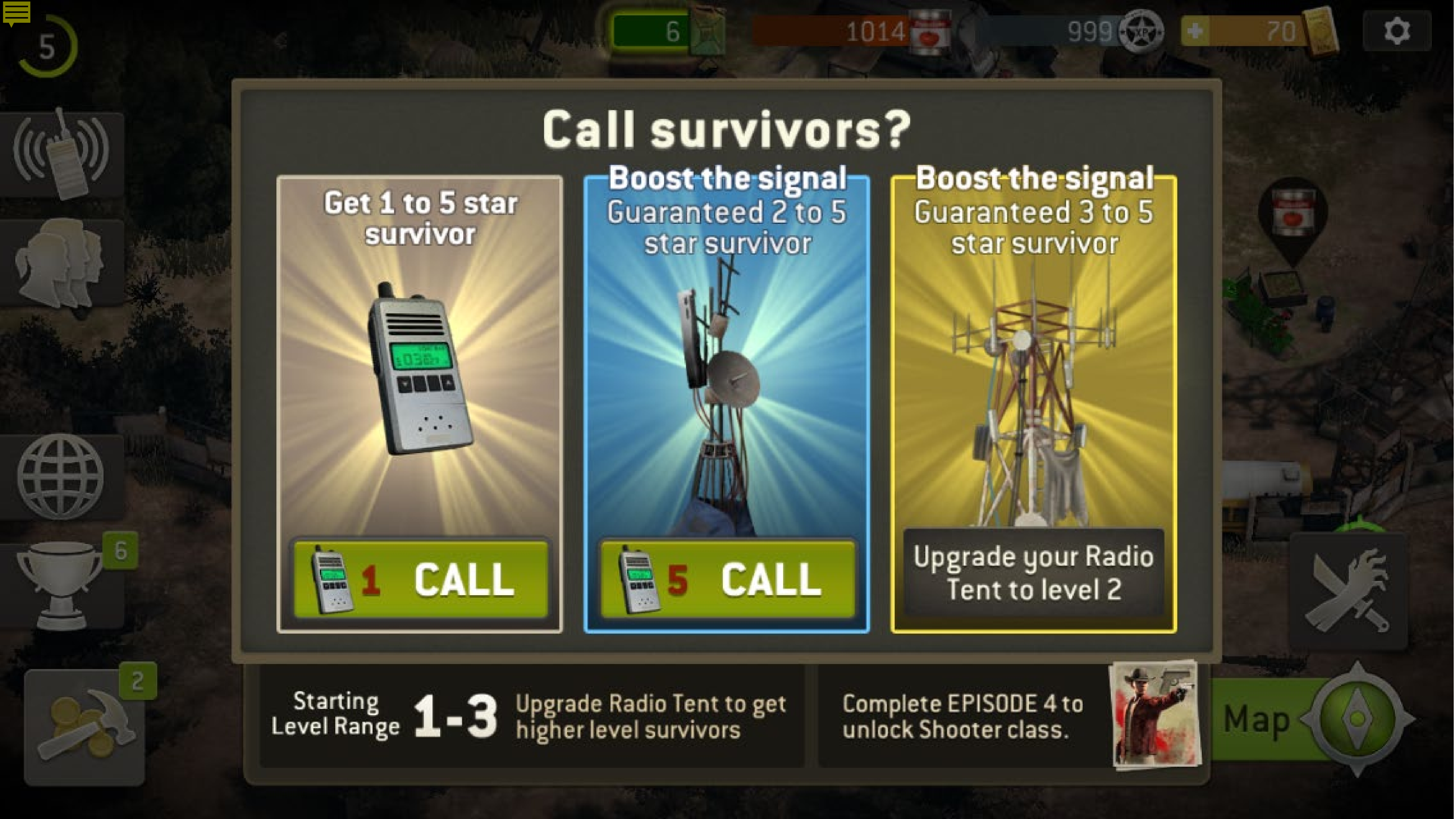
Dawson, Chris and de Meza, David Emmanuel, Wishful Thinking, Prudent Behavior: The Evolutionary Origin of Optimism, Loss Aversion and Disappointment Aversion (January 24, 2018). Available at SSRN: https://ssrn.com/abstract=3108432 or http://dx.doi.org/10.2139/ssrn.3108432

Artificial scarcity

- Adding artificial scarcity or urgency increases desirability & sales
    - Limited time sales (e.g., Steam sales of computer games)
    - Limited edition books etc.
    - Limited art prints
    - Rarity of game items / characters
- Goal: make the customer buy quickly without thinking too much about it (i.e., without engaging System 2)
- One explanation: A form of loss-aversion – avoid losing the special opportunity to buy


Special Offer Reward
This limited offer is a ONE time purchase!
Celebrating your progress to Arena 9!
Legendary Arena Value Pack
X5 VALUE
Legendary Chest
1 200
Bucket of Gems
100 000
Wagon of Gold
9,99 €
OFFER ENDS IN: 12H 12MIN
CLASHROYALEARENA.COM


4
6
1314
999
83
Carol Wolf bundle
BUNDLE
1200
Gold!
Carol's Blade
New Outfit
Carol, Wolf
Offer ends in 1d 18h
€7,99 BUY
5
Map


5
6
1014
999
70
Call survivors?
Get 1 to 5 star survivor
1 CALL
Boost the signal
Guaranteed 2 to 5 star survivor
5 CALL
Boost the signal
Guaranteed 3 to 5 star survivor
Upgrade your Radio Tent to level 2
6
2
Starting Level Range
1-3
Upgrade Radio Tent to get higher level survivors
Complete EPISODE 4 to unlock Shooter class.
Map

Scarcity exploit examples in the real world

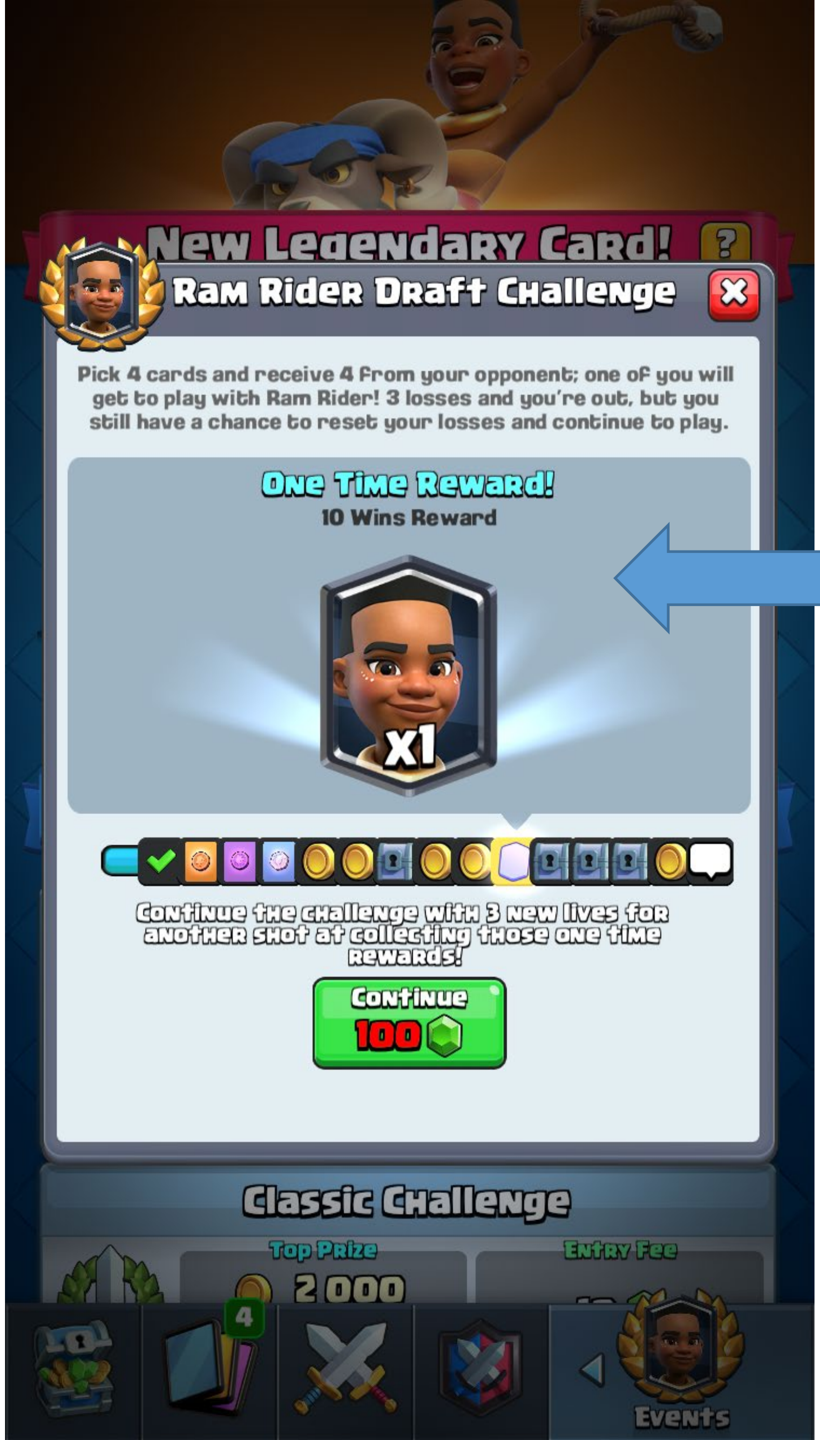
- A child photography company urged parents to buy as many poses and copies as they can because ”stocking limitations force us to burn the unsold pictures of your children within twenty-four hours”
- A home vacuum-cleaner operation instructed the sales trainees to claim ”I have so many other people to see that I have the time to visit a family only once. It’s company policy that even if you decide later that you want this machine, I can’t come back and sell it to you”

Sunk cost fallacy

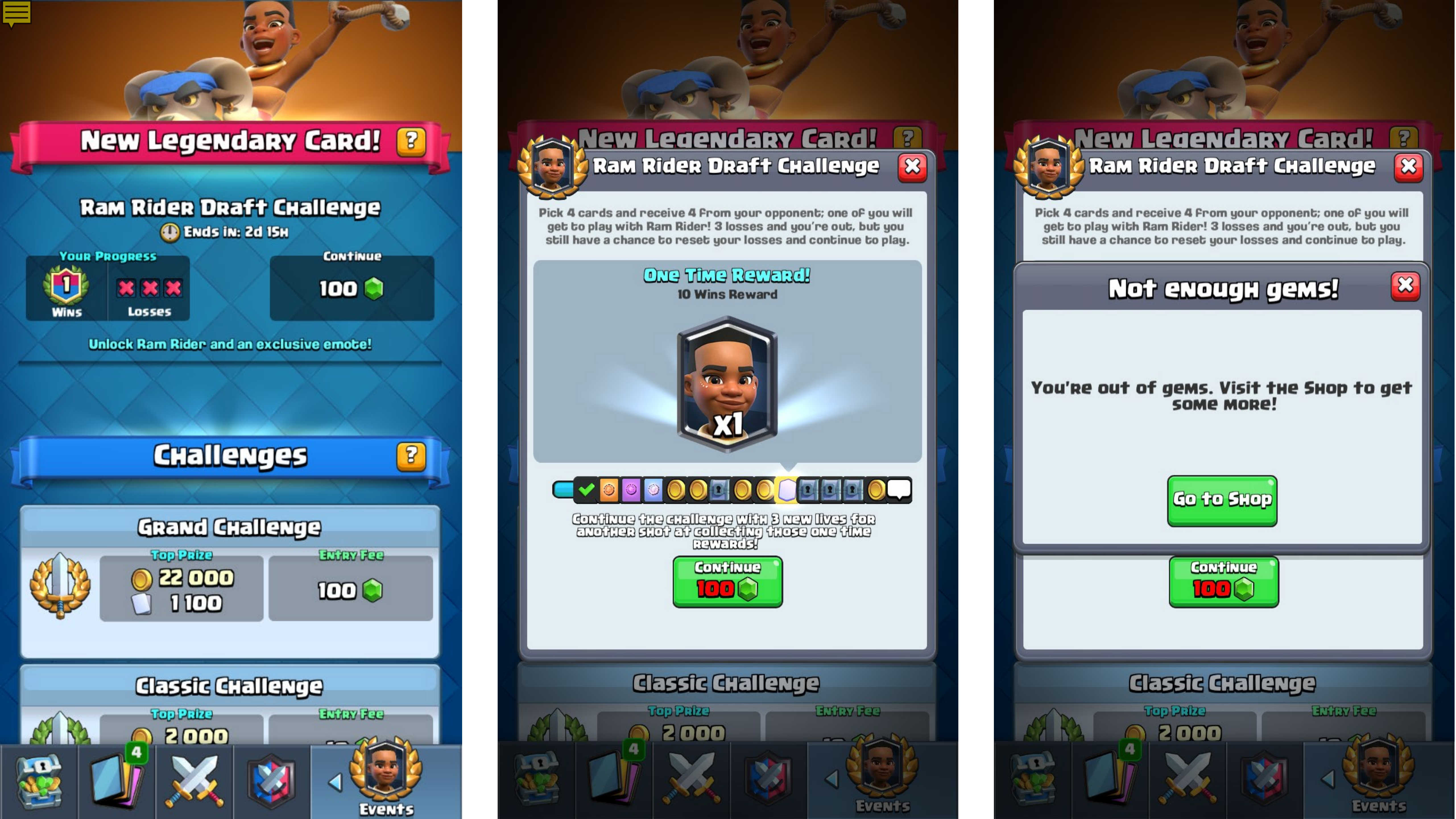
- When making an investment, people tend to throw good money after bad. ”Oh I’ve lost quite a bit but maybe my luck will turn if I give it one more go”
- Rationally, we should only consider the expected return of future investment, not the already sunk cost
- Can be explained through loss aversion and gambler’s fallacy
- Implication for games: People are willing to invest more time in games they have paid for, even if some other game might provide more value
- Exploiting commitment: Pay to continue –mechanics (e.g., Candy Crush boosters offered after player has invested time in a difficult level but failed)

Sunk cost fallacy in Clash Royale

- This screen was presented after I failed the Ram Rider Draft challenge
- Decision: Pay 100 gems or lose any progress



Heighten the anticipation & scarcity

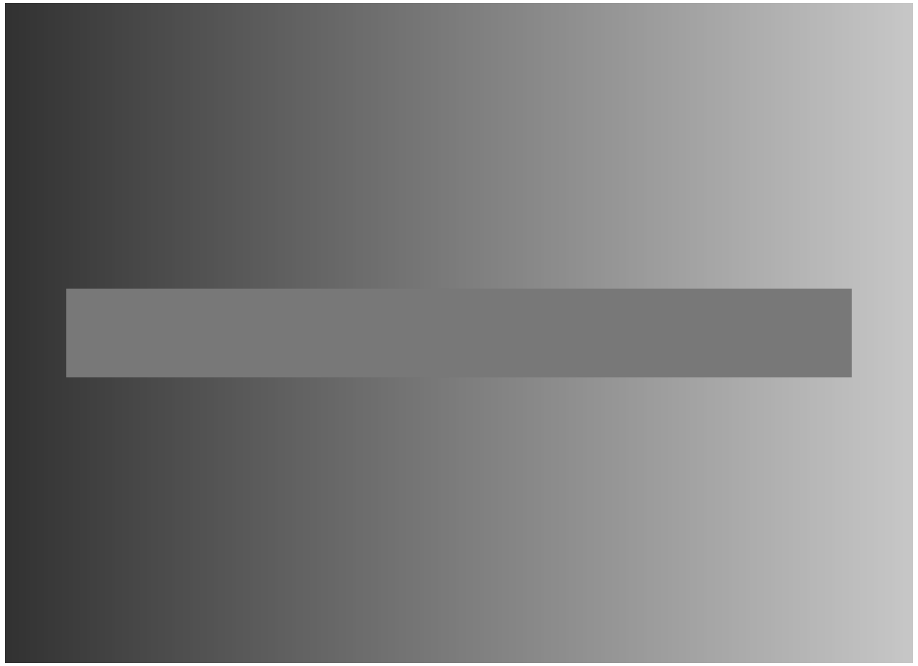

New Legendary Card!
Ram Rider Draft Challenge
Ends in: 2d 15h
Your Progress
1
Wins
Losses
Continue
100
Unlock Ram Rider and an exclusive emote!
Challenges
Grand Challenge
Top Prize
22 000
1 100
Entry Fee
100
Classic Challenge
Top Prize
2 000
Entry Fee
4
Events
New Legendary Card!
Ram Rider Draft Challenge
Pick 4 cards and receive 4 from your opponent; one of you will get to play with Ram Rider! 3 losses and you're out, but you still have a chance to reset your losses and continue to play.
One Time Reward!
10 Wins Reward
x1
Continue the challenge with 3 new lives for another shot at collecting those one time rewards!
Continue
100
Classic Challenge
Top Prize
2 000
Entry Fee
4
Events
New Legendary Card!
Ram Rider Draft Challenge
Pick 4 cards and receive 4 from your opponent; one of you will get to play with Ram Rider! 3 losses and you're out, but you still have a chance to reset your losses and continue to play.
Not enough gems!
You're out of gems. Visit the Shop to get some more!
Go to Shop
Continue
100
Classic Challenge
Top Prize
2 000
Entry Fee
4
Events

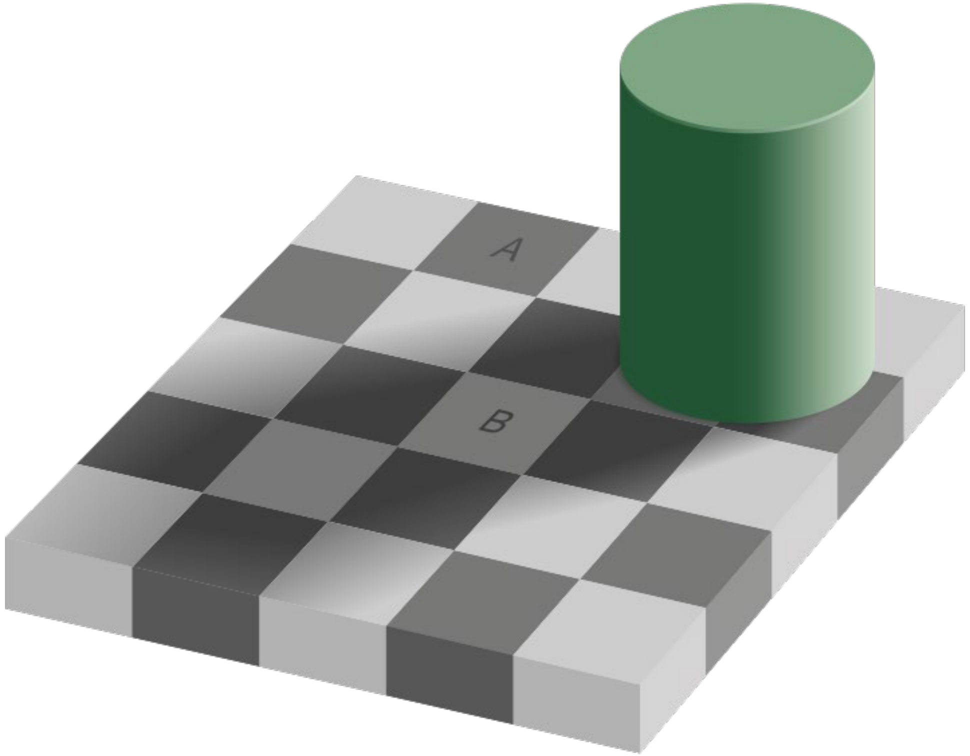
Design principles and implications

- Core reward design principles (anticipation and discounting of rewards)
- Avoiding thinking (System 1 vs. System 2, cognitive biases affecting reward evaluation)
- **Perception and attention (contrast, Halo effect, confirmation bias)**
- Memory (storing and retrieving information)
- Social (effect of other people)

Contrast principle (perception is adaptive and relative)

- Perception and judgements are always relative and adaptive
- A light seems brighter in the dark. We don’t notice our own smell.
- Figures: The horizontal bar and the A and B squares are of same color, but their perception is affected by the surroundings





Rewards of others affect how we perceive our own rewards

https://www.youtube.com/watch?v=meiU6TxysCg

Two Monkeys Were Paid Unequally: Excerpt from Frans de Waal's TED Talk

Contrast in sales

- The trick of three product versions:
    1. Cheap & clearly low value
    2. Cheap
    3. Expensive and only a bit higher value
- The middle one is perceived as having both high value and low price. The user feels smart selecting that one even if the others were not even designed to be purchased.
- Men pay more for accessories if purchasing them after purchasing a suit.


4
6
1314
999
83
BEST VALUE
Carol Wolf bundle
1200
€7,99
Fresh Survivor Bundle
€2,99
Pile of Gold
500
€4,99
Pocketful of Gold
1200
€9,99
Plenty of Gold
2500
€19,99
Buildings
Gold

Computational rationality and contrast

- Our environment is highly variable and adaptive perception is probably necessary for survival
- We often have incomplete information to judge the true value of objects => the most rational thing we can do is to make relative judgements based on the information we're given

Perception of time or cost is also subjective and affected by contrast

Endowed progress effect: perceived time-to-reward can be manipulated.

An illusion of already having made progress towards a goal can make the goal seem nearer and more motivating (remember the discounting of rewards that are far)

The Endowed Progress Effect: How Artificial Advancement Increases Effort

JOSEPH C. NUNES
XAVIER DRÈZE*

This research documents a phenomenon we call the *endowed progress effect*, whereby people provided with artificial advancement toward a goal exhibit greater persistence toward reaching the goal. By converting a task requiring eight steps into a task requiring 10 steps but with two steps already complete, the task is reframed as one that has been undertaken and incomplete rather than not yet begun. This increases the likelihood of task completion and decreases completion time. The effect appears to depend on perceptions of task completion rather than a desire to avoid wasting the endowed progress. Moderators include the reason, if any, offered for the endowment and the currency in which progress is recorded.

Consumers often persist in their efforts to achieve goals that are accompanied by discrete, extrinsic rewards. For example, they might delay purchasing a cellular phone a determinate number of months in order to get the newest product with the latest features. They might forgo various small discretionary purchases in order to save enough money to buy a big-ticket item such as a plasma TV. Or they might steer multiple purchases toward a particular air carrier with the hope of earning enough miles for a free flight. The notion that goals motivate individuals, making them work harder and perform better than people without goals, has been supported broadly in the literature (Locke and Latham 1990).

This research documents a phenomenon we call the *endowed progress effect*, whereby people provided with artificial advancement toward a goal exhibit greater persistence toward reaching the goal. By artificial advancement, we are referring to moving someone toward a goal while simultaneously moving the goal away such that the task requirements and reward remain unchanged. For example, consider reframing a frequency program that requires eight purchases in order to earn a specific reward as a program requiring 10, but with two purchases awarded upon enrollment. Both programs require eight purchases and provide the same reward, yet for two reasons, we expect those who receive the endowed progress to exert more effort.

First, by framing the task as one that has been undertaken and is incomplete rather than one not yet begun, we expect people to be more committed to completing the task. Zeigarnik (1927) demonstrated that interrupted or uncompleted actions engender a strong motivation to complete the action, and psychologists agree that once a person accepts a task, for whatever reason, he or she tends to stay on that course until the goal is achieved (Fox and Hoffman 2002). Second, according to the *goal gradient effect* (see Hull 1932), people who are closer to their goal should exert comparatively more effort. Hence, we expect the initial momentum provided by the endowed progress to be compounded as effort increases with each step taken toward the goal.

The concept of persistence as a component of goal-directed behavior has been an integral part of motivation research for decades. Two central paradigms in the literature seek to explain persistence and have formed the foundation for modern approaches. First, Atkinson's work on achievement motivation (1957) depends on two fundamental elements: *inertial tendency* and *expectancy*. Inertial tendency is a psychological analog to Newton's first law of motion. Just as motion instigated in the physical world persists indefinitely unless acted upon by external forces, Atkinson believed a goal-directed tendency would persist until satisfied. Hence, inertial tendency reflects persistence and must be taken into account when evaluating other aspects of motivation. Expectancy is determined by the likelihood of success and the perceived value of attaining the goal. As the distance from the goal decreases, both the desirability and the feasibility of completion are believed to increase (Atkinson and Birch 1974). Models in this tradition have been

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Perception of time is subjective

- A reward seems closer if we don’t understand how far it is, or remember or foresee all the hurdles that lie ahead
- The initial enthusiasm of a game project: Many projects would not even start if people realistically anticipated the difficulties.
- Game design: Some games like WDNML obfuscate the time-to-reward

WDNML time-to-reward obfuscation:

- Reward: a new weapon
- Needs leveling up a character
- Leveling up a character needs higher-level training ground
- Leveling up the training ground needs a council upgrade
- Council upgrade needs lot's of supplies => need to upgrade supply storage
- Hard to keep the whole cascade in mind and anticipate how much grinding/waiting/gold needed => boosts the anticipation of getting to use the new weapon.

Integration of multiple information sources

- In presence of incomplete, uncertain and noisy information, it is optimal/rational to combine multiple information sources
- We integrate information across multiple senses, and combine new information with prior beliefs
  - Limitations: attention, working memory
- Effects:
  - McGurk illusion
  - Halo effect
  - Anchoring
  - Confirmation bias
  - Commitment & consistency

#bbc #illusion

Try this bizarre audio illusion! 👁👂😮 - BBC

https://www.youtube.com/watch?v=G-lN8vWm3m0

Halo effect

- Some qualities of a person or product may be irrationally dominant (possible reason: our attention may be selective)
- Attribute A affects the perception/judgement of attribute B
- Handsome people have higher salaries and get more votes in elections
- Game design: better to invest resources in making some aspect of the game really stand out.
- Conversely, if some part of the game is really broken, the whole game can be perceived as low quality.

Anchoring and confirmation bias

- Our perception is affected by prior information
- Price estimates of houses affected by asking price (the ”anchor”)
- Number of pebbles in a jar: the mean of people’s guesses is surprisingly accurate, but only if they guess without knowing what others guessed (no anchoring)
- Confirmation bias: We trust information that matches our prior beliefs


Rate Your Experience
Enjoying Dungeon Keeper?
5-Star ratings from you help us provide free updates!
How would you rate Dungeon Keeper?
1-4 Stars
5 Stars

The importance of first impressions

Alan: Intelligent, industrious, impulsive, critical, stubborn, envious.

vs.

Bill: Envious, stubborn, critical, impulsive, industrious, intelligent.

Design implications

- Importance of first impressions, in both pitching and designing a game.
- Optimizing the first few minutes of gameplay/onboarding is of utmost importance, especially in free games where there’s no sunk cost to keep the player from quitting.
- Loading time, menu flow, tutorial…
- Can’t raise the price of a game (or virtual goods) after launch, can only lower it. Thus, rather set a too high than too low initial price.

Commitment & consistency

- Our actions may change our self-concept, how we perceive ourselves
- If you’ve paid at least once, you’re more likely to pay again
  - Conversion rate: how many players ”convert” to paying customers
  - F2P design implication: There should be at least one **no-brainer first purchase** that one is insane not to make (e.g., due to contrast effect)
- I’m not sure how strong the effect really is, but this belief is prominent in the F2P game design literature

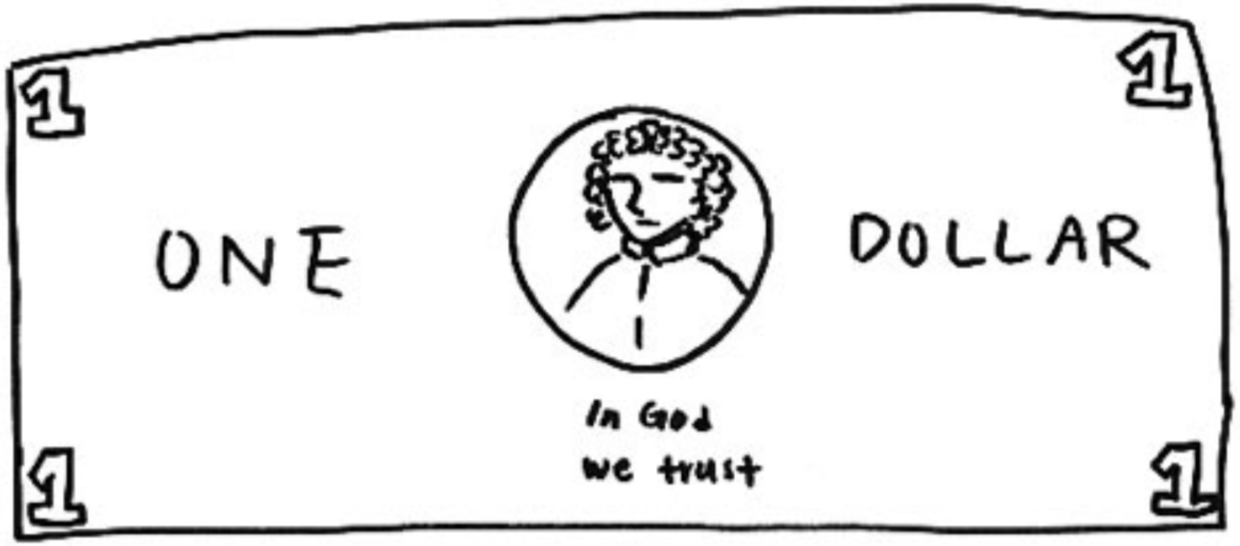

4
6
1095
810
83
Fresh Survivor
BUNDLE
400 Gold!
1 Survivor slot
Legendary Weapon Scout
5 Phones!
Full supplies
€2,99 BUY
Map

Perception recap

- Perception is **adaptive and relative**, affected by **spatial and temporal context**
- Contrast in sales: 3 product variants
- Subjective perception of time: It is possible to manipulate how close one feels to achieving a goal or reward
- Halo effect: a single feature may bias the overall perception of a game, for both good and bad
- Anchoring & confirmation bias => Importance of first impressions (game pitching, onboarding of players)

Design principles and implications

- Core reward design principles (anticipation and discounting of rewards)
- Avoiding thinking (System 1 vs. System 2, cognitive biases affecting reward evaluation)
- Perception and attention (contrast, Halo effect, confirmation bias)
- **Memory (storing and retrieving information)**
- Social (effect of other people)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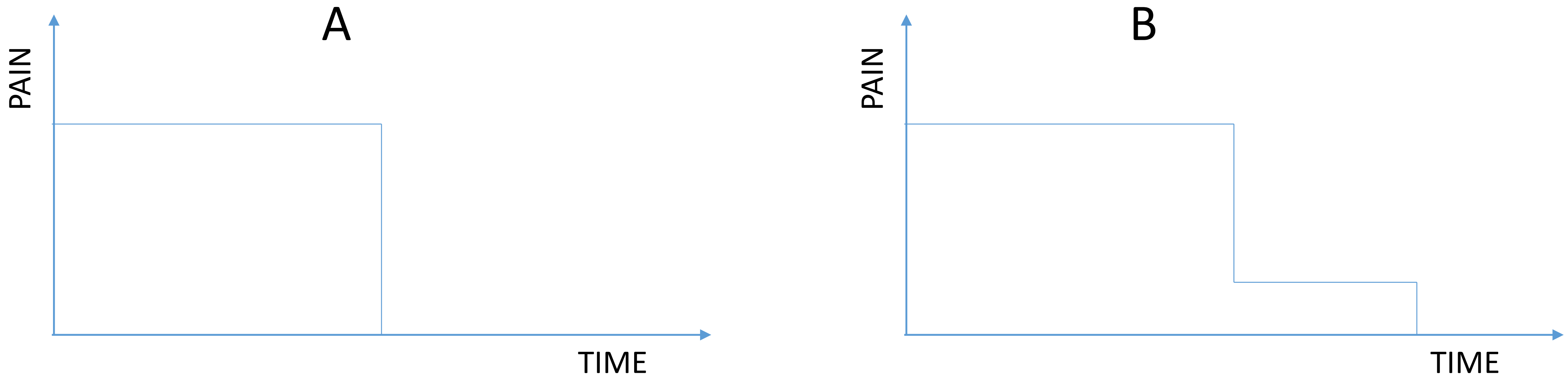
ONE
DOLLAR
In God
we trust


FEDERAL RESERVE NOTE
THE UNITED STATES OF AMERICA
THIS NOTE IS LEGAL TENDER FOR ALL DEBTS, PUBLIC AND PRIVATE
L54836042D
WASHINGTON, D.C.
ONE
12
SERIES 2013
ONE DOLLAR

Peak-end-rule

- Our memory of pain, fun etc. roughly equals the mean of the peak and end
- If experience A has 50 seconds of intense pain and experience B has 50 seconds of intense pain followed by mild pain, people want to repeat B although there is more total pain



Peak-end-rule

- Implication in game design: to make the player come back, every play session should be structured to have an engaging end and at least some peak moment
  - Can you predict when the session is going to end, e.g., average length?
- Also related to randomness: adding randomness adds peaks and thus boosts the remembered experience, even if the mean remains unchanged.
- Development resource allocation: for the remembered experience, the peak(s) and end matter most, which one should consider when prioritizing.

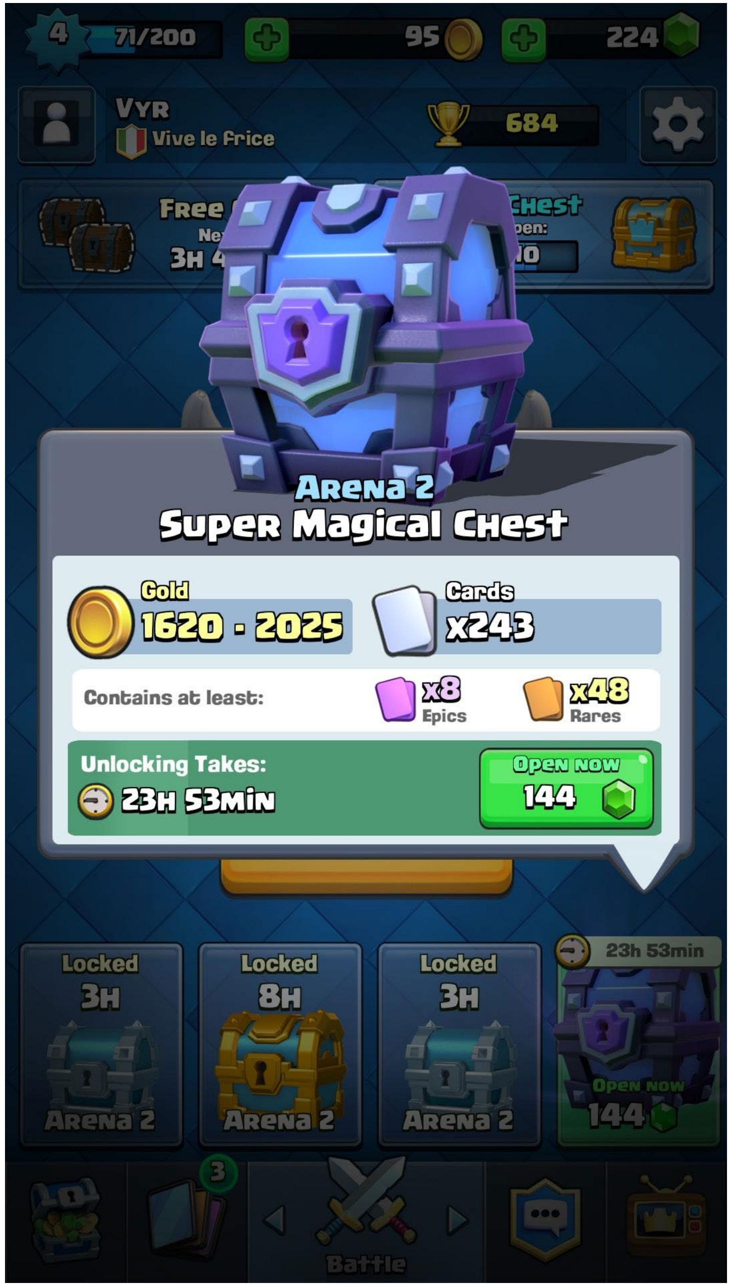
Peak-end-rule in user interfaces

- Progress bars feel better if progress accelerates towards the end.
- Conversely, it’s very annoying if the bar gets stuck at 95%

Peak-end-rule

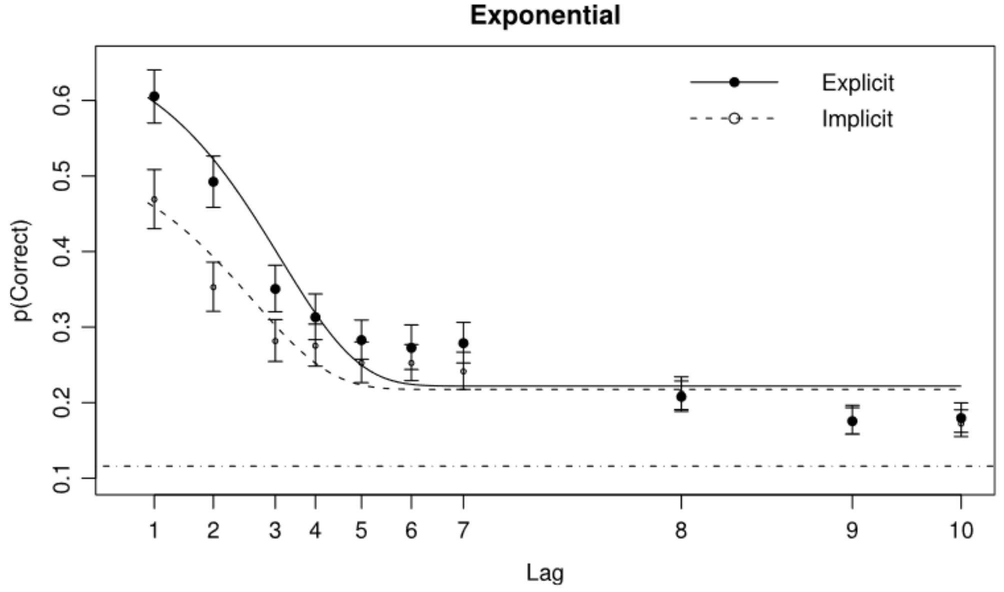
Peak-end-rule

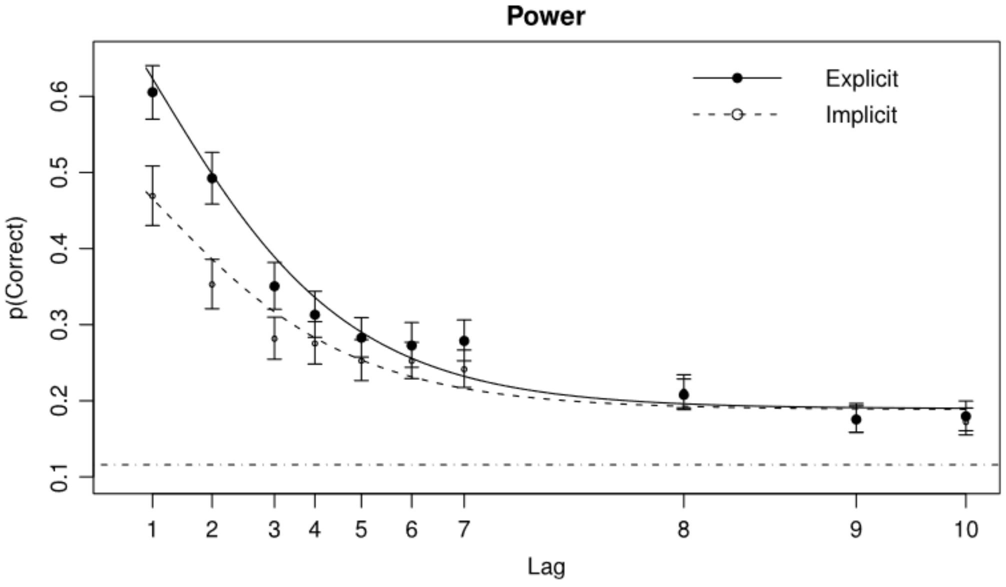
- In Clash Royale, very tight/improbable wins (right before time ends or winning when one's King has only a few HP left) seem to be rewarded with more rare chests
- Can be interpreted as the designers boosting the game's natural peak moments, making them even more memorable



Beyond peak-end rule

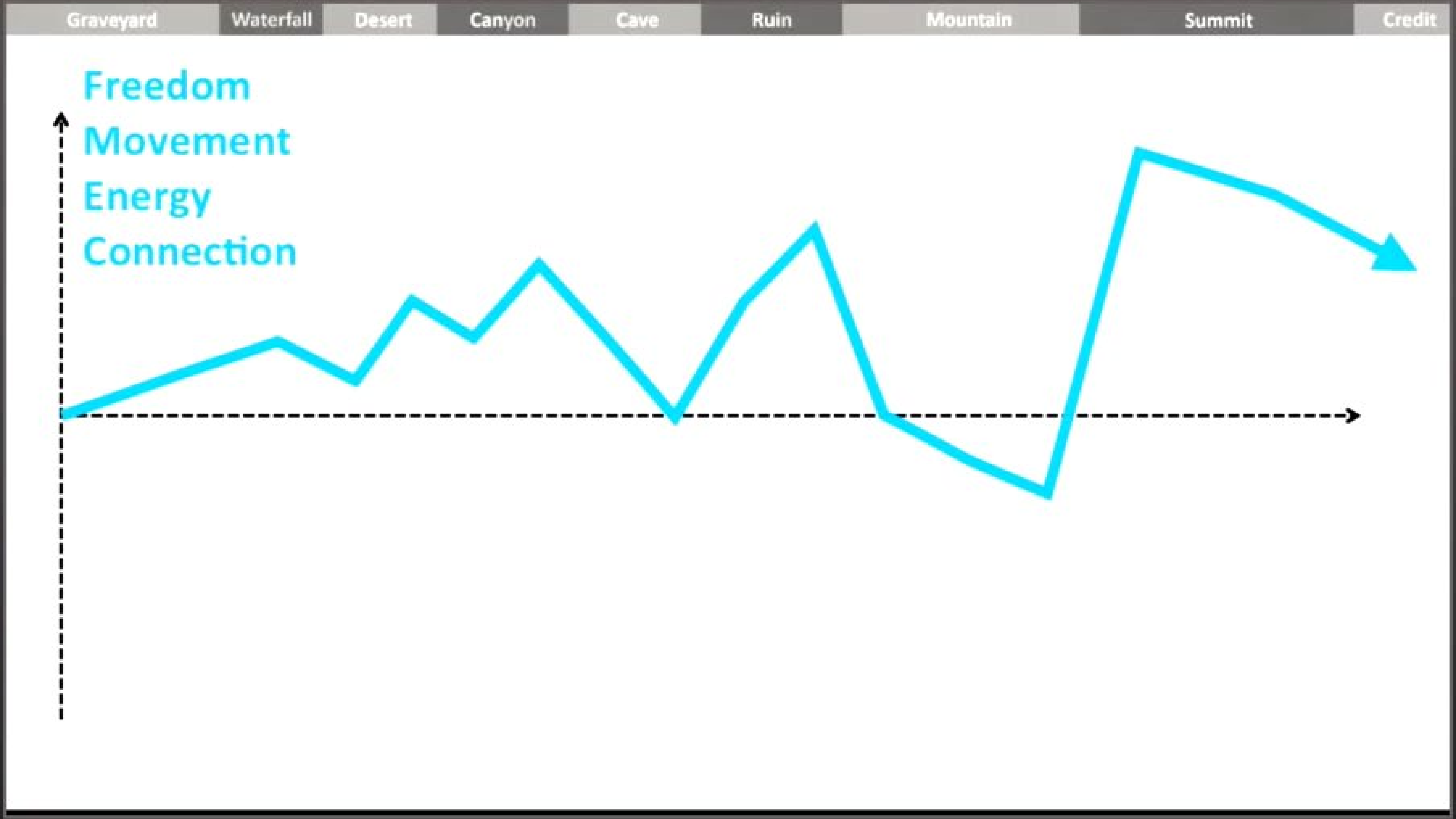
- The rule seems too simplistic, and goes against more general memory research (e.g., forgetting curves)
- My hypothesis: What we remember is a function of time (most recent memories are strongest, hence the importance of the end) and other factors such as contrast and novelty/unpredictability (which amplifies surprising peaks)



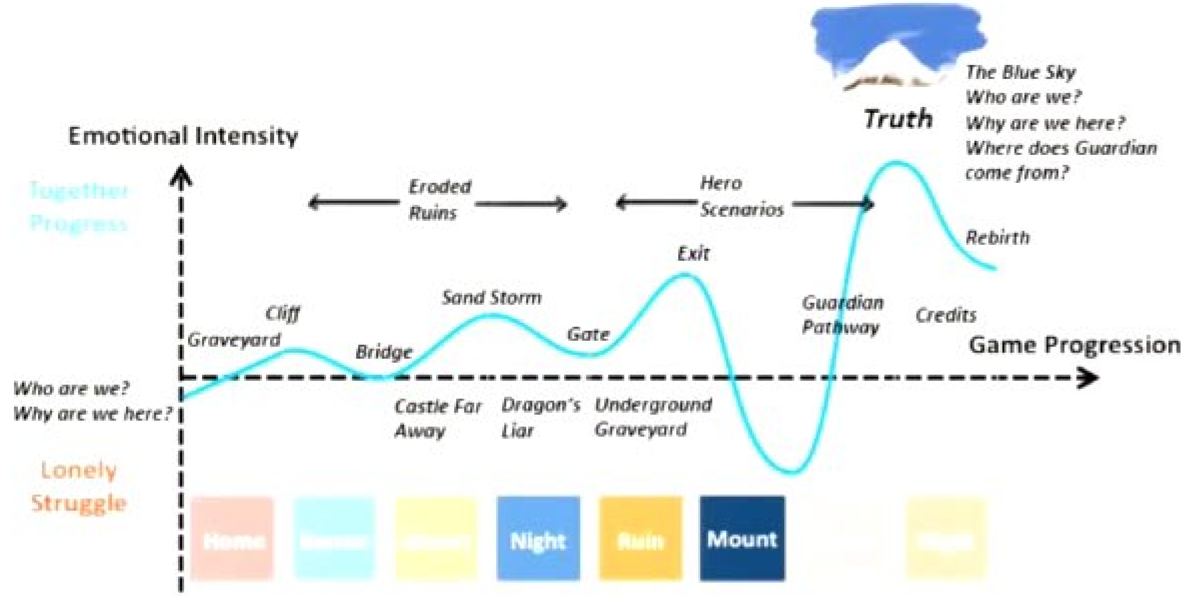


Forgetting curve fits from Averell & Heathcote 2011.

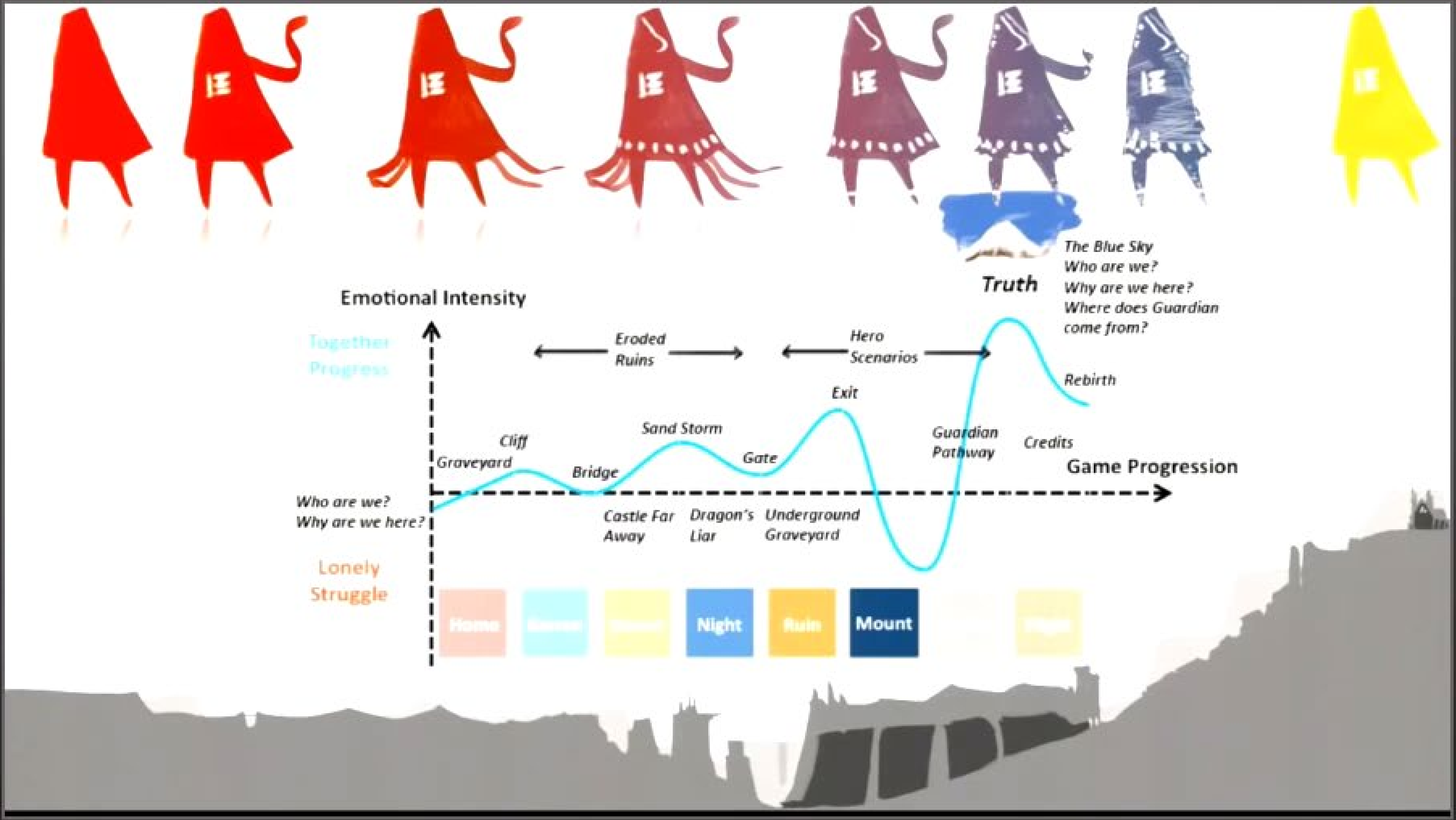
Peak-end rule and drama



"Catharsis, a sudden emotional breakdown or climax that constitutes ... any overwhelming change in emotion that results in renewal, restoration, and revitalization."



The Blue Sky
Who are we?
Why are we here?
Where does Guardian come from?
Truth
Emotional Intensity
Together Progress
Eroded Ruins
Hero Scenarios
Rebirth
Exit
Sand Storm
Cliff
Graveyard
Bridge
Gate
Guardian Pathway
Credits
Game Progression
Who are we?
Why are we here?
Castle Far Away
Dragon's Liar
Underground Graveyard
Lonely Struggle
Home
Night
Ruin
Mount



Emotional Intensity
Together
Progress
Lonely
Struggle
Who are we?
Why are we here?
Graveyard
Cliff
Bridge
Castle Far
Away
Sand Storm
Dragon's
Liar
Gate
Underground
Graveyard
Exit
Eroded
Ruins
Hero
Scenarios
Guardian
Pathway
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Who are we?
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Ruin
Mount

Design principles and implications

- Core reward design principles (anticipation and discounting of rewards)
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- Perception and attention (contrast, Halo effect, confirmation bias)
- Memory (storing and retrieving information)
- **Social (effect of other people)**

Social proof

- The oldest sales trick, ”Finland’s most popular car”, ”Already 10 Million downloads” etc.
- Highlighting most frequently purchased items or ”people who bought X also bought...”
- The effect is stronger with closer social ties
  - Facebook shows ”Friend X likes Y” ads
  - ”90% of your facebook friends purchased Y” in IAPs?
- Base building games: players can see the bases of other players, what they’ve bought or achieved.


4
6
1314
999
83
Carol Wolf bundle
BUNDLE
1200
Gold!
Carol's Blade
New Outfit
Carol, Wolf
Offer ends in 1d 18h
€7,99 BUY
5
Map

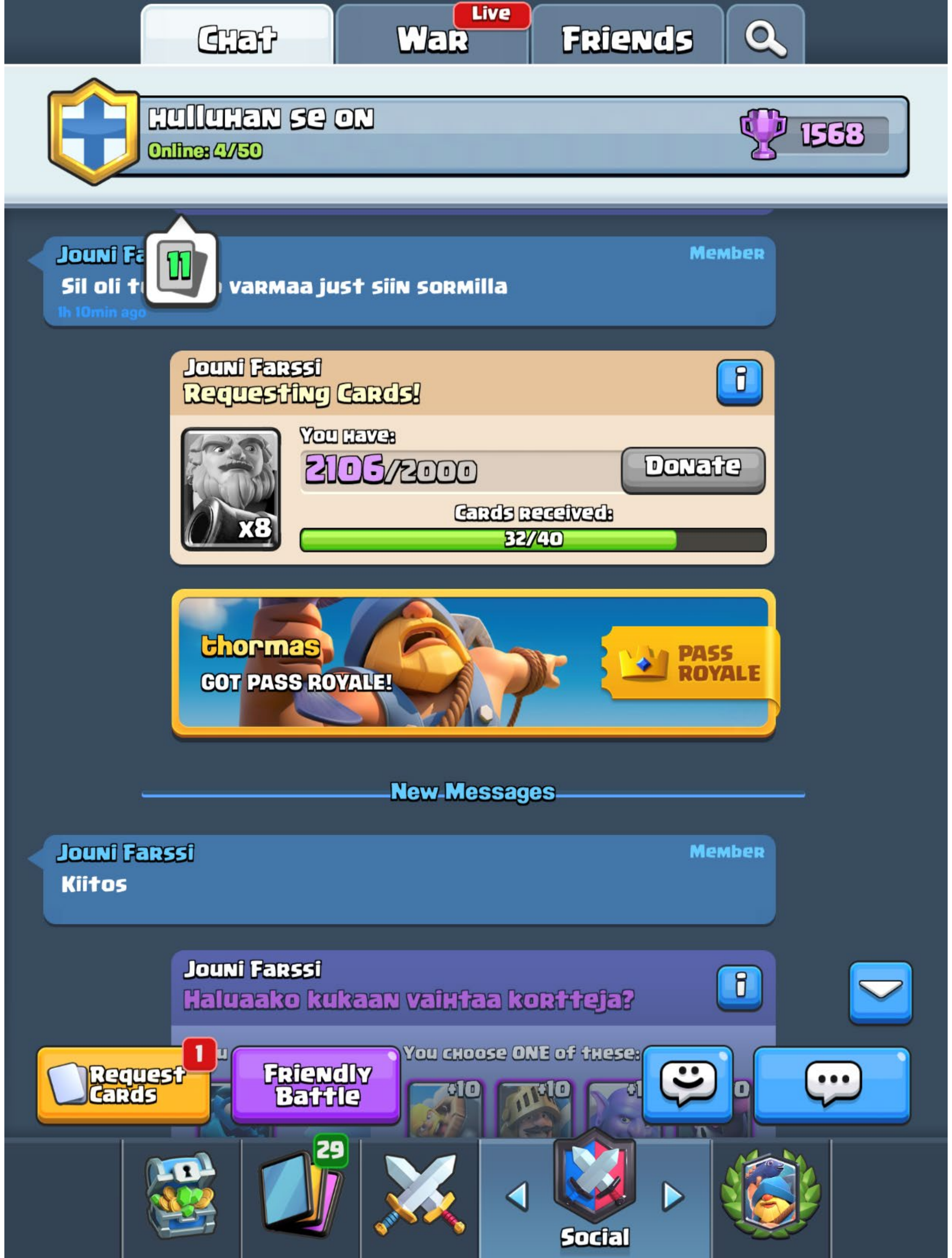
The weight is over.
Finally, smoother, softer, satiny style in half the time.
Living proof.
style | lab™
satin
hair serum
no oils or silicones
superior smoothing
frizz eliminating
shine creating
Living Proof Satin exclusively at
SEPHORA
Visit Sephora and receive a free mini of Satin*
Jennifer Aniston
Co-Owner, Living proof
You are the
Living proof.®

Computational rationality and social proof

- An instance of integrating multiple information sources – mitigating one's own cognitive limitations by offloading some of the computation to others
- Rational if assuming reliability of others => makes sense that strength of experienced social connection affects the effect

Reciprocity (reciprocal altruism)

- Tendency to return favors (sharing of rewards/utility, on average over a long enough time span)
- **System 1 bias: Even an unwanted favor, once received, can produce indebtedness.**
- Sales and marketing: free samples.
- Games: gifting behaviors may be used to drive monetization



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1568
Jouni Fa
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Requesting Cards!
You have:
2106/2000
Donate
x8
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32/40
thormas
GOT PASS ROYALE!
PASS ROYALE
New Messages
Jouni Farssi
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Jouni Farssi
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You choose ONE of these:
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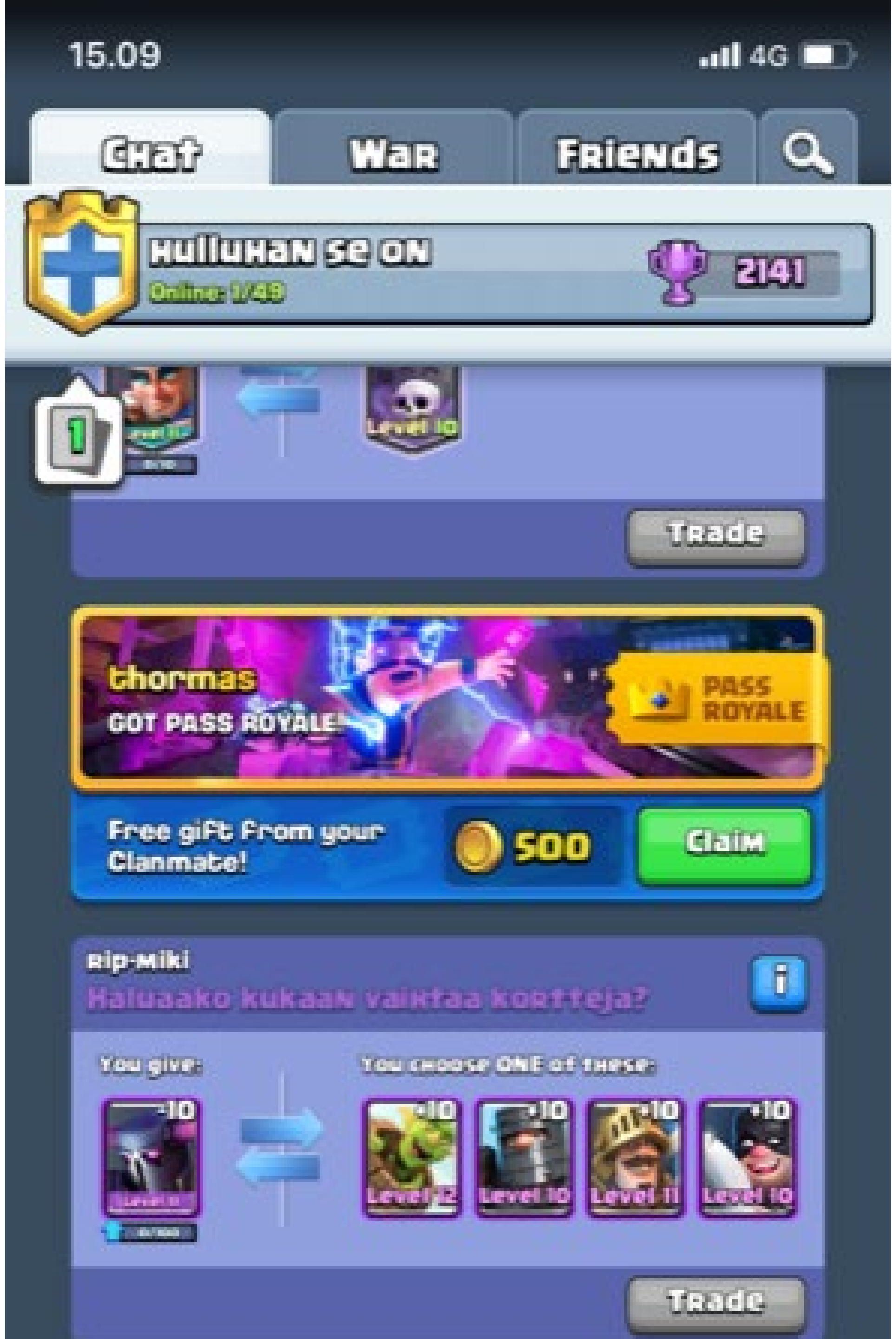
1
Friendly Battle
29
Social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Level 10
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GOT PASS ROYALE!
PASS ROYALE
Free gift from your Clanmate!
500
Claim
Rip-Miki
Haluaako kukaan vaihtaa kortteja?
You give:
You choose ONE of these:
x10
x10
x10
x10
x10
Level 12
Level 10
Level 11
Level 10
Trade

Computational rationality and reciprocity

- Reciprocating can be rational in a social environment, in the long term
- Both learned (upbringing, religion…) and innate
  - Considerable amount of literature on the evolutionary basis

Chapter 4

Reciprocal altruism: 30 years later

Robert Trivers

"Two are better than one; because they have a good reward for their labour. For if they fall, the one will lift up the other: but woe to him that is alone when he falleth; for he hath not another to help him up. Again, if two lie together, then they have heat: but how can one be warm alone? And if one prevails against him, two shall withstand him; and a three-fold cord is not easily broken." (Ecclesiastes 4, 9–12; King James Version).

4.1 Introduction

A little over 30 years ago, I had the good fortune of publishing my first scientific paper on reciprocal altruism, a subject that had not yet been addressed from an evolutionary standpoint. Hamilton's (1964) great work on kinship and altruism made it clear that in humans there existed a major form of altruism that could not be explained by kinship. Its elaboration was responsible for the complex economic systems in which we now live and its regulation could plausibly be explained by a system of interconnected human emotions, including feelings of friendship, gratitude, sympathy, guilt, moralistic aggression, a sense of justice and (I would now add) forgiveness.

I brought no great talents to this enterprise, beyond a willingness to take the evolutionary problem seriously and to model evolutionary logic on easily inferred psychological facts regarding our own behavior (for a description of how the paper was written, see Trivers 2002). The paper was certainly timely. My 600 reprints were quickly exhausted and the evolutionary idea was off and running. There now exists a very large literature on the subject and many subareas have advanced far beyond my original paper.

The purpose of the present paper is to provide a personal review of some major developments since my paper. These include the Prisoner's Dilemma (PD) as a model for reciprocal altruism, other models and third-party observer effects. I concentrate on the human sense of justice and the selective forces likely to have molded it. In the process, I discuss recent empirical work (using economic games) that bears on our sense of fairness and what seems to me the most plausible way to interpret these results. I neglect many important topics, for example, discrimination against cheaters in symbioses (see Sachs et al. 2004).

Reciprocity in games

- Social games: gifts were popular on fb but fell out of fashion.
- Can virtual characters or game creators trigger social reciprocation in players?
- Waifu/husbando characters, maybe (I don’t have experience myself)
- Some games try to solicit reviews by making the player feel that the team has struggled to make a great game for the player’s benefit, and the player can give back by giving a 5-star review.
- Youtubers/influencers getting free games and in-game items, probably biases their reviews and videos

Recap time…

Very common and well-established principles

- Anticipation of reward (Clearly advertise upcoming rewards)
- Rewards motivate more when closer (Provide both short and long-term rewards)
- Random rewards (Loot boxes, game balancing)
- Peak-end-rule (provide a satisfying ending and one or more peak moments that are memorable and that your players want to talk about and share)
- Contrast effect (microtransaction pricing)
- Social proof (microtransaction advertising, seeing what other players have purchased or invested in)
- Artificial scarcity (limited offers, rarities of items)
- Going with the default (frame the desired player action as the default)
- Halo effect (Something really unique/terrible can dominate the perception of an otherwise average game)

Somewhat less common, still worth knowing

- Reciprocity (gifting mechanics increase engagement & virality)
- Loss aversion (framing paying as avoiding losing something the player has already earned)
- Sunk cost fallacy (e.g., people invest more in games they've paid for, "pay to continue" after investing a lot of time on a level and failing)
- Commitment & consistency (Importance of no-brainer first purchase)
- Anchoring (Attempts to solicit 5-star reviews)

Utilization of the two systems outside games

- Martial arts: probing and then exploiting the opponent’s automatic (i.e., predictable) behaviors
- Politics: designing campaigns and advertising to trigger strong emotions that make people behave without thinking
- Magic tricks
- Sales and marketing

We’re constantly being manipulated by our media environment

GET
READY!

Explanations

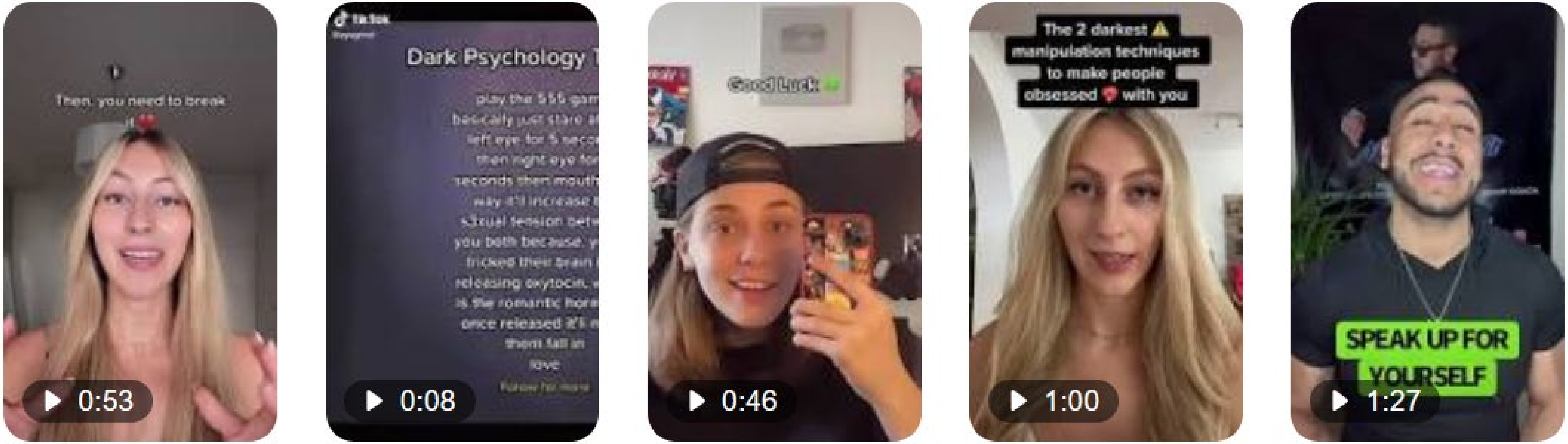
- 11-4=7, 12-5=7, and the last arithmetic operation before the final question was a subtraction
- 7 is close to the mean of the range 5…12
- 7 is the only number not shown (might work for those that try to come up with something unexpected)
- Odd numbers are perceived as slightly more random
- 7 is simply a common number people think of

The real psychological trick?

- Asking for the shares from those who ”fell” for it
- Maximizes perceived success rate
- Maximizes virality

https://www.tiktok.com › Discover

psychological manipulation tips | TikTok Search

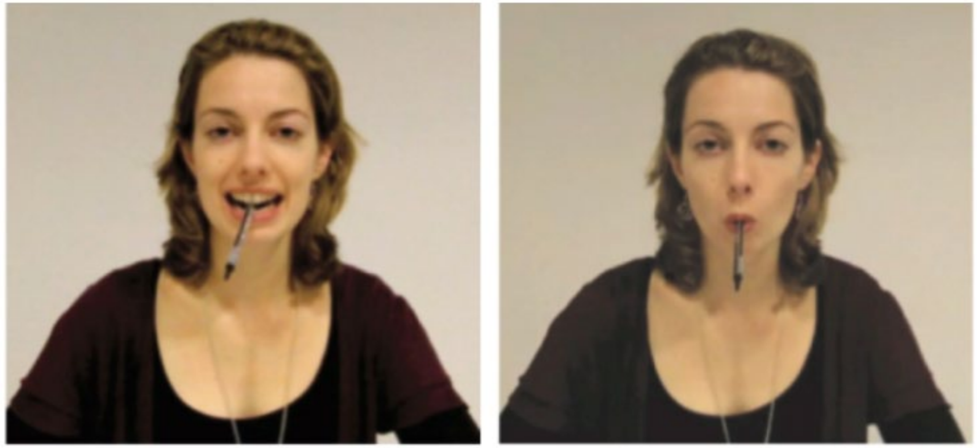


17 Sept 2022 — Discover short videos related to **psychological manipulation** tips on **TikTok**. Explore the latest videos from hashtags: ...

Popular TikTok genre: False claims about psychological manipulation

Unbelievable findings are sometimes just that.

- Social psychology is undergoing a replicability crisis
- Some papers present findings based on too few participants and questionable research practices (QRP:s)
- Does not replicate: Forced smile (pen in mouth) makes you positive, Power posing affects hormones, Elderly priming, many other priming studies.
- Still, many classic effects such as anchoring and loss aversion do seem to replicate



The Power of the Pen Paradigm: A Replicability Analysis

September 4, 2017 Classic Article, Darwin, Facial Feedback Hypothesis, Kahneman, Median Observed Power, Pen in Mouth Paradigm, Power, r-index, Replicability, Replication, Social Psychology

https://replicationindex.com/category/pen-in-mouth-paradigm/

“I placed too much faith in underpowered studies:” Nobel Prize winner admits mistakes

Although it’s the right thing to do, it’s never easy to admit error — particularly when you’re an extremely high-profile scientist whose work is being dissected publicly. So while it’s not a retraction, we thought this was worth noting: A Nobel Prize-winning researcher has admitted on a blog that he relied on weak studies in a chapter of his bestselling book.

Daniel Kahneman

https://retractionwatch.com/2017/02/20/placed-much-faith-underpowered-studies-nobel-prize-winner-admits-mistakes/

Statistical Significance Testing at CHI PLAY: Challenges and Opportunities for More Transparency

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ABSTRACT

Statistical Significance Testing – or Null Hypothesis Significance Testing (NHST) – is common to quantitative CHI PLAY research. Drawing from recent work in HCI and psychology promoting transparent statistics and the reduction of questionable research practices, we systematically review the reporting quality of 119 CHI PLAY papers using NHST (data and analysis plan at OSF.io). We find that over half of these papers employ NHST without specific statistical hypotheses or research questions, which may risk the proliferation of false positive findings. Moreover, we observe inconsistencies in the reporting of sample sizes and statistical tests. These issues reflect fundamental incompatibilities between NHST and the frequently exploratory work common to CHI PLAY. We discuss the complementary roles of exploratory and confirmatory research, and provide a template for more transparent research and reporting practices.

CCS CONCEPTS

• **Human-centered computing** → *Empirical studies in HCI.*

data to produce new insights regarding player-computer interaction [179]. Often, data analysis proceeds by way of p values (e.g., as computed via t-test or ANOVA), which are used to understand whether trends in data represent real effects, or merely noise. This is commonly called *Null Hypothesis Significance Testing* (NHST).

However, NHST methods have become increasingly subject to critique. False positive results, whereby noise is misidentified as a real effect, can easily occur as a result of common practices performed during analysis [79, 154]. These *Questionable Research Practices* [177, QRPs] threaten the legitimacy of statistical significance and therefore complicate interpretation of published research findings [79, 154]. QRPs are facilitated by a publishing climate biased towards statistically significant results[1], leaving non-significant research findings in the file drawer [33, 49, 131, 170].

A growing number of HCI scholars have consequently called for greater consideration of the quality of NHST analyses, and statistical reporting more broadly [26, 27, 48, 75, 88]. However, the extent to which these issues affect HCI research on games and play – and CHI PLAY in particular – is yet to be determined.

Yet CHI PLAY arguably has much to gain from other fields where

https://acris.aalto.fi/ws/portalfiles/portal/44527123/NHST_at_CHI_PLAY_CameraReady.pdf

Summary

- There are multiple psychological principles that a designer should know.
- They are not a silver bullet, but a foundation that should feel natural, same as proper use of colors, UI design principles etc.
- At the same time, there are also false positive results. If there is only a single study about an effect or principle, take it with a grain of salt.
- Especially important: understand how human **perception,attention, information processing** and **memory** all have features and limitations that affect behavior, and how social interaction also contributes.
- Reward anticipation & discounting!
- Two systems theory: interplay of instinctive/fast and analytic/slow, and our tendency to avoid the latter.

Exercise: improve your reward design!

Think about a game you are making: What is rewarding/satisfying for the player? Can you improve the reward design?

Report your findings using 3 slides (submit as a .pdf via MyCourses, before next week's Monday session):

1. A brief summary of your game, with a screenshot if possible
2. The game's current reward design
3. How would you improve it considering the following?
   - Build anticipation of upcoming rewards or otherwise satisfying moments
   - Provide both short-term and long-term rewards (core loop, breadcrumbing, daily login rewards, weekly "Epic Sunday" rewards, longer term progress rewards…)
   - Include at least some randomness/novelty/surprisal to boost the rewards?
   - Consider peak-end rule to make sure each player has a memorable experience they want to talk about?

Exercise: in groups, pick a game & analyze

- What psychological principles are utilized?
  - Add screenshots (or series of them) to illustrate the principles.
- Focus on the most common principles to avoid overinterpretation:
  - Building anticipation of rewards
  - Providing short and long term rewards (breadcrumbing, daily login rewards…)
  - Providing random rewards
  - Contrast effect (e.g., in-game shop)
  - Loss aversion, especially in form of artificial scarcity
  - Framing desired player action as the default choice
  - Social proof (e.g., in advertising microtransactions)
  - Using social reciprocation to elicit gifting or other desired player behaviors
- What principles could be utilized better? Can you improve the reward design?
- Collect the results in a shared Google Slides

Resources

Books:

Kahneman 2011: Thinking, fast and slow (but, see also: https://retractionwatch.com/2017/02/20/placed-much-faith-underpowered-studies-nobel-prize-winner-admits-mistakes/)

Cialdini 2006: Influence – The psychology of persuasion, revised edition

Research papers and reports:

UTA Free2Play Research Project Final Report: http://tampub.uta.fi/handle/10024/98584

Hamari 2011: Perspectives from behavioral economics to analyzing game design patterns: loss aversion in social games

Butler 2014: Game design through the lens of behavioral economics

Lewis et al. 2012: Motivational Game Design Patterns of 'Ville Games

Video:

South Park episode: Freemium isn't free

Web:

http://www.psychologyofgames.com

http://www.gamasutra.com/view/feature/172409/10_years_of_behavioral_game_design_.php

https://en.wikipedia.org/wiki/List_of_cognitive_biases

https://www.youtube.com/watch?v=xNjI03CGkb4 (Let's go Whaling talk – informative if not ethical)