FLASHFEED STUDY GUIDE

The Science of Sticky Apps

Unofficial study guide by FlashFeed

November 2026 edition · pack version 1.0.33

flashfeedlearningapp.com

The Science of Sticky Apps: unofficial study guide

The full scientific stack behind habit-forming mobile apps: the dopamine of anticipation, B.F. Skinner's variable rewards, Fogg's B=MAP and Eyal's Hook Model, loss aversion and the streak, gamification and Octalysis, network effects and viral K-factors, retention and the Aha moment, the design patterns — and the ethics of it all, from FarmVille to TikTok.

Unofficial study guide for *Hooked: How to Build Habit-Forming Products* by Nir Eyal, Ryan Hoover. FlashFeed is not affiliated with the author or publisher.

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In the app	flashfeedlearningapp.com/packs/sticky-apps

How to use this guide

Take one lesson at a time: read the study guide, then go over any key facts. Where a lesson has a self-test, try it from memory before you check the answer key at the back. Follow the Go deeper links when you want more.

Free, with no ads and no account to make.

Contents

01	How We Got Here	4
02	The Brain Chemistry of Engagement	14
03	The Psychological Frameworks	23
04	Gamification Mechanics	34
05	Social Architecture & Network Effects	45
06	Engineering Viral Growth	58
07	Retention Architecture	68
08	Design Patterns & Ethics	77
09	Case Studies in Stickiness	90
10	Who's Who & What's What of Stickiness	100
11	Essential Vocabulary & Quick Recall	108
	Answer key	120
	Sources	142
	Image credits	143
	Useful links	145
	About FlashFeed	146

LESSON 1 OF 11

How We Got Here

Captology & the persuasion roots · Social games & the mobile Skinner box · Hooked and the algorithm era

WHAT YOU'LL BE ABLE TO DO

- Define captology and identify BJ Fogg as the researcher who coined it and founded the Stanford Persuasive Technology Lab.
- Place persuasive tech's founding milestones on a timeline: the Charismatic Computers dissertation, coining captology, the Stanford lab, the book.
- Explain how the 2007 Facebook Developer Platform and FarmVille turned social obligation into a viral engagement engine.
- Identify infinite scroll and the smartphone-as-portable-Skinner-box, crediting Aza Raskin and Anna Lembke.
- Trace the shift from Nir Eyal's Hook Model to TikTok's algorithm-driven For You Page, with the key launch years.

Captology & the persuasion roots

Persuasive technology didn't emerge from a product roadmap. It came out of a Stanford dissertation, and the academic scaffolding built around it became the blueprint that an industry later adopted wholesale.

It started with a dissertation

BJ Fogg's 1993 doctoral dissertation, *Charismatic Computers*, established a counterintuitive premise: computers don't just process tasks — they shape what people think and do. The work was early enough that most practitioners ignored it, but rigorous enough to survive. The key insight was that persuasion, long studied as a property of humans and media, could be systematically engineered into software. Fogg wasn't describing a bug; he was describing a design opportunity. **Captology** — a term he coined in **1996** — names this exact discipline: the study of Computers As Persuasive Technologies.

The Persuasive Technology Lab

In **1998** Fogg founded the **Stanford Persuasive Technology Lab**, institutionalizing a field that had previously been scattered across psychology and HCI. His 2003 book *Persuasive Technology: Using Computers to Change What We Think and Do* crystallized the research into a form engineers could apply. The lab's influence was direct: a significant portion of Silicon Valley's product designers passed through Stanford, absorbed this framework, and carried it into companies that had never heard the word captology. The book predated the iPhone; the smartphone era gave every principle in it a global distribution channel.

B = MAP, foreshadowed

Fogg's career-spanning synthesis condensed into one equation: **B = MAP** — Behavior equals Motivation times Ability times Prompt. A behavior occurs only when all three converge in the same moment. Low motivation can be offset by high ability (make it frictionless) or a well-timed prompt; a perfectly motivated user won't act if the action is too hard or no trigger arrives. This framework encoded the entire discipline of **friction reduction** and **notification design** into a single testable model. The product teams that later built pull-to-refresh, push notifications, and streaks were operationalizing Fogg's equation whether they knew his name or not.

Social games & the mobile Skinner box

Two things converged in 2007–2009 that turned persuasive design from a niche academic topic into an industry default: social platforms opened to third-party developers, and a computing device powerful enough to run games landed in every pocket.

A platform opens the gates

The **Facebook Developer Platform** launched in **May 2007**, allowing outside teams to build directly on top of Facebook's social graph. The effect was immediate. Text-based games gave way to visual simulations — farms, cities, aquariums — where social obligation was the core mechanic. Your friends could see your farm. Your crops wilted if you didn't return. Helping a friend yielded in-game resources. The platform didn't invent these loops, but it provided the social infrastructure that made them visceral. A game's engagement wasn't just about its content; it was about who else was playing.

FarmVille and the viral loop

Zynga launched **FarmVille** in June 2009 on that platform. It reached **1 million Daily Active Users in four days** and **30 million in six months** — figures that had no precedent in consumer software. The driver wasn't depth of gameplay. It was a tightly engineered viral loop: visible farms created social proof, resource-gifting required friends to reciprocate, and 'a friend needs help' notifications pulled lapsed users back. **Anna Lembke**, Stanford psychiatrist and author of *Dopamine Nation*, later called the smartphone the modern hypodermic needle delivering **digital dopamine** — FarmVille demonstrated early that social mechanics could produce the same compulsive return behavior.

The phone in your pocket

The iPhone launched in **2007**. The App Store followed in **2008**, giving developers direct distribution to a device users carried constantly. **Aza Raskin** patented **infinite scroll** in **2006** — a feed design with no natural stopping point where content loads endlessly, removing the visual cues that previously told you to stop. On mobile, that mechanic became ruinous: a desktop user had to sit down to be conditioned; a smartphone user could be conditioned in every idle moment. The smartphone became what researchers called a **portable Skinner box** — a conditioning chamber that travels everywhere you do.

Hooked and the algorithm era

By 2014 persuasive design had a practitioner canon. By 2018 it had a machine capable of learning faster than any practitioner could iterate — and the discipline shifted from human-designed loops to algorithm-optimized conditioning.

Hooked

Nir Eyal's 2014 book *Hooked: How to Build Habit-Forming Products* synthesized a decade of practitioner knowledge into the **Hook Model**: **Trigger → Action → Variable Reward → Investment**. The trigger prompts behavior (internal: boredom; external: a notification). The action is the simplest behavior possible in anticipation of a reward. The variable reward — unpredictable, like a slot machine — is what sustains compulsion; fixed rewards extinguish quickly. The investment deposits something (data, followers, content) that makes the next trigger more likely. The model became the dominant framework at Snapchat, Instagram, Twitter, and beyond. Eyal published it in **2014**; the iPhone had launched in **2007**, the App Store in **2008**, so an entire cohort of mobile teams was waiting for exactly this synthesis.

The algorithm era

TikTok launched globally in **2018** and represented a qualitative leap. Previous apps relied on social graphs and hand-tuned heuristics. TikTok's **For You Page (FYP)** runs on a **reinforcement-learning algorithm** that infers preferences from watch time, video completions, and skips — signals users are not consciously aware of providing. It optimizes not for what you declare you like, but for what you demonstrably cannot stop watching. A **$1.7 million** Georgia Tech study auditing the FYP confirmed the algorithm's precision and its opacity: users had limited ability to understand or correct what it had inferred. The result is a feed that personalizes faster than habit and adapts in real time — the endpoint of a lineage that started with Fogg's dissertation and ran through FarmVille, the Hook Model, and the smartphone.

Key terms

Captology

The study of Computers As Persuasive Technologies — how computers can be designed to change human thoughts and behaviors. BJ Fogg coined the term in 1996.

Infinite scroll

A feed design with no natural stopping point — content loads endlessly as you scroll, removing the cues that previously told you to stop. Aza Raskin patented it in 2006.

For You Page (FYP)

TikTok's main feed, driven by a reinforcement-learning algorithm that infers preferences from watch time, completions, and skips to optimize for what a user can't stop watching.

Key concepts

Captology

- A term coined in 1996 that named a new discipline: the study of computers as tools of persuasion.
- It grew out of a 1993 Stanford doctoral dissertation titled Charismatic Computers.
- Its name is compressed from the phrase 'Computers As Persuasive Technologies.'

FarmVille

- This 2009 Zynga simulation launched on a newly opened social platform and made social obligation its core mechanic.
- Its viral loop combined visible progress as social proof, resource-gifting that forced friends to reciprocate, and 'a friend needs help' notifications to pull lapsed players back.
- It reached 1 million Daily Active Users in four days and 30 million in six months — numbers with no precedent in consumer software.

Infinite Scroll

- Aza Raskin patented this feed design in 2006 — a layout with no natural stopping point.
- Content loads endlessly, removing the visual cues that once told a user when to stop.
- On mobile it turned ruinous, erasing the page-turns and load screens that used to give the brain a moment to reassert control.

TikTok

- This app launched globally in 2018 and marked a qualitative leap beyond social-graph and hand-tuned platforms.
- Its feed runs on a reinforcement-learning algorithm that infers preferences from watch time, video completions, and skips — signals users don't know they're giving.
- A $1.7 million Georgia Tech study audited its For You Page and confirmed both its precision and its opacity.

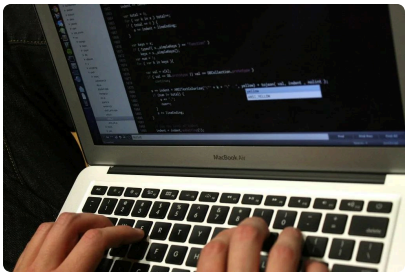
Key facts

> **It started with a dissertation**
>
> The lineage of sticky design starts not with a product manager but with a Stanford doctoral student. **BJ Fogg's** 1993 dissertation, *Charismatic Computers*, showed for the first time that computers could change human thoughts and behaviors in predictable ways.

> **The Persuasive Technology Lab**
>
> In **1998**, Fogg founded the **Stanford Persuasive Technology Lab**. His 2003 book *Persuasive Technology: Using Computers to Change What We Think and Do* became the academic foundation — and later the product-design bible — of the mobile era.

B = MAP, foreshadowed

Fogg's work eventually formalized into **B = MAP**: Behavior = Motivation × Ability × Prompt. The claim: a behavior happens only when motivation, ability, and a prompt converge in the same moment. It encoded the whole discipline of friction reduction into one equation.



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What Captology Means

Captology stands for Computers As Persuasive Technologies — the study of how computers can be designed to change what people think and do.



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Captology's Birth Year

The term captology was coined in 1996 — three years after Fogg's 1993 dissertation and two years before he founded the Persuasive Technology Lab in 1998.

A platform opens the gates

The **Facebook Developer Platform** arrived in **May 2007**, triggering a Cambrian explosion of social apps. Text games gave way to visual 'farms' and 'cities' that used social obligation as their core mechanic.

Patented In 2006

Aza Raskin patented infinite scroll in 2006, engineering away the natural stopping points that once told users when to stop.

No Natural Stopping Point

Infinite scroll is a feed designed with no natural stopping point, loading new content endlessly so the cues that once told you to stop simply disappear.

Hooked

Nir Eyal's 2014 book *Hooked: How to Build Habit-Forming Products* synthesized the field's practitioner knowledge into the **Hook Model** (Trigger → Action → Variable Reward → Investment) — which became the dominant framework for teams at Snapchat, Instagram, Twitter, and beyond.

> **The Hook Model's Order**
> Eyal's Hook Model runs in a fixed loop: Trigger, then Action, then Variable Reward, then Investment — a different framework from Fogg's separate B=MAP equation.

> **What Powers The FYP**
> TikTok's For You Page runs on a reinforcement-learning algorithm that infers what you want from watch time, completions, and skips — not from your social graph.

> **Primed By The App Store**
> Hooked landed in 2014, but only after the iPhone (2007) and App Store (2008) had spent years priming a whole cohort of mobile teams to receive its ideas.

By the numbers

Year of BJ Fogg's Charismatic Computers dissertation
1993 year

Year BJ Fogg coined the term captology
1996 year

Year the Stanford Persuasive Technology Lab was founded
1998 year

Year Fogg published Persuasive Technology
2003 year

FarmVille's Daily Active Users after four days
1000000 users

FarmVille's Daily Active Users after six months
30000000 users

Year the iPhone launched
2007 year

Year the App Store opened
2008 year

Year Nir Eyal published Hooked
2014 year

Year TikTok launched globally
2018 year

Budget of Georgia Tech's study auditing TikTok's algorithm
1700000 USD

Matched pairs

Each item on the left goes with the one on the right.

BJ Fogg → Coined captology; founded the Stanford Persuasive Technology Lab

Anna Lembke → Called the smartphone the modern hypodermic needle delivering digital dopamine

Aza Raskin → Patented the infinite scroll in 2006

Nir Eyal → Wrote Hooked (2014); formalized the Hook Model

Self-test

Answer each question from memory, then check your work against the answer key.

1. In **1998**, Fogg founded the **___**. His 2003 book *Persuasive Technology: Using Computers to Change What We Think and Do* became the academic foundation — and later the product-design bible — of the mobile era.

A Stanford HCI Group
B Xerox PARC
C MIT Media Lab
D Stanford Persuasive Technology Lab

2. Captology is the study of computers as what kind of technology?

A Persuasive technologies
B Collaborative networks
C Productivity tools
D Educational aids

3. Who coined the term captology in 1996?

A Anna Lembke
B Aza Raskin
C BJ Fogg
D Nir Eyal

4. BJ Fogg is credited with which pair of contributions?

A Building TikTok's For You Page and Dopamine Nation
B Coining captology and founding the Stanford Persuasive Technology Lab
C Launching FarmVille and the Facebook Platform
D Patenting infinite scroll and writing Hooked

5. Which statement about captology is NOT accurate?

A BJ Fogg coined the term
B It studies how computers change human thoughts and behaviors
C It was coined by Nir Eyal in his book Hooked
D It means Computers As Persuasive Technologies

6. In what year did BJ Fogg complete his Charismatic Computers dissertation?

A 2003
B 1993
C 1996
D 1998

7. In what year did Fogg coin the term captology?

A 1996
B 1993
C 2003
D 1998

8. In what year was the Stanford Persuasive Technology Lab founded?

A 1996
B 1993
C 2003
D 1998

9. In what year did Fogg publish Persuasive Technology: Using Computers to Change What We Think and Do?

A 2007
B 1996
C 2003
D 1998

10. Which sequence lists these milestones in correct chronological order?

A Dissertation → coining captology → founding the lab → publishing the book
B Founding the lab → dissertation → coining captology → publishing the book
C Publishing the book → founding the lab → coining captology → dissertation
D Coining captology → dissertation → publishing the book → founding the lab

11. The **___** arrived in **May 2007**, triggering a Cambrian explosion of social apps. Text games gave way to visual 'farms' and 'cities' that used social obligation as their core mechanic.

A Apple App Store
B Facebook Developer Platform
C Google Play Store
D MySpace Developer Platform

12. What did the Facebook Developer Platform give outside game teams that let them make social obligation the core mechanic?

A Unlimited free push notifications to non-users
B A reinforcement-learning recommendation algorithm
C Built-in cryptocurrency payments for in-game purchases
D Direct access to users' social graph, so friends could see and affect each other's games

13. How many Daily Active Users did FarmVille reach in just four days?

A 1 million
B 30 million
C 100,000
D 10 million

14. How many Daily Active Users did FarmVille reach within six months?

A 5 million
B 300 million
C 1 million
D 30 million

15. What primarily drove FarmVille's explosive growth?

- A Exclusive availability on the iPhone App Store
- B Deep, innovative gameplay mechanics
- C An engineered viral loop of social proof, gifting, and 'friend needs help' notifications
- D A large paid advertising budget

16. The iPhone's 2007 launch and the 2008 ___ opening moved apps from the desktop to the pocket — available in every idle moment. The smartphone became a **portable Skinner box**: a conditioning chamber you carry everywhere.

- A Amazon Appstore
- B App Store
- C BlackBerry World
- D Samsung Galaxy Store

17. Who patented infinite scroll in 2006?

- A Anna Lembke
- B Aza Raskin
- C BJ Fogg
- D Nir Eyal

18. Which best defines infinite scroll?

- A A social graph that lets friends see your activity
- B A reward that arrives on a fixed, predictable schedule
- C A feed that loads content endlessly as you scroll
- D A notification that pulls lapsed users back to an app

19. Which figure called the smartphone the modern hypodermic needle delivering 'digital dopamine'?

- A BJ Fogg
- B Nir Eyal
- C Aza Raskin
- D Anna Lembke

20. Calling the smartphone a 'portable Skinner box' means it is best described as what?

- A A conditioning chamber you carry everywhere
- B A device that blocks all notifications by default
- C A feed with a fixed daily stopping point
- D A tool that only works when you sit at a desk

21. What are the four stages of Nir Eyal's Hook Model, in order?

- A Action → Trigger → Investment → Reward
- B Motivation → Ability → Prompt → Reward
- C Trigger → Action → Variable Reward → Investment
- D Acquisition → Activation → Retention → Referral

22. Who wrote Hooked and formalized the Hook Model?

- A Nir Eyal
- B Aza Raskin
- C BJ Fogg
- D Anna Lembke

23. In what year was Nir Eyal's Hooked published?

- A 2009
- B 2018
- C 2007
- D 2014

24. In what year did TikTok launch globally, marking the algorithm era?

A 2009
B 2018
C 2007
D 2014

25. What powers TikTok's For You Page, distinguishing it from earlier apps?

A A social graph showing what your friends liked
B A team of editors hand-picking each video
C A chronological feed of posts from accounts you follow
D A reinforcement-learning algorithm inferring preferences from watch time, completions, and skips

Go deeper

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LESSON 2 OF 11

The Brain Chemistry of Engagement

Dopamine: wanting, not liking · The four neurochemicals · The Default Mode Network

WHAT YOU'LL BE ABLE TO DO

- Explain that dopamine drives wanting and seeking and fires in anticipation via Reward Prediction Error, not at the reward itself.
- Identify variable-ratio reinforcement as the unpredictable, slot-machine schedule behind compulsive use.
- Map each of the four neurochemicals (dopamine, oxytocin, serotonin, endorphins) to the human drive it powers.
- Determine which neurochemical lever a given feature pulls and reject mismatched chemical-to-drive pairings.
- Explain how habitual, frictionless scrolling shifts control from the prefrontal cortex to the Default Mode Network and basal ganglia ('zoning out').

Dopamine: wanting, not liking

The single most misunderstood molecule in tech discourse, **dopamine** does not deliver pleasure — it drives pursuit. Getting that distinction right changes how you read every engagement mechanic you encounter.

Dopamine fires before the reward

Dopamine is not a reward signal; it is an anticipation signal. The brain releases it during the *expectation* of something good, not when the good thing arrives. That timing gap is the engine of compulsive use: the feed holds your attention not because the next post is satisfying but because the dopamine hit comes from the act of seeking it. Satisfaction, if it arrives at all, is a different, quieter system.

Wanting vs. liking

Neuroscientist **Kent Berridge** demonstrated through decades of lesion studies that **wanting** and **liking** are neurochemically separable. Dopamine governs the *wanting/seeking* system; opioid circuits govern *liking/enjoyment*. An app can ramp your craving for the next swipe while the swipe itself leaves you flat — the two experiences draw on entirely different brain hardware. This is why "I don't even enjoy this anymore but I can't stop" is neurologically coherent, not a contradiction.

The brain runs on surprise

The VTA (Ventral Tegmental Area) encodes **Reward Prediction Error (RPE)**: the difference between what you expected and what actually happened. When an outcome *exceeds* expectation, dopamine spikes. When it meets expectation, the signal is flat. When it falls short, dopamine dips below baseline. The practical consequence: a perfectly predictable reward trains dopamine out of existence. Uncertainty is the fuel, not the content.

The pocket-sized Skinner box

B.F. Skinner showed in the 1950s that rats pressing a lever on a **variable-ratio** schedule — rewarded unpredictably, not on a fixed interval — pressed far more relentlessly than those on any predictable schedule. The variable-ratio pattern is the slot machine. It is also the social-media notification, the loot box, and the streak reminder. The schedule, not the reward's quality, drives compulsion. Every modern engagement loop is a lever and a variable-ratio payoff, running on the same neurobiology Skinner's rats demonstrated seventy years ago.

The four neurochemicals

App engagement does not run on a single chemical. It pulls four distinct neurochemical levers, each tied to a different human drive. Recognising which lever a feature targets tells you both why it works and how durable that retention will be.

Four chemicals, four levers

Dopamine drives *seeking and anticipation* — the pull toward the next notification, the next variable reward. **Oxytocin** drives *social bonding and trust* — the warmth from peer acknowledgment, cooperative features, or a message from a friend. **Serotonin** drives *status and belonging* — leaderboards, follower counts, and any visible signal that you rank somewhere meaningful among others. **Endorphins** suppress pain and reward exertion — the release that comes from finishing a hard lesson or completing a workout. Each chemical maps to a design pattern; each design pattern is legible once you know the map.

Why social features stick harder

When a user receives social acknowledgment — a reply, a co-op win, recognition from peers — the brain does not release one chemical. In this model it releases **oxytocin** followed by **serotonin**, and that coordinated sequence lands in the **nucleus accumbens**, the brain's primary reward center. The pairing matters: bonding (oxytocin) and status (serotonin) are delivered together to the same circuit that dopamine targets. The result is qualitatively richer and more durable than solo-use dopamine loops alone. In this model, a leaderboard or follower count works through serotonin; a hard lesson you finish works through endorphins. The serotonin link is contested: animal studies tie serotonin signaling to social hierarchies, but a 2022 *Neuropsychopharmacology* study notes that direct evidence in humans is lacking. Knowing the lever tells you which population will respond and how long the effect will last.

The Default Mode Network

The **Default Mode Network (DMN)** is the brain network associated with mind-wandering, self-referential thought, and inward drift. When a task becomes automatic, the DMN takes over from deliberate attention — and engagement designers know exactly how to get you there.

Zoning out is the design goal

Under conscious, deliberate use, the **prefrontal cortex** maintains executive control: you can decide to stop. But when scrolling becomes habitual and the interface presents no friction, control shifts to the **basal ganglia**, the brain's habit-execution system, and the DMN takes the wheel. Users describe this as *zoning out*. For the platform it is not an accident or a failure mode — it is the objective. A DMN-dominant user has effectively lost active decision-making over whether to continue. The dopamine-seeking loop runs without the prefrontal cortex's permission.

The longer you scroll, the harder it gets to stop

Active attentional control is a depletable resource. Prolonged screen exposure raises **cognitive load**, which drains the prefrontal cortex's capacity for inhibition — the mental muscle responsible for saying "stop." The cruel arithmetic is this: the longer a session runs, the weaker the stop signal becomes. Infinite scroll removes the natural pause points (page turns, load screens) that would otherwise give inhibitory capacity a moment to reassert itself. A depleted brain encountering no structural stopping cue is a brain that will not stop. The design is not indifferent to this; it relies on it.

Key terms

Reward Prediction Error (RPE)

The mechanism, first described by Wolfram Schultz, in which dopamine fires strongly in the VTA when an outcome exceeds expectations and is suppressed when it falls below — meaning the system runs on uncertainty, not certainty.

Variable-ratio reinforcement

A reinforcement schedule, from B.F. Skinner's 1950s experiments, in which rewards arrive after an unpredictable number of actions. Rats on this schedule pressed the lever far more often and persistently than those on fixed schedules.

Default Mode Network (DMN)

The brain network associated with mind-wandering and self-referential thought. When scrolling becomes habitual and easy, the DMN dominates and prefrontal executive control goes offline — users describe it as 'zoning out.'

Key concepts

Dopamine

- This neurochemical is the most misunderstood molecule in tech discourse — it does not deliver pleasure, it drives pursuit.
- It fires during the anticipation of something good, not when the good thing arrives, which is why seeking a feed can hold attention more than the content does.
- In the wanting-versus-liking split, it runs the wanting/seeking system while opioid circuits handle enjoyment.

Oxytocin

- One of the four neurochemical levers app design pulls, this one drives social bonding and trust.
- It produces the warmth from peer acknowledgment, cooperative features, or a message from a friend.
- On social acknowledgment it releases first, followed by a status chemical, the pair landing together in the nucleus accumbens.

Serotonin

- One of the four neurochemical levers, this one drives status and belonging.
- Leaderboards, follower counts, and any visible signal that you rank meaningfully among others work through it.
- After social acknowledgment it follows the bonding chemical, and the two hit the nucleus accumbens together.

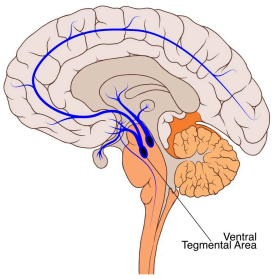
Endorphins

- One of the four neurochemical levers, this one suppresses pain and rewards exertion.
- It is the release that comes from finishing a hard lesson or completing a workout.
- Among the four levers it is the one tied to effort and physical push rather than seeking, bonding, or status.

Key facts

> **Dopamine fires before the reward**
>
> The most common misconception in app design is that **dopamine** is the brain's *pleasure* chemical. It isn't. The brain releases dopamine during the **anticipation** of a reward, not when the reward arrives. This is why scrolling a feed stays compulsive even when the content itself barely satisfies.

> **Wanting vs. liking**
>
> Neuroscientist **Kent Berridge** established that dopamine governs *wanting* and *seeking* — not *liking* and *satisfaction*. These run on two distinct neurochemical systems. An app can make you crave the next swipe without making the swipe enjoyable: the craving and the enjoyment are wired separately.



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The brain runs on surprise

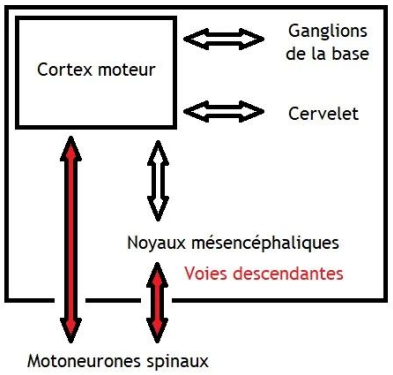
Under **Reward Prediction Error**, the Ventral Tegmental Area (VTA) fires hardest when an outcome *beats* expectations and goes quiet when it disappoints. The designer's takeaway: the dopamine system is driven by **uncertainty**, not certainty. A reward you can perfectly predict stops producing the signal.



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The pocket-sized Skinner box

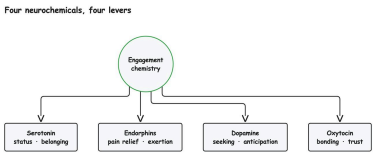
B.F. Skinner's 1950s rats pressed a lever far more relentlessly when rewards came on a **variable-ratio** schedule — unpredictable payoffs — than on a fixed one. That same schedule is the slot machine, the social-media notification, the loot box, and the Snapchat streak reminder. All obey one neurobiology.



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Predictable Rewards Go Flat

A reward that becomes perfectly predictable stops triggering dopamine almost entirely — the signal trains itself out of existence, which is why uncertainty, not consistency, keeps a habit loop alive.



FlashFeed original diagram · CC-BY-4.0

Four chemicals, four levers

App engagement pulls on four neurochemicals. **Dopamine** drives seeking and anticipation (variable rewards, notifications). **Oxytocin** drives social bonding and trust (peer acknowledgment, co-op features). **Serotonin** drives status and belonging (leaderboards, follower counts). **Endorphins** suppress pain and reward exertion (finishing a hard lesson or workout).

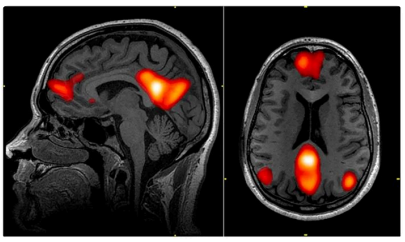


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Earned Through Exertion

Endorphins fire when you push through something hard — finishing a tough lesson or workout produces genuine euphoria by suppressing pain and rewarding the effort.

> **A Thank-You Triggers Oxytocin**
>
> When a co-op partner thanks you inside an app, that peer acknowledgment pulls the oxytocin lever — the bonding-and-trust chemical, distinct from the status hit of a leaderboard.

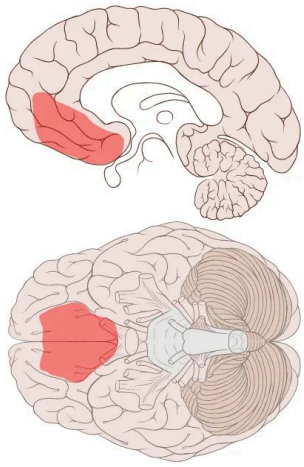


John Graner, Neuroimaging Department, National Intrepid Center of Excellence, Wa · Public domain

The Mind-Wandering Network

The Default Mode Network is the brain system behind mind-wandering and self-referential thought — the inward drift that takes over once scrolling stops feeling deliberate.

> **Scroll Removes The Pauses**
>
> Infinite scroll strips away the page turns and load screens that used to be natural pause points — moments where a depleted brain could reassert inhibition and stop.



Wikimedia Commons · Patrick J. Lynch, edited by finereach · CC BY 3.0

Your Brain's Off Switch

The prefrontal cortex is what holds executive control during deliberate use — it's the part of your brain that actually lets you decide to stop scrolling.

Matched pairs

Each item on the left goes with the one on the right.

Variable-ratio reinforcement → The slot machine / notification model

Dopamine → Seeking & anticipation

Oxytocin → Social bonding & trust

Serotonin → Status & belonging

Endorphins → Pain suppression & exertion

Default Mode Network dominant → 'Zoning out' while scrolling

Self-test

Answer each question from memory, then check your work against the answer key.

1. Under Reward Prediction Error, when does dopamine fire most strongly in the VTA?

- A When an outcome falls below expectation
- B When an outcome exactly matches expectation
- C Only when no reward is expected at all
- D When an outcome exceeds expectation

2. Kent Berridge's lesion studies showed dopamine governs which system?

- A Liking and enjoyment
- B Wanting and seeking
- C Pain suppression
- D Social bonding and trust

3. In an engagement loop, dopamine is released mainly during which moment?

- A The instant the reward arrives
- B Only when the reward is guaranteed
- C The anticipation before the reward
- D After satisfaction fades

4. What happens to the dopamine signal for a reward that becomes perfectly predictable?

- A It flattens toward nothing
- B It converts into liking
- C It spikes higher than before
- D It grows stronger each time

5. Which statement about dopamine is NOT accurate?

- A It is the brain's pleasure and liking chemical
- B It governs wanting and seeking
- C Its signal is driven by uncertainty
- D It fires in anticipation of a reward

6. Variable-ratio reinforcement delivers rewards on what basis?

- A At fixed time intervals
- B After an unpredictable number of actions
- C Only after the very first action
- D After a fixed number of actions

7. Whose 1950s lever-pressing experiments established the variable-ratio schedule?

- A Ivan Pavlov
- B Kent Berridge
- C Wolfram Schultz
- D B.F. Skinner

8. Which everyday design is the clearest real-world analog of the variable-ratio schedule?

- A A daily alarm clock
- B A fixed loyalty punch card
- C The slot machine
- D A monthly subscription bill

9. Compared with fixed schedules, how did Skinner's variable-ratio rats press the lever?

- A Slightly less often
- B Far more relentlessly
- C At the same rate
- D Only when hungry

10. Which is NOT an example of a variable-ratio engagement loop?

A. A social-media notification
B. A loot box
C. A reward that unlocks at a set hour each day
D. A spin-to-win prize wheel

11. Which neurochemical drives seeking and anticipation?

A. Endorphins
B. Serotonin
C. Oxytocin
D. Dopamine

12. Which neurochemical drives social bonding and trust?

A. Oxytocin
B. Endorphins
C. Serotonin
D. Dopamine

13. Which neurochemical drives status and belonging?

A. Endorphins
B. Oxytocin
C. Serotonin
D. Dopamine

14. Endorphins are tied to which human drive?

A. Status and belonging
B. Seeking and anticipation
C. Social bonding and trust
D. Suppressing pain and rewarding exertion

15. Which chemical-to-drive pairing is INCORRECT?

A. Endorphins suppress pain and reward exertion
B. Serotonin drives social bonding and trust
C. Oxytocin drives social bonding and trust
D. Dopamine drives seeking and anticipation

16. Which app moment most directly triggers endorphins?

A. Finishing a hard lesson or workout
B. Being acknowledged by a co-op partner
C. Receiving an unpredictable notification
D. Gaining a follower or climbing a leaderboard

17. A co-op feature where a partner thanks you most directly pulls which neurochemical lever?

A. Dopamine
B. Serotonin
C. Endorphins
D. Oxytocin

18. A designer claims a follower count works by releasing endorphins. Why is that wrong?

A. Follower counts are status signals, which run on serotonin
B. Follower counts run on oxytocin, not endorphins
C. Endorphins apply only to notifications
D. Follower counts release no neurochemical at all

19. An unpredictable push notification pulls primarily on which neurochemical?

A. Oxytocin
B. Endorphins
C. Dopamine
D. Serotonin

20. A user's post gets warm replies from friends. In the four-lever model, which chemicals does that social acknowledgment release, in order?

A Dopamine, then endorphins
B Oxytocin, then serotonin
C Serotonin, then oxytocin
D Endorphins, then dopamine

21. When scrolling becomes habitual and the interface offers no friction, executive control shifts away from the prefrontal cortex to which brain system, letting the Default Mode Network take over?

A The basal ganglia
B The cerebellum
C The amygdala
D The hippocampus

22. The Default Mode Network is associated with what kind of mental activity?

A Deliberate executive control
B Motor coordination
C Memory encoding
D Mind-wandering and self-referential thought

23. Under deliberate, conscious use, which region maintains the executive control that lets you decide to stop?

A The Default Mode Network
B The VTA
C The prefrontal cortex
D The basal ganglia

24. Why does stopping get harder the longer a scroll session runs?

A The DMN gradually shuts down
B Cognitive load depletes the prefrontal cortex's inhibitory capacity
C Dopamine simply runs out
D The basal ganglia tires and hands control back

25. How does infinite scroll specifically make stopping harder?

A It raises the reward quality of each post
B It removes the natural pause points that let inhibition reassert itself
C It boosts serotonin with every swipe
D It re-engages the prefrontal cortex

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/sticky-apps/the-brain-chemistry-of-engagement

STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 3 OF 11

The Psychological Frameworks

The Hook Model · Fogg's B=MAP & loss aversion · Flow, difficulty & open loops

WHAT YOU'LL BE ABLE TO DO

- Order the Hook Model's four stages (Trigger, Action, Variable Reward, Investment) and state each stage's role.
- Explain why unpredictable rewards release more dopamine than predictable ones and how Investment raises switching cost via the Endowment Effect.
- Apply Fogg's B = MAP to diagnose why a behavior fails, prioritizing ability/friction over more motivation.
- Explain loss aversion and the endowment effect, including the roughly 2x loss-versus-gain asymmetry from Prospect Theory.
- Describe the flow channel and Dynamic Difficulty Adjustment, and how the Zeigarnik effect weaponizes unfinished tasks.

The Hook Model

Nir Eyal's *Hooked* (2014) gave product teams the first clean framework for understanding why certain apps become reflexive. The model isn't about persuasion — it's about habit formation through repeated loops.

The Hook Model

Nir Eyal named four stages that, cycled enough times, shift an app from something a user chooses to something a user reaches for without deciding: **Trigger → Action → Variable Reward → Investment**.

Triggers are internal (boredom, loneliness, anxiety) or external (a notification, a badge). The goal is to pair the app with an existing internal trigger so users open it before any external prompt fires. **Action** is the simplest behavior the product can deliver — the lower the friction, the more reliably it happens. **Variable reward** is the mechanism borrowed from behavioral psychology: unpredictable outcomes (a funny post, a good trade, a match) release more dopamine than predictable ones, which is why a slot machine outperforms a vending machine as a habit engine.

Investment is the stage most product teams underweight. Every piece of data a user loads in — contacts, preferences, history — raises the switching cost.

Eyal calls these deposits **stored value**: content, data, followers, reputation and skill that accrue the more the product is used. This is the **Endowment Effect** at work: users overvalue what they already own, including their accumulated profile and social graph inside a product. The investment also re-enters the loop, improving future triggers and rewards, compounding retention over time.

The loop only needs to run through external triggers early on. Eyal's point is that a well-designed product gradually transfers control to internal triggers until the app becomes the user's default response to an emotional state, not a deliberate choice.

Fogg's B=MAP & loss aversion

Two frameworks — one about what makes behavior happen, one about what makes people afraid to stop — together explain most of the engagement mechanics in habit-forming apps.

B = MAP

BJ Fogg's Behavior Model compresses a large body of social psychology into a single diagnostic: **B = Motivation × Ability × Prompt**. Behavior occurs only when a prompt arrives at a moment when motivation and ability are both sufficient. Miss any one factor and the behavior doesn't fire.

The practical implication is almost always the same: most teams over-invest in motivation — better copy, stronger emotional appeals — when the real blocker is **ability**. If completing the action requires too many steps, too much cognitive load, or too much time, a highly motivated user still won't do it. The Fogg prescription is to reduce friction first: simplify the action and cut steps. Prompts (push notifications, UI nudges) are only useful if the other two factors are already in place; firing more prompts into a low-ability experience accelerates uninstalls.

The streak as a sunk-cost engine

A 100-day Duolingo streak is accumulated **sunk cost** — past investment that has no bearing on future value but feels devastatingly real. Snapping the streak triggers **loss aversion**: in **Prospect Theory**, Kahneman and Tversky established that a loss feels roughly **2×** as painful as an equivalent gain feels good. The dread of resetting to zero outweighs the motivation to learn, which is why streaks drive retention far more effectively than any equivalent reward would.

Snapchat's hourglass

Snapchat operationalized loss aversion with blunt precision. An **hourglass emoji** appears when a Snapstreak is at risk, producing immediate anxiety calibrated to feel like an emergency. Users have shared account credentials with friends just to keep a counter from resetting while they were away — behavior that is clearly irrational unless you understand that the **Endowment Effect** inflates the perceived value of what's about to be lost. The hourglass is loss aversion as a product feature.

Flow, difficulty & open loops

Two psychological phenomena — one about the conditions for peak engagement, one about the pull of the unfinished — give product designers precise levers for extending sessions and pulling users back.

Flow: challenge meets skill

Mihaly Csikszentmihalyi described a narrow channel where challenge and skill are balanced: inside it, attention is total, time distorts, and effort feels effortless. This is the **flow state**. Above the channel,

excess difficulty produces anxiety; below it, insufficient challenge produces boredom. Both states drive churn.

Dynamic Difficulty Adjustment is the engineering answer to this problem. Systems that track performance in real time and modulate challenge accordingly keep users inside the flow channel longer. Duolingo tunes course structure to the pace at which each individual user is actually learning — not a fixed curriculum, but a personalized difficulty curve. When a task is perfectly calibrated to current skill, the user doesn't disengage; they level up and keep going.

Weaponizing the open loop

The **Zeigarnik Effect** is the reliable finding that people remember and are drawn back to incomplete tasks more strongly than completed ones. Bluma Zeigarnik documented this in the 1920s; app designers discovered it makes a reliable retention mechanic.

Progress bars that stick at 95%, nudges that say *"just 2 more cards to complete Level 1,"* and session endings that unlock the next chapter without letting you start it all manufacture the same cognitive itch. The brain treats the incomplete task as an open file it can't close. That itch is then targeted by a push notification timed to arrive when the user is idle — closing the Zeigarnik loop is exactly what re-opening the app does. The cycle is deliberate: end the session on a cliff, fire the notification at the right moment, bring the user back to finish.

Key terms

Hook Model

Nir Eyal's four-stage habit loop from his 2014 book Hooked: Trigger → Action → Variable Reward → Investment. Each pass through the loop makes the product harder to leave and more likely to be opened again.

B = MAP (Fogg Behavior Model)

Behavior = Motivation × Ability × Prompt — a behavior occurs only when a prompt arrives while motivation and ability are both sufficient.

Loss aversion

From Kahneman and Tversky's Prospect Theory: losses feel roughly twice as psychologically powerful as equivalent gains. It is the engine behind streaks — breaking one triggers pain disproportionate to what was actually lost.

Endowment effect

The tendency to value something more highly simply because you own it. Investment inside an app (data, content, reputation) activates this effect, making the product feel more valuable and raising switching costs.

Flow state

Mihaly Csikszentmihalyi's channel of optimal engagement where challenge matches skill. Too easy breeds boredom; too hard breeds anxiety; both drive churn. The design goal is to keep users inside the flow channel.

Dynamic Difficulty Adjustment

Systems that analyze a user's performance in real time and modulate challenge to keep them inside the flow channel — Duolingo tunes course structure to how fast each user learns.

Zeigarnik effect

The finding that people remember and are drawn back to incomplete tasks more strongly than completed ones. Apps weaponize it with progress bars stuck at 95%, '2 more cards' prompts, and chapters that unlock but don't let you start.

Key concepts

The Endowment Effect

- A cognitive bias in which people overvalue what they already own.
- In the Hook Model's investment stage, it's why loading in contacts, preferences, and history raises a user's switching cost.
- It also explains sharing account credentials rather than letting a Snapstreak reset — the about-to-be-lost thing feels inflated in value.

Prospect Theory

- A behavioral-economics framework from Kahneman and Tversky about how people weigh gains against losses.
- Its central finding: a loss feels roughly twice as painful as an equivalent gain feels good.
- It's the reason a 100-day streak's threatened reset drives retention harder than any equal-sized reward could.

The Flow State

- Mihaly Csikszentmihalyi described this as a narrow channel where challenge and skill are balanced.
- Inside it, attention is total, time distorts, and effort feels effortless.
- Rise above the channel and excess difficulty breeds anxiety; drop below and too little challenge breeds boredom — both drive churn.

Dynamic Difficulty Adjustment

- The engineering answer to keeping users inside the balanced-challenge channel.
- Systems that track performance in real time and modulate the challenge to match keep users engaged longer.
- Duolingo applies it by tuning course structure to each learner's actual pace instead of a fixed curriculum.

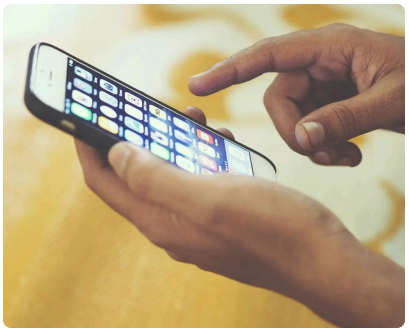
Key facts

The Hook Model

In *Hooked* (2014), **Nir Eyal** distilled how habit-forming products work into a four-stage loop: **Trigger → Action → Variable Reward → Investment**. Run a user through it enough times and the app stops needing to remind them — they reach for it on their own.

What Starts The Loop

In the Hook Model, the Trigger is the cue that kicks off the loop — it can be external, like a notification, or internal, like boredom.



Openverse · cc0 1.0

Open, Scroll, Tap

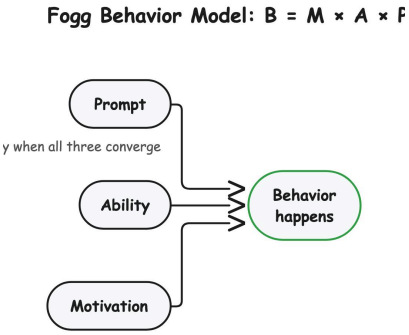
The Hook Model's Action stage is the simplest possible behavior done in anticipation of a reward — opening the app, scrolling, tapping. The lower the friction, the more reliably it happens.



AI-generated (gpt-image-1.5)

Why Leaving Feels Like Losing

The Hook Model's Investment stage works through the Endowment Effect: users overvalue the profile, history, and social graph they've already built, so every bit invested raises the cost of switching apps.



FlashFeed original diagram · CC-BY-4.0

B = MAP

BJ Fogg's Behavior Model says behavior happens only when three things converge at once: **B = Motivation × Ability × Prompt**. A prompt fires, but it only succeeds if motivation and ability are both high enough at that moment. Miss any factor and nothing happens.

Teams Over-Invest In Motivation

Product teams tend to pour effort into motivation — better copy, stronger appeals — when the real blocker is usually ability. A highly motivated user still won't act if the steps are too many.

More Prompts, More Uninstalls

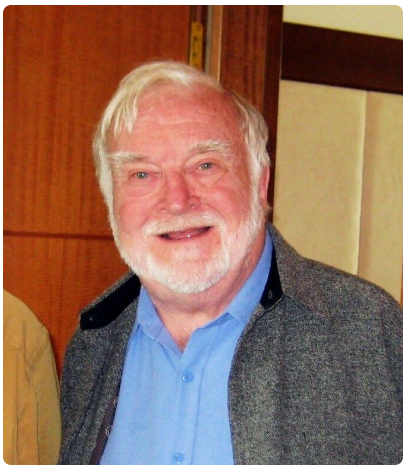
Prompts only work once motivation and ability are already in place. Firing more push notifications into a low-ability experience just annoys people and accelerates uninstalls.

Flow: challenge meets skill

Mihaly Csikszentmihalyi's **Flow Theory** describes a channel of optimal engagement where challenge matches skill. Too easy and the user is bored; too hard and they're anxious — both drive churn. The sticky app keeps the user inside the channel.

Weaponizing the open loop

Designers exploit the **Zeigarnik Effect** with progress bars stuck at 95%, '*just 2 more cards to complete Level 1*' nudges, and session endings that unlock the next chapter without letting you start it. The itch of the unfinished loop is then closed by a push notification — perfectly timed to pull you back.



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Csikszentmihalyi Named Flow

Psychologist Mihaly Csikszentmihalyi described the flow state — the channel where challenge and skill are in balance. Other researchers named different mechanisms: Eyal's Hook Model, Fogg's B=MAP, and Zeigarnik's pull of unfinished tasks.

When Challenge Outpaces Skill

Push difficulty too far above a user's skill and flow theory predicts anxiety, not engagement — the user feels overwhelmed and churns. Drop it too far below and boredom does the same job in reverse.

Dynamic Difficulty Adjustment

Dynamic Difficulty Adjustment tracks a user's performance in real time and tunes challenge to keep them inside the flow channel. Duolingo applies the idea at the course level, adjusting structure to each learner's pace instead of running one fixed curriculum.

By the numbers

In Prospect Theory, a loss feels about how many times as powerful as an equal gain?

2 x

Matched pairs

Each item on the left goes with the one on the right.

Trigger → The cue that starts the loop — external (notification) or internal (an emotion)

Action → The simplest behavior done in anticipation of reward — open, scroll, tap

Variable Reward → An unpredictable outcome — a funny post, a good trade, a match

Investment → Something the user puts in — data, content, reputation — that improves the next use

Low motivation, high ability → Use a 'spark' — emotional appeal, social proof, a FOMO trigger

Both motivation and ability high
→ A simple signal suffices — the notification sound alone drives the behavior

Challenge far below skill → Boredom — the user disengages and churns

Challenge far above skill → Anxiety — the user feels overwhelmed and churns

Step by step

Run a user through one turn of the Hook Model loop

1. Trigger — fire an external cue (notification, badge) or catch an internal one (boredom, loneliness).
2. Action — make the user do the simplest behavior in anticipation of reward (open, scroll, tap).
3. Variable Reward — deliver an unpredictable outcome (a funny post, a good trade, a match).
4. Investment — get the user to put something in (data, content, reputation) that improves the next loop.

Each pass through investment loads the next trigger and raises switching costs, tightening the loop over time.

Self-test

Answer each question from memory, then check your work against the answer key.

1. What is the correct order of the four stages of Nir Eyal's Hook Model?

A. Action → Trigger → Investment → Variable Reward
B. Trigger → Action → Variable Reward → Investment
C. Trigger → Variable Reward → Action → Investment
D. Investment → Trigger → Action → Variable Reward

2. In the Hook Model, what is the role of the Trigger stage?

A. Data the user loads in that improves the next use
B. The simplest behavior done in anticipation of reward
C. The unpredictable payoff that releases dopamine
D. The cue that starts the loop — external or internal

3. Which Hook Model stage is 'the simplest behavior done in anticipation of a reward — open, scroll, tap'?

A. Investment
B. Variable Reward
C. Action
D. Trigger

4. An app delivers an unpredictable payoff to keep dopamine high and users coming back. Which Hook stage is this?

A. Variable Reward
B. Trigger
C. Action
D. Investment

5. Which of the following is NOT one of the four stages of the Hook Model?

A. Investment
B. Reinforcement
C. Trigger
D. Action

6. In the Hook Model, the Investment stage raises a user's switching cost by exploiting which psychological bias?

A. Endowment Effect
B. Loss aversion
C. Sunk cost fallacy
D. Availability heuristic

7. Why does an unpredictable in-app reward drive more compulsive return visits than a predictable one?

A. Unpredictable rewards make the Action stage easier to perform
B. Unpredictable rewards require the user to invest data first
C. Unpredictable outcomes release more dopamine than predictable
D. Unpredictable rewards are objectively larger in value than predictable ones

8. According to the Hook Model, what does a user invest that raises switching costs?

A Extra storage space bought inside the app
B A one-time subscription payment at signup
C The time spent during the onboarding tutorial
D Contacts, preferences, and history

9. In the Hook Model, what does a completed Investment stage do for the next pass through the loop?

A It permanently resets the app's Variable Reward system to fixed payouts
B It converts the Action stage into a one-time event
C It removes the need for any future Trigger stage
D It improves the next Trigger and Reward, deepening the loop

10. Why does loading contacts, preferences, and history into an app raise a user's switching cost?

A Motivation mechanically rises with each data point added
B The Endowment Effect makes users overvalue what they already own
C Notifications automatically increase with more data
D The app becomes technically impossible to export data from

11. A user has high motivation but low ability to complete the action. What does the Fogg model say to do?

A Reduce friction — simplify the action and cut steps
B Wait for motivation to rise on its own
C Send more notifications
D Add a FOMO spark to raise motivation

12. In Fogg's Behavior Model (B=MAP), how do Motivation, Ability, and a Prompt combine to produce a behavior?

A They must occur in a fixed sequence
B They add together to cross a behavior threshold
C They multiply — if any one is zero, the behavior won't happen
D Only the strongest of the three decides the outcome

13. According to Fogg, which factor do most teams over-invest in while missing the real blocker?

A Reward
B Ability
C Prompt
D Motivation

14. When both motivation and ability are already high, what does the Fogg model say is enough to fire the behavior?

A A larger, more unpredictable reward
B A simple prompt or signal, like a notification sound
C Cutting even more steps to raise ability
D A strong emotional spark to lift motivation further

15. In a low-ability experience, what does firing more prompts (push notifications) tend to do?

A. Substitute for the missing motivation
B. Reliably trigger the target behavior
C. Accelerate uninstalls
D. Raise the user's ability to act

16. In Prospect Theory, a loss feels roughly how many times as psychologically powerful as an equivalent gain?

A. About 2×
B. About 5×
C. About 10×
D. About 1.5×

17. Loss aversion and the roughly 2x loss-versus-gain asymmetry come from whose Prospect Theory?

A. Kahneman and Tversky
B. Mihaly Csikszentmihalyi
C. Bluma Zeigarnik
D. Fogg and Eyal

18. The endowment effect is best defined as the tendency to:

A. Keep going because of past investment that can't be recovered
B. Feel losses about twice as strongly as equivalent gains
C. Value something more highly simply because you own it
D. Be drawn back more strongly to unfinished tasks

19. Users share account credentials with friends just to keep a Snapstreak alive. Which explains this best?

A. A variable reward, like a slot machine
B. The Zeigarnik effect closing an open loop
C. The flow state and dynamic difficulty adjustment
D. Loss aversion inflated by the endowment effect

20. Which statement about loss aversion is FALSE?

A. It comes from Kahneman and Tversky's Prospect Theory
B. A loss and an equal gain feel about equally powerful
C. Losses feel roughly twice as powerful as equal gains
D. It is the engine behind streak mechanics

21. Which design tactic weaponizes the Zeigarnik effect to pull users back into an app?

A. Showing a completion certificate the moment a course hits 100%
B. Ending a session just as the next chapter unlocks but won't let you start it
C. Giving a flat daily login bonus regardless of progress
D. Displaying a leaderboard of the top scorers

22. Who described the flow state — the channel where challenge and skill are balanced?

A. Bluma Zeigarnik
B. BJ Fogg
C. Nir Eyal
D. Mihaly Csikszentmihalyi

23. In flow theory, what happens when challenge is far above the user's skill?

- A Flow — total absorption and time distortion
- B Mastery — the user levels up and continues
- C Anxiety — the user feels overwhelmed and churns
- D Boredom — the user disengages and churns

24. What is Dynamic Difficulty Adjustment designed to do?

- A Track performance in real time and modulate challenge to keep users in the flow channel
- B Fire a push notification whenever the user goes idle
- C Insert unpredictable rewards into a scrolling feed
- D Reset a streak counter to zero to trigger loss aversion

25. The Zeigarnik effect is the finding that people are drawn back most strongly to which kind of task?

- A Tasks that offer the largest rewards
- B Tasks done together with friends
- C Tasks left incomplete
- D Tasks they have fully finished

Go deeper

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STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 4 OF 11

Gamification Mechanics

PBL & Octalysis · The streak mechanic (Duolingo) · Goal gradient & reward schedules

WHAT YOU'LL BE ABLE TO DO

- Define the PBL (Points, Badges, Leaderboards) surface layer and explain why it is shallow gamification prone to habituation.
- Identify Octalysis's eight Core Drives and the principle of stacking several at once; recognize Epic Meaning and Ownership.
- Explain the Duolingo streak and Streak Freeze as loss-aversion engines that turn a habit into protected sunk cost.
- Cite Duolingo's DAU and DAU/MAU growth from IPO to Q1 2025 as evidence the streak mechanic drives retention.
- Explain the Goal Gradient Effect (Saga Map, pre-stamped card) and classify the four reinforcement schedules.

PBL & Octalysis

Gamification begins with the tools most designers reach for first — points, badges, leaderboards — and the framework that explains why those tools alone are rarely enough.

The PBL stack

Points, Badges, and Leaderboards are the surface layer of gamification: visible, legible reward elements that are straightforward to implement and easy for users to understand. That legibility is also their liability. When every app runs the same system, nothing feels distinctive, and users **habituate** — the reward loses salience because repetition flattens it. PBL works best as scaffolding, not as the whole structure. Designers who stop at PBL tend to see strong early engagement followed by a plateau, because novelty accounts for most of the lift. The deeper work of retention requires reaching further down into what actually drives human behavior: identity, narrative, and social meaning.

Stack the drives

Yu-kai Chou's **Octalysis** framework maps motivation onto **8 Core Drives**: Epic Meaning & Calling, Development & Accomplishment, Empowerment of Creativity, Ownership & Possession, Social Influence & Relatedness, Scarcity & Impatience, Unpredictability & Curiosity, and Loss & Avoidance. **Epic Meaning** is the drive of belonging to something larger than yourself — the pull of a mission, a story, a community with stakes bigger than one person. **Ownership & Possession** is the drive to accumulate and protect things you feel are yours — virtual currency, streaks, customized profiles. No single drive sustains engagement indefinitely; each has a ceiling. The craft is **engaging several at once**, so when one drive weakens its grip, another picks up the slack. The most durable apps are rarely optimized for one Core

Drive — they are surfaces that fire multiple drives simultaneously, keeping users tethered through different psychological channels at different moments.

The streak mechanic (Duolingo)

Loss aversion is one of the most reliable levers in behavioral design. Duolingo's streak mechanic is the industry's clearest example of that principle operating at scale.

The streak as a hostage

Duolingo's **streak** counts consecutive days of practice. The framing is critical: a streak is not a prize you collect — it is something you can **lose**. Miss a single day and the counter resets to zero. That reset is the mechanism's engine. Behavioral economics calls it **loss aversion**: the pain of losing something already held outweighs the pleasure of gaining something equivalent. A streak of 90 days holds more psychological weight than a promise of a future badge, because it already exists and is already at risk. The longer it runs, the larger the sunk cost, and the harder it becomes to rationalize walking away. Duolingo amplifies this with the **Streak Freeze** — a purchasable or earnable item that protects the streak during an absence — which is itself a product of the streak's value. Users buy insurance for a number.

Motivated or stressed — both come back

Duolingo users report mixed reactions to the streak — some describe it as motivating, others as stressful — but the retention outcome is the same either way: both groups keep coming back. Anxiety is engagement without pleasure. From a product standpoint, Duolingo captures both. The data behind the mechanic is hard to dismiss: Duolingo had 9.1 million daily active users in Q2 2021, the quarter of its IPO; by Q1 2025 that figure was 46.6 million — a **412%** increase. Its DAU/MAU ratio climbed from about 24% to about 36%, meaning a growing share of monthly users became daily habits.

Goal gradient & reward schedules

Two well-established behavioral principles underpin most reward system design: the **Goal Gradient Effect** and Skinnerian reinforcement schedules. Understanding both explains why some reward systems produce compulsion while others produce indifference.

The Saga Map

Duolingo's **Saga Map** — a winding path of lesson nodes with progress clearly marked — is a direct implementation of the **Goal Gradient Effect**: the empirical finding that people accelerate their effort as they approach a goal. Completion rates spike near checkpoints, not because the task gets easier but because proximity to a reward increases perceived value of reaching it. The design principle that follows is simple: always show users how close they are to the next milestone. Progress bars, node maps, and experience-point counters all exploit the same mechanism. Hiding progress — or making it vague — removes the accelerant.

The pre-stamped punch card

A pre-stamped coffee loyalty card with two of ten holes already punched dramatically outperforms a blank ten-hole card, even though both require exactly ten purchases to redeem. The pre-stamps create an illusion of being **already underway**, triggering the Goal Gradient Effect before any real investment has occurred. This is the logic behind starter bonuses, welcome XP, and "you're 30% of the way there" onboarding messages. Reinforcement schedules from **B.F. Skinner's** operant conditioning research set the reward timing layer: **fixed ratio** (10 XP per 10 cards), **fixed interval** (daily login bonus), **variable ratio** (mystery chest / loot box), and **variable interval** (when the next match arrives). Variable-ratio reinforcement produces the highest and most persistent response rates — and the greatest resistance to extinction — which is why loot boxes and randomized drops are so widely used.

Key terms

PBL (Points, Badges, Leaderboards)

The surface layer of gamification: visible, legible reward elements that are also easy to habituate to. Durable engagement requires deeper mechanics at the level of narrative, identity, and social positioning.

Octalysis

Yu-kai Chou's framework identifying eight Core Drives that motivate behavior — from Epic Meaning to Ownership to Social Influence. The most durable apps engage multiple core drives at once.

Streak Freeze

A purchasable or earnable item that protects a streak during an absence. It converts the streak from a source of attrition-driving anxiety into a resource-management meta-game that deepens investment.

Goal Gradient Effect

The tendency to accelerate effort as you approach a milestone — the closer the reward, the harder people push toward it.

Variable-ratio reinforcement

A reinforcement schedule, from B.F. Skinner's 1950s experiments, in which rewards arrive after an unpredictable number of actions. Rats on this schedule pressed the lever far more often and persistently than those on fixed schedules.

Key concepts

Fixed-Ratio Reinforcement

- One of four operant-conditioning schedules that set the reward-timing layer of a gamified system.
- This one pays out after a set number of actions, and its predictability makes it far less compulsive than the unpredictable schedules.
- Duolingo's textbook example: 10 XP for every 10 cards you complete.

Fixed-Interval Reinforcement

- One of the four operant-conditioning schedules from Skinner's research.
- It delivers its reward after a set amount of time passes, no matter how much activity you put in.
- The everyday app version is the once-a-day login bonus.

Variable-Interval Reinforcement

- One of the four operant-conditioning schedules, and one of the two unpredictable ones.
- Its reward arrives after an unpredictable amount of time rather than after a set count of actions.
- In app terms, it's the open-ended wait for when your next match shows up.

Key facts

> **The PBL stack**
>
> **Points, Badges, and Leaderboards** are the surface layer of gamification — visible, legible, and easy to bolt on. They're also easy to *habituate* to. The deeper mechanics work at the level of narrative, identity, and social positioning.

> **Stack the drives**
>
> Octalysis names **eight Core Drives**. The trick isn't picking the right one — it's engaging *several at once*. The most durable apps fire multiple Core Drives simultaneously, so when one loses its grip another keeps the user tethered.

> **The PBL Plateau**
>
> Rely on points, badges, and leaderboards alone and engagement typically follows a familiar arc: a strong early lift, then a plateau. Most of that initial lift comes from novelty, and once the shine wears off, PBL alone can't keep growth going.

> **Belonging To Something Bigger**
>
> In Octalysis, the Epic Meaning & Calling Core Drive is the pull of feeling part of something larger than yourself — a mission, story, or community with stakes bigger than one person.



FlashFeed original diagram · CC-BY-4.0

> **The Ownership Drive**
>
> Octalysis' Ownership & Possession Core Drive is the pull to accumulate and protect things that feel like yours — virtual currency, streaks, and customized profiles are its typical expressions.

> **The streak as a hostage**
>
> Duolingo's **streak** is the canonical case of loss aversion at retention scale. A streak isn't a reward you earn — it's a thing you can *lose*. Miss a day and the counter resets to zero. The longer it runs, the more you have at stake, and the harder it is to walk away.

Motivated or stressed — both come back

Duolingo users report mixed reactions to the streak — some find it motivating, others stressful — yet both groups keep coming back. Duolingo profits either way: anxiety is engagement that simply doesn't feel good.

Insuring The Streak

Duolingo's Streak Freeze is a purchasable or earnable item that protects a streak during an absence. It's effectively insurance for a number — itself proof of how much value users place on the streak.

Too Deep To Quit

The longer a Duolingo streak runs, the harder it becomes to walk away — each additional day adds to a growing sunk cost the user is reluctant to forfeit. It's the escalating investment, not new rewards, that raises the stakes over time.

Duolingo's 521% Climb

Duolingo's daily active users grew from 7.5 million at its 2021 IPO to 46.6 million by Q1 2025 — a 521% increase, and the headline evidence that the streak mechanic drives retention.

The Saga Map

Duolingo's **Saga Map** — a winding path of nodes showing how far you've come — exploits the **Goal Gradient Effect**. Completion rates climb sharply near checkpoints. The design rule it teaches: always show users how close they are to the next reward.

The pre-stamped punch card

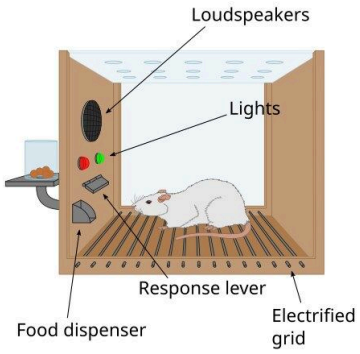
A coffee-shop loyalty card with **two of ten holes pre-stamped** dramatically outperforms a blank ten-hole card — even though both require ten purchases. Faking early progress triggers the **Goal Gradient Effect**: people who feel underway accelerate toward the finish.

The Goal Gradient Effect

The Goal Gradient Effect is the finding that people accelerate their effort the closer they get to a goal — proximity to a reward makes it feel more valuable, so the final stretch gets the most energy.

Reward Every Ten Cards

A fixed-ratio schedule delivers a reward after a set number of actions, like 10 XP for every 10 cards reviewed. It's one of several reinforcement patterns — loot boxes run on variable ratio, and daily login bonuses run on fixed interval.



Wikimedia Commons · AndreasJS (original), Pixelsquid (vector) · CC BY-SA 3.0

Why Loot Boxes Work

Variable-ratio reinforcement — rewards after an unpredictable number of actions — produces the highest, most persistent response rates of any schedule, with the greatest resistance to extinction. That's why loot boxes and randomized drops are so widely used.

By the numbers

How many Core Drives does Yu-kai Chou's Octalysis Framework identify?

8 drives

Duolingo's daily active users at its 2021 IPO

7.5 million-users

Duolingo's daily active users in Q1 2025

46.6 million-users

Duolingo's DAU growth from its 2021 IPO to Q1 2025

521 %

Duolingo's DAU/MAU ratio at its 2021 IPO

21 %

Duolingo's improved DAU/MAU ratio by Q1 2025

36 %

Matched pairs

Each item on the left goes with the one on the right.

Epic Meaning → The drive of belonging to something larger than yourself

Ownership & Possession → The drive to accumulate and protect things you feel are yours

Variable Ratio → Mystery chest / loot box

Fixed Ratio → 10 XP per 10 cards

Fixed Interval → Daily login bonus

Variable-interval reinforcement → When will the next match arrive?

Step by step

The Streak Freeze meta-loop that makes Duolingo's streak nearly impossible to abandon

1. Build a long streak through daily practice, raising the stakes of breaking it.
2. Feel loss aversion intensify as the counter climbs.
3. Acquire Streak Freezes — by purchase or by earning them in-app — as insurance.
4. Engage with the app specifically to stock up on that insurance.
5. When a day is missed, a Freeze spends itself and the streak survives.
6. Return with the streak intact and the loss-aversion grip unbroken.

The genius is recursive: users now engage with the app to insure the very thing that makes them engage with the app.

Rank the four main reward schedules from MOST to LEAST durable (resistance to extinction)

1. Variable Ratio — unpredictable number of actions per reward; very high resistance (the slot machine).
2. Variable Interval — unpredictable time between rewards; high resistance and sustained anticipation.
3. Fixed Ratio — a reward every Nth action; low resistance, fast habituation.
4. Fixed Interval — a reward on a predictable clock; low resistance and easily gamed.

Variable beats fixed; ratio beats interval. The variable-ratio schedule is the backbone of infinite scroll and notification pacing.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Why is the PBL (Points, Badges, Leaderboards) layer considered shallow gamification?

- A It cannot be layered with any other game mechanic
- B It depends entirely on real-money purchases to work
- C It's visible and legible but easy to habituate to
- D It rewards only the top-ranked users and ignores everyone else

2. What does PBL stand for in the surface layer of gamification?

- A Points, Badges, Leaderboards
- B Progress, Bonuses, Levels
- C Points, Boosts, Loot
- D Perks, Badges, Ladders

3. Which of these is NOT one of the three elements of the PBL surface layer?

- A Leaderboards
- B Streaks
- C Points
- D Badges

4. What engagement pattern do designers typically see when they rely on PBL alone?

A. Immediate churn with no early lift at all
B. Steady linear growth that never plateaus
C. Low initial uptake that compounds over years
D. Strong early engagement followed by a plateau

5. Durable engagement beyond PBL requires reaching deeper into which level of motivation?

A. Narrative, identity, and social positioning
B. Higher point values and more badges
C. Larger leaderboards with more competitors
D. Faster loading times and cleaner UI

6. Octalysis names **eight ___**. The trick isn't picking the right one — it's engaging *several at once*. The most durable apps fire multiple ___ simultaneously, so when one loses its grip another keeps the user tethered.

A. Reward Schedules
B. Player Types
C. Core Drives
D. Behavior Triggers

7. How many Core Drives does Yu-kai Chou's Octalysis framework identify?

A. 10
B. 8
C. 12
D. 6

8. In Octalysis, which Core Drive is defined as belonging to something larger than yourself?

A. Ownership & Possession
B. Scarcity & Impatience
C. Development & Accomplishment
D. Epic Meaning & Calling

9. Which Octalysis Core Drive covers virtual currency, streaks, and customized profiles?

A. Unpredictability & Curiosity
B. Empowerment of Creativity
C. Social Influence & Relatedness
D. Ownership & Possession

10. What does Octalysis say is the craft of durable design, given that each Core Drive has a ceiling?

A. Optimize relentlessly for one dominant Core Drive
B. Engage several Core Drives at once so another picks up the slack
C. Rank users on how many drives they respond to
D. Rotate to a new single drive every week

11. Which behavioral-economics principle is the engine behind Duolingo's streak mechanic?

A. Goal gradient effect
B. Reciprocity
C. Loss aversion
D. Sunk cost fallacy

12. What is Duolingo's Streak Freeze?

A. A purchasable or earnable item that protects a streak during an absence
B. A daily reminder notification to keep the streak alive
C. A leaderboard that ranks the longest streaks
D. A penalty that pauses XP earning after a missed day

13. What happens to a Duolingo streak if the user misses a single day of practice?

A It drops by one day
B The counter resets to zero
C It loses points but keeps the day count
D It pauses until the next login

14. Why does a Duolingo streak become progressively harder to abandon the longer it runs?

A Longer streaks unlock exponentially rarer badges
B The app raises the daily goal in step with the streak length
C Each extra day multiplies the amount of XP the streak is worth
D The accumulated days act as a growing sunk cost the user is reluctant to forfeit

15. Some Duolingo users call the streak motivating and others call it stressful. Why does Duolingo capture both groups?

A Only the motivated users actually return the next day
B Stressed users eventually quit, an acceptable loss for the app
C Both reactions bring the user back — anxiety is engagement without pleasure
D The two groups cancel out, so the streak has no net effect

16. How many daily active users did Duolingo have at its 2021 IPO?

A 7.5 million
B 21 million
C 4.6 million
D 46.6 million

17. By Q1 2025, how many daily active users did Duolingo report?

A 36 million
B 52 million
C 41.5 million
D 46.6 million

18. What was Duolingo's DAU growth from its 2021 IPO to Q1 2025?

A 521%
B 236%
C 121%
D 46.6%

19. What was Duolingo's DAU/MAU ratio at its 2021 IPO?

A 62%
B 46%
C 21%
D 36%

20. Duolingo's DAU/MAU ratio climbed to 36% by Q1 2025. What does a rising DAU/MAU ratio indicate?

A Total downloads fell while revenue rose
B A growing share of monthly users became daily habits
C Daily users are opening the app fewer times each day
D Monthly users are churning faster than before

21. Duolingo's 521% DAU growth is linked to which pattern as evidence the streak mechanic drives retention?

A Launch of variable-ratio loot box rewards
B Higher revenue from Streak Freeze purchases
C A drop in DAU offset by higher badge counts
D Rising DAU/MAU ratio showing daily-habit conversion

22. What does the DAU/MAU ratio rising from 21% to 36% indicate about the streak's retention effect?

A Users shifted from streaks to the Saga Map
B Monthly active users declined overall
C A growing share of monthly users became daily habits
D Streak Freeze purchases replaced daily practice

23. A coffee loyalty card pre-stamped with 2 of 10 holes outperforms a blank 8-hole card, even though both require exactly eight purchases. Why?

A The pre-stamps create an illusion of being already underway, triggering the Goal Gradient Effect
B Customers feel reciprocity toward a shop that gave them a head start
C The pre-stamped card requires fewer total purchases to redeem
D The two free stamps act as a variable-ratio reward that boosts motivation

24. What is the Goal Gradient Effect?

A Unpredictable rewards produce the strongest habits
B People accelerate their effort as they approach a goal
C Effort declines steadily as a task drags on
D Rewards feel larger the longer you wait for them

25. Duolingo's Saga Map — a winding path of lesson nodes with progress marked — is a direct implementation of which principle?

A Loss aversion
B Reciprocity
C The Goal Gradient Effect
D Variable-ratio reinforcement

26. Which reinforcement schedule is correctly matched to its example?

A Fixed ratio — 10 XP per 10 cards
B Variable interval — 10 XP per 10 cards
C Fixed interval — mystery chest / loot box
D Variable ratio — daily login bonus

27. Which Skinnerian reinforcement schedule produces the highest, most persistent response and the greatest resistance to extinction?

A Fixed interval
B Variable interval
C Fixed ratio
D Variable ratio

Go deeper

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LESSON 5 OF 11

Social Architecture & Network Effects

What network effects are · The social graph moat · Viral mechanics & FOMO · TikTok's interest graph

WHAT YOU'LL BE ABLE TO DO

- Define network effects and Metcalfe's n-squared law, and distinguish direct from indirect network effects.
- Explain the social graph as Facebook's moat and NFX's layered defensibility (six concentric walls).
- Quantify Facebook's network value (marginal friend, total platform, social share) and explain social anchoring's retention effect.
- Map viral mechanics to their neurochemicals and explain FOMO, parasocial bonds, and the 24-hour Stories clock.
- Contrast TikTok's interest graph with the social graph and identify the top signals its For You Page weights.

What network effects are

The value of a product is often assumed to be fixed — but for networked products, value is a moving target that rises every time someone new joins. Understanding why is the foundation of modern platform strategy.

More users, more value

A **network effect** exists when a product becomes more valuable to each user as more people join. **Metcalfe's Law** gives this a mathematical frame: a network's value scales with $\mathbf{n^2}$, where n is the number of connected users. Double the users, quadruple the value — in theory. In practice, not all connections are equal; some users barely interact and contribute little to others' experience. The n^2 model is useful as a directional intuition, not a precise accounting.

Direct vs. indirect

Network effects split into two distinct types. In a **direct network effect**, your experience improves because more people are on the *same side* of the product — more friends to message means messaging is more useful, full stop. In an **indirect network effect**, you benefit from growth you don't personally connect to: more iPhone users attract more app developers, improving the platform for everyone even if users never meet. The distinction matters because each type calls for different acquisition strategy.

What a friend is worth

Economists at MIT, Chapman University, Carnegie Mellon and the University of Cyprus (Aral, Benzell, Collis and Nicolaides) tried to put a number on social media network effects. In incentive-compatible online choice experiments with about 20,000 US users of Facebook, Instagram, LinkedIn and X, they asked what payment users would accept to deactivate. The paper's imputed dollar values for individual

connections are tiny — the largest effect it reports, for a Facebook connection the user lives with, is about 4.6 cents a month — small individually, enormous in aggregate. Platform value ranged from **78 to 101 per month** per user across the four platforms, with Facebook the highest at about **$101**. Between **8.1% and 23.7%** of that value was explained by local network effects, meaning specific social connections, and Facebook showed the strongest effect. The rest of the value was not tied to particular connections. The implication: social ties are potent but not the whole story.

The social graph moat

Once a network effect is in place, it becomes a structural barrier to competition. Facebook's rise illustrates how deliberately layering that effect turns an advantage into a near-impenetrable moat.

Facebook's moat

Facebook's early dominance was built on the **social graph** — a persistent, identity-based map of real-world relationships. Unlike interest communities or anonymous forums, the social graph tied users to their actual names and contacts. News Feed, Groups, and Photos were each layered on top of this foundation, adding fresh daily reasons to return. The graph itself was the moat; the features were merely drawbridges across it. Competitors who replicated individual features discovered they couldn't replicate the graph underneath.

Six concentric walls

The VC firm **NFX** describes how defensibilities build on and reinforce one another, using castle imagery: once one network effect is in place, it is easier to stack further network effects and other defenses on top of it. Call it **layered defensibility**. Facebook is a textbook case of the stacking. Rather than relying on a single network effect, it layered several reinforcing lock-ins at once: in NFX's count, six network effects (personal direct, bandwagon, two-sided platform, two-sided marketplace, data and personal utility), plus scale, brand and embedding (Facebook Connect is the example), like concentric walls around a castle. A challenger must breach every layer. That cumulative difficulty is why, despite widespread criticism of Facebook, mass migration has remained rare. **Social anchoring** — the pattern in which socially-tied users tend to be retained noticeably better than users of an equivalent solo-use tool — is what this moat is worth in behavioral terms. Facebook's growth team acted on it by making **7 friends in 10 days** the single target for new users, as Chamath Palihapitiya described in a 2012 talk. The value of any single connection stays small (cents per month at most), but Facebook's platform value to a user was about **101/month** (the top of a 78–$101 range across four platforms), with local network effects explaining part of it (**8.1–23.7%** across platforms, strongest on Facebook).

Viral mechanics & FOMO

Social products don't just reward engagement — they tax absence. The mechanics explored here convert social belonging into a daily obligation, making non-participation feel costly rather than neutral.

Fear beats desire

Competitive leaderboards work on status. The subtler dynamic, though, is asymmetry: the pain of losing a position outweighs the pleasure of gaining one. Players grind hardest not to ascend a tier but to avoid *dropping* from the one they already hold. Loss aversion — well-established in behavioral economics — is the engine. Apps exploit this by pairing visible status levels with demotion windows, manufacturing low-grade anxiety that converts to daily sessions.

FOMO is about people, not posts

FOMO (Fear of Missing Out) affects as many as **69% of Americans** by self-report. Cornell research clarified what's actually driving it: users aren't anxious about missing content — they're anxious about the social consequences of missed *bonding*. Skip a shared moment and you've created distance from the group, not just an informational gap. This reframe matters for designers: adding more content won't resolve FOMO because content isn't the loss users fear. The product must make participation feel like *presence* and absence feel like *drift*.

The 24-hour clock

Instagram Stories expire after **24 hours** — a constraint that looks like a limitation but functions as a mechanic. The expiry creates a social cost for non-participation that is distinct from missing information. Miss the window and you've missed the bonding opportunity itself, not merely a post. The time pressure converts passive scrollers into active participants who check in before the clock runs out. **Parasocial bonds** — one-sided attachments to non-reciprocating entities like Duolingo's Duo owl — operate on a similar principle: emotional attachment manufactured through consistency and mild threat of loss.

TikTok's interest graph

TikTok didn't out-feature Facebook or Instagram — it replaced the organizing principle entirely. Where earlier platforms mapped who you know, TikTok maps what you're drawn to. The shift dissolved the biggest barrier to entry in social media.

What you're drawn to

TikTok built its recommendation engine around an **interest graph** rather than a **social graph**. The For You Page ingests completion rate, shares, comments, follows, and re-watches, weighting **completion and sharing** most heavily. The machine learns your interests from behavior, not from who you've explicitly connected to. This means the product gets more accurate the more you use it — a network effect of one, compounding over time.

No followers? No problem

The interest graph solves something that crippled earlier platforms: the **cold-start problem**. On a social graph, new creators reach almost no one because they have no followers. On TikTok, a brand-new account with **zero followers** can earn viral distribution within 24 hours if the content clears engagement thresholds with a small test group. The video is judged, not the creator's history. That single design choice democratized reach and made TikTok's content supply self-sustaining from day one.

Always testing

TikTok continuously **A/B tests** every piece of content against live engagement signals. A video that performs above threshold with a small seed audience gets propagated to progressively larger cohorts. The system optimizes for raw behavioral **engagement over social connection**, which produces sessions far longer than a social graph would generate. The trade-off: **weaker social bonding** than a Facebook-style network, since ties are to content categories, not to people. Socially-anchored products tend to retain users better than solo-use tools, so TikTok captures time but sacrifices some of that structural stickiness.

Key terms

Network effect

The dynamic where a product becomes more valuable to each user as more people use it. Effects can be direct (more users helps you) or indirect (more users improves the content or infrastructure you rely on).

Metcalfe's Law

A model stating that a network's value scales with the square of its number of users (n^2). Real-world dynamics are more nuanced, since not every connection is equally valuable.

Social graph

A map of real-world, identity-based relationships — who you know. Facebook's early dominance was built on the social graph, which made the platform uniquely defensible and is hard for rivals to replicate.

Parasocial bond

An oxytocin-mediated emotional attachment to a non-human or non-reciprocating entity, such as Duolingo's Duo owl. The mascot becomes a relationship the user does not want to disappoint.

FOMO (Fear of Missing Out)

Anxiety driven not by missing content but by the social consequences of missed bonding opportunities. Instagram Stories' 24-hour expiry works because it imposes a social cost for non-participation.

Interest graph

A machine-curated map of what you are drawn to rather than who you know. TikTok's For You Page replaced the social graph with an interest graph, letting a follower-less user get viral distribution in 24 hours.

Key concepts

Metcalfe's Law

- A principle that gives network effects a mathematical frame.
- It holds that a network's value scales with the square of the number of connected users — n^2.
- Double the users and you quadruple the value, in theory — though unequal connections make it a directional intuition, not precise accounting.

The Social Graph

- Facebook's early moat was built on this — a persistent, identity-based map of real-world relationships.
- It tied users to their real names and contacts, unlike interest communities or anonymous forums; News Feed, Groups, and Photos were layered on top.
- Rivals could copy any single feature but never the underlying web of who-knows-whom.

Layered Defensibility

- A phrase coined by the VC firm NFX for stacking many network effects at once instead of relying on just one.
- NFX pictures it as a castle with six concentric walls a challenger must breach one at a time.
- Its six walls: identity, social relationships, data, payment credentials, media, and platform integrations.

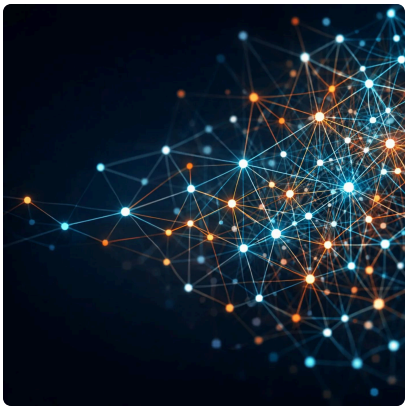
The Interest Graph

- TikTok built its recommendation engine around this rather than around a map of who you know.
- It's a map of what you're drawn to, inferred from behavior — completion rate, shares, comments, follows, re-watches — weighting completion and sharing most.
- Because it judges the content, not the creator's follower history, a zero-follower account can still go viral.

The Cold-Start Problem

- The barrier that crippled follower-based platforms: a newcomer reaches almost no one because they have no audience yet.
- TikTok's interest graph dissolves it — a brand-new account with zero followers can win viral distribution within 24 hours.
- The fix is judging each video against a small test group's engagement thresholds rather than the creator's history.

Key facts



AI-generated (gpt-image-1.5)

More users, more value

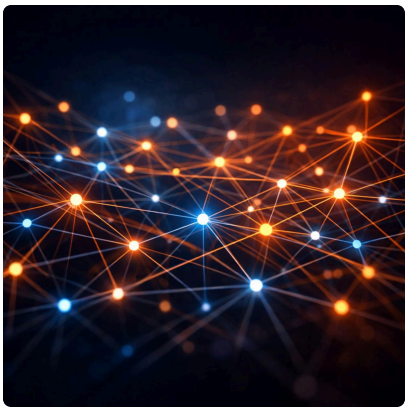
A **network effect** exists when a product gets more valuable to each user as more people join. Metcalfe's Law models this as value scaling with $\mathbf{n^2}$. But the real dynamics are messier — not all connections are equal.

Direct vs. indirect

Network effects come in two flavors. **Direct**: more users is directly better for you (more friends to message). **Indirect**: more users yields better infrastructure or content you benefit from, even without connecting to them.

What a friend is worth

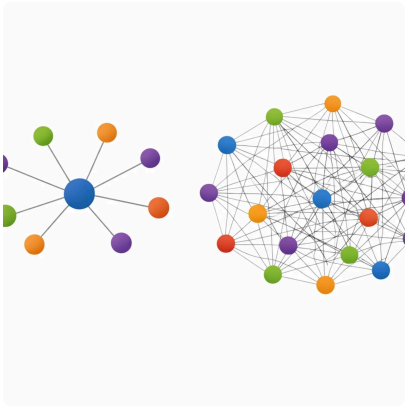
Economists at MIT, Chapman, Carnegie Mellon and the University of Cyprus measured social media network effects. A single connection is worth little — the largest effect, for a Facebook connection the user lives with, is about **4.6 cents a month**. Total platform value to a user: **78–101 per month**, with **8.1–23.7%** of it explained by local network effects.



AI-generated (gpt-image-1.5)

Metcalfe's Law

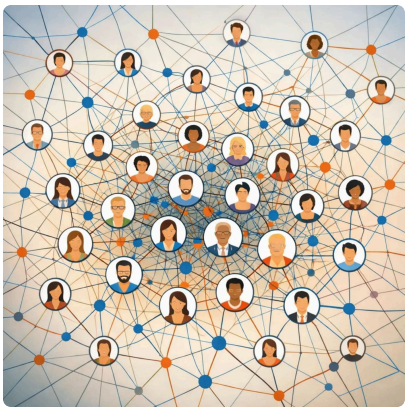
Metcalfe's Law models a network's value as scaling with the square of its user count (n^2) — because the number of possible connections between users grows roughly with the square of how many there are.



AI-generated (gpt-image-1.5)

Double Users, Quadruple Value

Metcalfe's Law implies that if a network's user base doubles, its value in theory quadruples, since $(2n)^2$ works out to four times the original n^2. It's a directional intuition about network value, not precise accounting.



AI-generated (gpt-image-1.5)

Facebook's moat

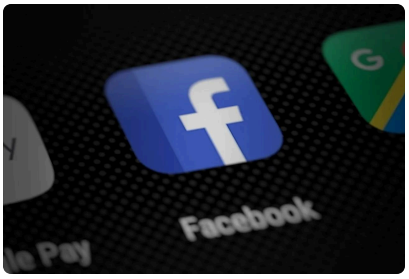
Facebook's early dominance rested on the **social graph** — a map of real-world, identity-based relationships. News Feed, Groups, and Photos were all built *on top of* this graph, each giving users a fresh reason to return.



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Six concentric walls

The VC firm NFX calls Facebook's structure **layered defensibility**: it deployed no fewer than six distinct types of network effect. Picture a castle with six concentric defensive walls — a competitor must breach them all.



Yuri Samoilov · CC BY 2.0

The Social Graph

The social graph that anchored Facebook's moat was a persistent, identity-based map of real-world relationships — tied to users' actual names and contacts, not just shared interests. An interest-based map, like TikTok's, is a different thing entirely.

> **Drawbridges Not The Moat**
>
> News Feed, Groups, and Photos were never the moat itself — they were drawbridges layered on top of the social graph, giving users fresh reasons to return. Rivals could copy the features easily; what they couldn't copy was the graph underneath.

> **Pricing Facebook's Whole Platform**
>
> MIT and Chapman economists (with Carnegie Mellon and Cyprus colleagues) ran choice experiments with about 20,000 US users. Facebook was valued at about 101 per user per month, the top of a 78–$101 range across Facebook, Instagram, LinkedIn and X. Local network effects, the value of specific connections, explained 8.1–23.7% of platform value.

> **Fear beats desire**
>
> Competitive leaderboards run on serotonin and status. The sharp insight: **fear of demotion outweighs the desire for promotion**. Players grind hardest not to climb a tier but to avoid dropping out of the one they hold.

FOMO is about people, not posts

As many as **69% of Americans** report FOMO. Cornell research found it isn't about missed *content* — it's anxiety over the social consequences of missed *bonding*. You don't fear missing a clip; you fear losing closeness with your group.

The 24-hour clock

Instagram Stories expire after **24 hours**. The expiry is the mechanic: it manufactures a *social* cost for non-participation, not just an informational one. Miss the window and you've missed the bonding, not merely a post.

The Serotonin Scoreboard

Competitive leaderboards work primarily through status and serotonin, not bonding. That's a different chemical driver than co-op quests or parasocial attachments, which run on oxytocin instead.

Bonding With A Cartoon Owl

The attachment users feel to Duolingo's Duo owl is a parasocial bond — an oxytocin-mediated connection to a non-reciprocating entity, manufactured through consistency and a mild threat of loss.

What you're drawn to

TikTok swapped the human-curated **social graph** for a machine-curated **interest graph**. The For You Page reads completion rate, shares, comments, follows, and re-watches — weighting **completion and sharing** most heavily.

No followers? No problem

Because the interest graph judges the video, not the creator, a brand-new account with **zero followers** can earn viral distribution within 24 hours. This dissolves the **cold-start problem** that throttled earlier social platforms.

Always testing

TikTok continuously **A/B tests** content against engagement signals: a video that clears a threshold with a small test group propagates to larger audiences. The system optimizes for raw behavioral **engagement over connection** — producing far longer sessions but **weaker social bonding** than a Facebook-style network.

Completion And Shares Win

TikTok's For You Page reads many signals — comments, follows, and re-watches among them — but weights completion rate and shares most heavily. It learns your interests from what you actually do, not from who you follow.

Longer Sessions, Weaker Bonds

Optimizing for raw engagement gives TikTok far longer sessions, but weaker social bonding — its ties are to content categories, not to people. That trade-off sacrifices structural stickiness for pure watch time.

By the numbers

Largest monthly value the study puts on one connection (a Facebook connection the user lives with)
0.046 USD

Low end of total Facebook platform value to a consumer, per month
78 USD

High end of total Facebook platform value to a consumer, per month
101 USD

Share of total platform value traceable to social connections (high end)
34 %

Share of total platform value traceable to social connections (low end)
20 %

Share of Americans who have experienced FOMO
69 %

Matched pairs

Each item on the left goes with the one on the right.

Direct network effect → More users = directly better for you

Indirect network effect → More users = better content/infrastructure for you

Social anchoring → Retention tends to be noticeably higher than for an equivalent solo-use tool

Competitive leaderboard → Serotonin — status

Co-op quest → Oxytocin — social obligation

Parasocial bond (Duo owl) → Oxytocin — bonding with a non-human entity

Self-test

Answer each question from memory, then check your work against the answer key.

1. Per Metcalfe's Law, a network's value scales with what?

(A) The square of the number of users (n^2)
(B) Daily revenue per user
(C) The number of users (n)
(D) The logarithm of users

2. What defines a network effect?

A. Ad revenue rises with each new advertiser onboarded
B. A product gets cheaper to produce as output scales up
C. A product becomes more valuable to each user as more people join
D. Server costs fall as the user base grows

3. Which is an example of a DIRECT network effect?

A. More iPhone users attract more app developers
B. More friends on a messaging app makes messaging more useful
C. More content on a platform improves it for everyone
D. More sellers on a marketplace attract more buyers

4. Which scenario is an example of an INDIRECT network effect?

A. Doubling users quadruples value per Metcalfe's Law
B. Users on the same side of the product improve your experience
C. More friends to message makes messaging more useful
D. More iPhone users attract more app developers, improving the platform

5. Per Metcalfe's Law, if a network's users double, its value in theory does what?

A. Grows by the logarithm of users
B. Halves
C. Quadruples
D. Doubles

6. What does NFX mean by Facebook's 'layered defensibility'?

A. It stacked six distinct network effects, like six concentric walls
B. It runs six redundant data centers
C. It encrypts user data in six layers
D. It charges advertisers six different rates

7. What is the 'social graph' that Facebook built its moat on?

A. A ranked feed of trending public content
B. A map of users' interests inferred from their behavior
C. An anonymous forum of shared interest communities
D. A persistent, identity-based map of real-world relationships

8. Which VC firm coined the phrase 'layered defensibility' for Facebook's stacked network effects?

A. Y Combinator
B. NFX
C. a16z
D. Sequoia

9. In the moat metaphor, what role did News Feed, Groups, and Photos play relative to the social graph?

A Six concentric defensive walls locking users in
B The identity layer underpinning every other feature
C The moat itself that competitors could never cross
D Drawbridges layered on top of the graph, adding reasons to return

10. NFX likens Facebook's stacked defenses to a castle with concentric walls. Which of these is one of the reinforcing lock-ins layered into Facebook's moat?

A Embedding in third-party sites
B Daily streak counts
C Professional reputation scores
D Daily login bonuses

11. In the study of Facebook, Instagram, LinkedIn and X, the largest dollar value reported for a single connection was about how much per month?

A About 4.6 dollars a month
B About 4.6 cents a month
C About 0.46 cents a month
D About 46 cents a month

12. A choice-experiment study by MIT and Chapman economists and colleagues put the average value of Facebook, Instagram, LinkedIn and X to US users in what range per user per month?

A $20–$34
B $10–$15
C $78–$101
D $101–$150

13. Across Facebook, Instagram, LinkedIn and X, what share of total platform value did a large choice-experiment study attribute to local network effects (the value of specific connections)?

A 52.8–68.5%
B 8.1–23.7%
C 31.4–46.2%
D 69%

14. What pattern does 'social anchoring' describe?

A Retention depends only on how often push notifications are sent
B Solo-use tools retain users better than social products do
C Users anchor on the first price they see inside an app's store
D Socially-tied users are retained better than users of an equivalent solo-use tool

15. Which of these is NOT a finding of the study of social media network effects?

A Facebook had the highest platform value, about $101 per user per month
B Platform value ranged from $78 to $101 per user per month
C Facebook showed the weakest local network effects of the four platforms
D 8.1–23.7% of platform value came from local network effects

16. Content shared to **___** expires after **24 hours**. The expiry is the mechanic: it manufactures a *social* cost for non-participation, not just an informational one.

A Instagram Stories
B News Feed
C Facebook Timeline
D For You Page

17. Competitive leaderboards primarily run on which neurochemical and driver?

A Dopamine — anticipation
B Serotonin — status
C Oxytocin — social bonding
D Cortisol — stress relief

18. What is a parasocial bond, like the attachment to Duolingo's Duo owl?

A A serotonin-driven status competition with peers
B A reciprocal friendship between two active users
C An oxytocin-mediated attachment to a non-reciprocating entity
D A financial reward for maintaining a daily streak

19. Cornell research found FOMO is driven by anxiety about what?

A Losing a competitive leaderboard position
B Falling behind on unread notifications
C Missing informational content or news
D The social consequences of missed bonding

20. On competitive leaderboards, what makes players grind hardest?

A Avoiding demotion outweighs the pleasure of promotion
B Earning the most points in a single session
C Unlocking exclusive cosmetic rewards
D The desire to reach the very top tier

21. TikTok's For You Page ingests many engagement signals, but which two does it weight most heavily?

A Comments and follows
B Follower count and account age
C Completion rate and shares
D Likes and profile visits

22. What does TikTok's interest graph map?

A Your identity and phone contact list
B Your explicit follow and friend connections
C Who you know in real life
D What you're drawn to, learned from your behavior

23. How does the interest graph solve the cold-start problem?

A It pays new creators to seed an initial audience
B A zero-follower account can go viral in 24h if content clears thresholds
C It requires new creators to import their contact list
D It ranks accounts by follower count and account age

24. What is the trade-off of TikTok optimizing for engagement over social connection?

A Longer sessions but weaker social bonding
B Higher retention and stronger social ties
C Shorter sessions but stronger social bonding
D Slower growth but far deeper loyalty

25. Which statement contrasting the interest graph and the social graph is correct?

A The interest graph maps who you already know
B The interest graph needs followers to distribute content
C The social graph gets more accurate the more you use it
D The interest graph judges the video on its own merits

Go deeper

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STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 6 OF 11

Engineering Viral Growth

The K-factor · The three growth loops · Shareable artifacts & referrals

WHAT YOU'LL BE ABLE TO DO

- Compute and interpret the K-factor (K = i x c) and the K > 1 threshold for self-sustaining growth.
- Define CAC and explain how viral growth lowers it, using Duolingo's CAC from IPO to Q1 2025.
- Distinguish the viral, content/ASO, and paid acquisition loops and explain why mature products run all three in parallel.
- Define LTV and explain the LTV-greater-than-CAC condition that keeps the paid acquisition loop viable.
- Explain shareable artifacts (Spotify Wrapped, Top 1% badge) and why double-sided referrals outperform single-sided via reciprocity.

The K-factor

Viral growth is not a mood — it is a measurement. Once you can quantify how the product spreads, you can tune it the same way an engineer tunes a system.

Virality is a number, not a vibe

The **viral coefficient**, written as **K-factor**, measures how many new users each existing user generates. The formula is `K = i × c` — **invitations sent** multiplied by the **conversion rate** on those invitations. A K of 0.2 means five users collectively produce one additional user over their lifetime; a K above **1** is the inflection point where the product is genuinely self-replicating — each cohort is larger than the last without additional spend. Below 1, virality still helps but the product depends on paid or organic top-of-funnel to survive. The K-factor is also a direct proxy for **product-market fit and low CAC**: users only bother to refer something they value, and a rising K means the product is earning those referrals. That combination — fit *and* cheap acquisition — is what a K above 1 signals simultaneously.

Duolingo's falling CAC

CAC (Customer Acquisition Cost) is the dollar amount spent to land one new user. It is the denominator that viral dynamics attack. By some analyst estimates, Duolingo's CAC fell from roughly **41 at its IPO** to roughly **33 by Q1 2025** — not because the ad budget shrank but because a larger and more engaged user base was doing more of the recruiting itself. Every dollar of referral-driven organic install is a dollar not spent on performance marketing. Watching CAC trend over time is one of the clearest ways to tell whether your viral loops are compounding or decaying; a flat or rising CAC at scale is a warning sign that organic growth has stalled.

The three growth loops

Growth at scale rarely runs on a single mechanism. Durable products stack multiple self-reinforcing loops so that when one weakens, the others carry the load.

Three loops that compound

The **viral loop** is the most celebrated: users recruit users through sharing, invitations, or social artifacts. It costs almost nothing per incremental install. The **content/ASO loop** is subtler — user activity (posts, reviews, public profiles) becomes indexable content that lifts **App Store** and search visibility, pulling in cold-search installs without a media buy. Both of these loops are compounding and nearly free at the margin. The **paid acquisition loop** works differently: ad spend buys installs whose in-app revenue (or LTV signal) funds more ad spend. It can scale fast but it only works when **LTV (Lifetime Value)** — the total value a user generates over their lifetime — far exceeds **CAC**. If the unit economics are negative, the paid loop accelerates losses rather than growth. Mature products use all three in parallel: the viral and content loops lower blended CAC so the paid loop can reach users who would never arrive organically, and the resulting scale generates more content and more referrers, reinforcing the first two.

Shareable artifacts & referrals

The most efficient acquisition channel is one where the user wants to do the work. Shareable artifacts and well-designed referral programs get there by aligning the app's growth interest with the user's self-interest.

The user promotes themselves

A **shareable artifact** is content a user chooses to broadcast because it reflects well on *them* — not the app. **Spotify Wrapped** is the canonical example: an identity-affirming yearly summary that detonates across social every December with zero paid media. Users are not promoting Spotify; they are performing a version of themselves — "I am the kind of person who listened to 40,000 minutes of ambient jazz." The app is the medium. The **Duolingo 'Top 1% of learners' badge** works the same way: it signals discipline to a user's social graph, and in doing so pulls curious onlookers into the funnel. The design principle is straightforward — create an output that makes the user look good, and distribution takes care of itself.

Give a ride, get a ride

Double-sided referral programs — where both the referrer *and* the new user receive value — consistently outperform single-sided ones because they exploit **reciprocity norms**: giving someone a benefit makes them feel obligated to act on it, and the referrer feels less like a salesperson when they are genuinely handing something over. Uber's original 'give a friend a free ride, get a free ride' structure is the textbook example. The more sophisticated version embeds the referral in content value rather than a discount — 'unlock this deck by inviting a study partner' — because it ties the incentive directly to the product's core loop rather than appending a cash reward that looks like a bribe. That framing also attracts users who want the product, not users who want the coupon.

Key terms

Viral coefficient (K-factor)

A measure of how many new users each existing user generates, calculated as K = i × c (invitations sent × conversion rate). K greater than 1 means exponential, self-sustaining growth.

CAC (Customer Acquisition Cost)

The cost to acquire one new user. A K-factor above 1 lowers CAC because users recruit each other, cutting the paid-acquisition spend needed to hit growth targets.

Viral loop

A growth loop in which users naturally recruit others through sharing, invitations, or social artifacts. It works best when sharing is intrinsic to the core value loop, not a bolted-on 'Share' button.

Content/ASO loop

A compounding growth engine where user activity generates content (reviews, shared artifacts, UGC), which increases App Store visibility, which drives downloads, which generates more content — essentially free marketing powered by your most engaged users.

LTV (Lifetime Value)

The total value a user generates over their lifetime. Paid acquisition loops are sustainable only when it greatly exceeds CAC.

Shareable artifact

Content a user wants to share because it reflects well on them — Spotify Wrapped, a 'Top 1% of learners' badge. The user is promoting themselves, not the app; the app is merely the medium.

Key concepts

The viral loop

- Of the three growth engines, this is the most celebrated — and it costs almost nothing per additional install.
- It works by having existing users recruit new ones through sharing, invitations, and social artifacts.
- This compounding, nearly-free growth engine is measured directly by the K-factor: invitations sent times conversion rate.

The content/ASO loop

- This subtler growth engine turns ordinary user activity into a free discovery channel.
- Posts, reviews, and public profiles become indexable material that lifts App Store and search visibility.
- It pulls in cold-search installs with no media buy, because user activity itself becomes the searchable asset that raises store ranking.

The paid acquisition loop

- Unlike the two compounding engines, this growth mechanism can scale fast but only under the right unit economics.
- Ad spend buys installs whose in-app revenue funds still more ad spend.
- It is sustainable only when a user's lifetime value far exceeds the cost to land them — negative unit economics make it accelerate losses instead of growth.

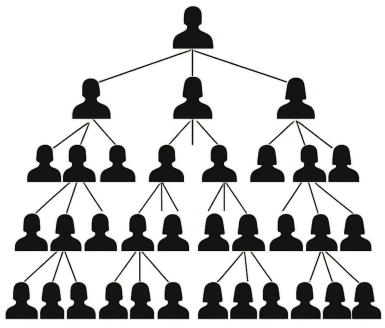
Key facts

> **Virality is a number, not a vibe**
>
> Growth teams don't hope a product spreads — they **measure** it. The viral coefficient, or **K-factor**, quantifies how many new users each existing user generates. Once you can put a number on it, you can engineer it.

> **Duolingo's falling CAC**
>
> Duolingo's customer acquisition cost dropped from an estimated **~41 at IPO** to **~33 in Q1 2025** — a direct measure of improving viral dynamics as the user base grew more self-referencing. Cheaper acquisition is what viral growth looks like on a spreadsheet.

> **Pricing A New User**
>
> Customer Acquisition Cost, or CAC, is the dollar amount a company spends to land one new user. It's the denominator that viral growth mechanics are designed to shrink.

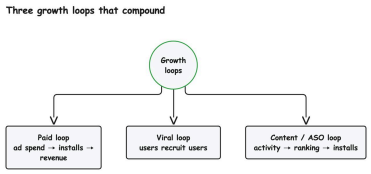
> **Five Users, One New One**
>
> A K-factor of 0.2 means it takes five existing users, collectively, to generate one additional user over their lifetime. That's below the K-above-1 threshold for self-sustaining growth, so it's a reciprocal relationship, not a multiplier.



AI-generated (gpt-image-1.5)

What K Above 1 Signals

When a product's K-factor climbs above 1, each user is recruiting more than one new user — self-sustaining growth that signals strong product-market fit, a low customer acquisition cost, and a genuinely good user experience.



FlashFeed original diagram · CC-BY-4.0

Three loops that compound

Sustainable growth runs on three engines: the **viral loop** (users recruit users), the **content/ASO loop** (activity becomes content that lifts store visibility), and the **paid acquisition loop** (ad spend buys installs that fund more spend). The first two are nearly free; the third only works when LTV far exceeds CAC.

Posts That Feed Search

The content/ASO loop turns everyday user activity — posts, reviews, and public profiles — into indexable material that lifts App Store and search visibility. It's how cold-search installs happen, distinct from direct recruiting or paid ads.

Ads That Fund More Ads

The paid acquisition loop works by spending on ads to buy installs, then reinvesting the in-app revenue those installs generate into more ad spend. Unlike the viral and content loops, it isn't nearly free at the margin.

Users Recruiting Users

The viral loop grows a product through users recruiting other users — via sharing, invitations, or social artifacts — at almost no cost per install. It works best when sharing is built into the core experience, not bolted on as a separate button.

The user promotes themselves

The most efficient acquisition channel is an artifact users *want* to share because it reflects well on them. **Spotify Wrapped** is the archetype: an identity-affirming summary that explodes across social every December with zero paid media. The user isn't promoting the app — they're promoting *themselves*. The app is just the medium.

Give a ride, get a ride

Double-sided referral programs — where both the referrer and the new user get value — beat single-sided ones by exploiting reciprocity norms. Uber's 'give a friend a free ride, get a free ride' is canonical. The advanced move: embed the referral in *content value* instead of a discount — 'unlock this deck by inviting a study partner.'

Spotify's December Detonation

Spotify Wrapped is the archetypal shareable artifact: an identity-affirming yearly summary that spreads across social media every December without any paid media behind it.

The Top 1% Badge

Duolingo's 'Top 1% of learners' badge works as a shareable artifact: it signals discipline to the user's social graph, and curious onlookers get pulled into the app.

> **Unlock It, Don't Bribe**
> The more sophisticated referral embeds its incentive in content value tied to the core loop, like unlocking a deck by inviting a partner — it draws people who want the product, not the coupon.

By the numbers

K-factor threshold above which growth becomes exponential and self-sustaining
1 x

K-factor where 5 users still generate 1 additional user 'for free' over their lifetime
0.2 x

Duolingo's estimated customer acquisition cost (CAC) at IPO
41 USD

Duolingo's estimated customer acquisition cost (CAC) in Q1 2025
33 USD

Matched pairs

Each item on the left goes with the one on the right.

Viral loop → Users recruiting users through sharing and invitations

Content/ASO loop → User activity becoming content that lifts App Store visibility

Paid acquisition loop → Ad spend buying installs whose revenue funds more spend

Spotify Wrapped → Identity-affirming yearly summary shared with zero paid media

Duolingo 'Top 1% of learners' badge → Achievement that signals discipline to a user's social graph

Shareable artifact (Spotify Wrapped) → Serotonin — content that markets the user, not the app

Step by step

Sequence the three growth loops as a startup scales

1. Engineer the viral loop from day one — bake sharing into the core value, not a bolted-on Share button.
2. Run the paid acquisition loop to buy your first installs, sustainable only while LTV far exceeds CAC.
3. Use that paid spend to reach critical mass — enough active users to seed real activity.
4. Let the content/ASO loop kick in as user activity generates reviews and artifacts that lift store visibility.
5. Watch the viral and content loops self-sustain organic growth, reducing reliance on paid spend.

Virality is engineered from day one; paid acquisition bootstraps reach until the organic loops compound on their own.

Self-test

Answer each question from memory, then check your work against the answer key.

1. A K-factor above 1 is a direct signal of which combination?

- A Weak retention but strong onboarding
- B Rising CAC and stalled organic growth
- C High churn and heavy ad spend
- D Product-market fit and low CAC

2. The K-factor is calculated as the product of which two quantities?

- A Lifetime value and retention rate
- B Customer acquisition cost and conversion rate
- C Invitations sent and the conversion rate on those invitations
- D Installs and churn rate

3. Above what K value is a product genuinely self-replicating, with each cohort larger than the last without extra spend?

- A 0.2
- B 1
- C 0.5
- D 10

4. What does a K-factor of 0.2 mean in practice?

- A Five users collectively produce one additional user over their lifetime
- B Each user recruits five new users
- C The user base doubles every cycle
- D The product loses one in five users

5. Which statement about a product with a K-factor below 1 is TRUE?

A. It is guaranteed to lose users every cohort
B. It grows exponentially on its own without any spend
C. Virality still helps, but the product depends on paid or organic top-of-funnel to survive
D. It needs no marketing because it is self-replicating

6. What does CAC (Customer Acquisition Cost) measure?

A. The dollar amount spent to land one new user
B. The share of users who convert on an invitation
C. The total revenue a user generates over their lifetime
D. The number of users each existing user recruits

7. Roughly what was Duolingo's estimated CAC at its IPO?

A. $33
B. $41
C. $28
D. $52

8. Roughly what had Duolingo's estimated CAC fallen to by Q1 2025?

A. $41
B. $21
C. $47
D. $33

9. Why did Duolingo's CAC fall from IPO to Q1 2025?

A. It stopped tracking performance marketing
B. The company slashed its advertising budget
C. A larger, more engaged user base did more of the recruiting itself
D. It raised subscription prices to offset ad spend

10. A flat or rising CAC at scale is a warning sign of what?

A. Organic growth has stalled and viral loops may be decaying
B. LTV is climbing rapidly
C. Viral loops are compounding faster than ever
D. The K-factor has just crossed above 1

11. Why do mature products run all three growth loops in parallel rather than relying on the paid acquisition loop alone?

A. Running all three loops eliminates the need to track LTV
B. The paid loop generates the content that feeds the other two loops
C. The paid loop is the only one of the three that compounds over time
D. The viral and content loops lower blended CAC, letting the paid loop reach users who'd never arrive organically

12. Which growth loop turns user activity such as posts, reviews, and public profiles into indexable material that lifts App Store and search visibility?

A. The retention loop
B. The content/ASO loop
C. The viral loop
D. The paid acquisition loop

13. How does the paid acquisition loop work?

A. Ad spend buys installs whose in-app revenue funds more ad spend
B. Public profiles generate cold-search installs for free
C. Users recruit users through sharing and invitations
D. User activity becomes content that lifts store rankings

14. Which of these growth loops is NOT nearly free at the margin?

A. The viral loop
B. The referral loop
C. The content/ASO loop
D. The paid acquisition loop

15. The viral loop drives growth primarily through which mechanism?

A. Subscription revenue reinvested into retention
B. Ad spend that buys installs which fund more spend
C. Users recruiting other users through sharing, invitations, or social artifacts
D. User reviews that raise App Store rankings

16. What does LTV (Lifetime Value) measure?

A. The share of trials that convert to paid
B. The total value a user generates over their lifetime
C. The cost to acquire one new user
D. The number of invitations a user sends

17. The paid acquisition loop is sustainable only when which condition holds?

A. LTV far exceeds CAC
B. The K-factor stays below 1
C. CAC far exceeds LTV
D. Invitations exceed conversions

18. If a product's unit economics are negative (CAC exceeds LTV), what does scaling the paid loop do?

A. Automatically lifts the K-factor above 1
B. Compounds free organic installs
C. Accelerates losses rather than growth
D. Lowers CAC through reciprocity

19. When LTV comfortably exceeds CAC, what happens as the paid acquisition loop scales?

A. It stops needing any further ad spend at all
B. It buys installs whose revenue funds even more ad spend
C. It becomes functionally the same as the viral loop mechanism
D. It automatically guarantees the K-factor rises above one

20. To judge whether the paid acquisition loop is viable, which two figures do you compare?

A. Retention against conversion rate
B. Invitations against installs
C. K-factor against churn
D. LTV against CAC

21. Why do double-sided referral programs outperform single-sided ones?

A. They guarantee a K-factor above 1, whatever the conversion rate
B. They exploit reciprocity norms by rewarding both the referrer and the new user
C. They swap the user's social graph for a machine-curated interest graph
D. They pay rewards in cash only, which users value more than app credit

22. A shareable artifact is content a user chooses to broadcast primarily because it:

A. Is required before they can keep using the app
B. Directly advertises the app's newest features
C. Pays them a cash reward for each share
D. Reflects well on them, letting them perform a version of themselves

23. Which is the canonical shareable artifact that detonates across social every December with zero paid media?

A. Duolingo's streak freeze
B. Uber's free-ride referral
C. Spotify Wrapped
D. The App Store featured banner

24. How does Duolingo's 'Top 1% of learners' badge pull new users into the funnel?

A. It signals discipline to the user's social graph, drawing curious onlookers
B. It buys App Store ad placements
C. It gives referred friends a cash bonus
D. It forces users to invite friends to continue

25. What is the more sophisticated version of a referral that avoids looking like a cash bribe?

A. Removing all incentives from the referral
B. Embedding the incentive in content value tied to the core loop, e.g. 'unlock this deck by inviting a partner'
C. Doubling the cash reward for both sides
D. Rewarding only the referrer with a discount

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LESSON 7 OF 11

Retention Architecture

Onboarding & the Aha Moment · Push notifications · Investment & cohort retention

WHAT YOU'LL BE ABLE TO DO

- Define the Aha Moment as feeling core value and match Facebook, Twitter, and Duolingo to their onboarding thresholds.
- Explain how teams locate the Aha Moment empirically from cohort data and cite the day-3 drop-off.
- State the three rules of effective push notifications (timing, personalization, curiosity/FOMO) and what not to do.
- Explain the Investment (Hook) stage as raising switching cost via the endowment effect, and identify a Duolingo streak as accumulated investment.
- Read cohort retention benchmarks (Day 1/7/30) and explain why a small retention gain can mean a large profit gain.

Onboarding & the Aha Moment

Retention isn't decided over months — it's decided in hours. The entire onboarding discipline exists to collapse the distance between "downloaded the app" and "understood why it matters."

Retention is won in the first session

Roughly **80% of users stop using an app after the third day** following install. That single statistic reframes onboarding as a survival problem: the app has two or three sessions to prove its value, and then most people are gone for good. The solution isn't a better tutorial — it's faster delivery of the **Aha Moment**, the instant the app's core value becomes emotionally real. Finishing a walkthrough is not the Aha Moment; *feeling* the value is.

Product teams locate the Aha Moment empirically: they **analyze which early actions correlate with long-term retention in cohort data**. When a specific behavior — reaching it within session one — predicts a user still being active 30 days later, that behavior is the Aha Moment. The engineering and UX then bend around getting every new user to that moment as fast as possible.

The canonical examples each involve a concrete threshold. **Facebook** landed on **"7 friends in 10 days"** — hit that social density and the feed becomes meaningful; miss it and the product is an empty room. **Twitter**'s equivalent was **"follow 30 accounts"** — enough signal to fill a timeline worth returning to. **Duolingo**'s is immediate and sensory: **completing the first lesson and receiving the animated XP reward** — the gamified dopamine hit that makes the habit feel attainable right now.

All three share a structure: a specific, measurable threshold that converts a passive visitor into someone with a felt reason to come back. Onboarding design is the art of removing every obstacle between install

and that threshold.

Push notifications

Getting a user to the Aha Moment buys time; keeping them returning requires a re-engagement channel. Push notifications are that channel — but only when used with restraint and precision.

Push: the re-engagement channel

Push notifications are the primary channel for reactivating users who have left the habit loop. When a user misses a day — or a week — a well-timed notification is often the only thing that pulls them back before they forget the app exists. Done badly, push becomes noise that triggers a permanent opt-out; done well, it mimics the gentle nudge of a real commitment.

Three rules separate effective push from spam. First, **timing**: notifications land better when they arrive at the moment a user has historically opened the app, not on a fixed broadcast schedule. Sending at the same fixed interval every day regardless of context is precisely what *not* to do — it is the one approach that is **not** among the three effective rules. Second, **personalization**: using the user's name and behavioral history — their streak length, their last completed action, their stated goal — outperforms generic copy significantly, because it signals the app is paying attention. Third, **curiosity and the FOMO gap**: copy that withholds just enough information ("Your streak is at risk" rather than "Open the app") creates mild anxiety that motivates a tap without being manipulative.

The underlying mechanism is the **curiosity gap** — the mild discomfort of an unresolved question. Combined with **FOMO** (fear of missing out on a streak, a reward, or a social event), even a short notification can feel urgent. The risk is habituation: if every push is framed as urgent, none are. The craft is calibrating frequency and intensity so the channel retains its pull.

Investment & cohort retention

The Aha Moment and a well-timed push notification win the first weeks. Whether a user stays for months depends on what they have built inside the product, and whether retention is working is measured one cohort at a time.

Investment and stored value

Investment is the fourth stage of the Hook Model: after the reward, the user puts something back into the product. Nir Eyal's *Hooked* calls the result **stored value**, which accrues as content, data, followers, reputation and skill the more the product is used. On his own site Eyal lists inviting friends, stating preferences, building virtual assets and learning new features as investments, and says they can make the next trigger more engaging, the action easier and the reward more exciting. He cites LinkedIn: an early product manager there, Josh Elman, found that users who entered even a little information were much more likely to return.

Investment holds users in two ways. It makes the product more valuable with each use, and it raises the **switching cost** of leaving, because the **endowment effect** leads people to overvalue what they already

own. Everything a user has built stays behind if they go.

The streak as investment

Duolingo's **streak count** is the clearest example in this pack. Each day of practice adds to a number the user built and can lose. A 100-day streak is accumulated **sunk cost**: past investment that has no bearing on future value but feels devastatingly real, so the threat of a reset triggers loss aversion. The counter does not measure fluency; it records the user's own run of daily practice.

Cohort analysis

Whether any of this works shows up in **cohort analysis**. A **cohort** is a group of users who share a starting point, such as the same install or sign-up date. Cohort retention tracks how many of that group return over time, and **N-day retention** is the share of the cohort active on the Nth day after they started. Common checkpoints are Day 1, Day 7 and Day 30, with longer views such as Day 90. Grouping users by early behavior instead of by date is how teams find the Aha Moment: the actions that correlate with higher long-term retention.

What typical retention looks like

Benchmarks show how steep the curve is. The mobile measurement company **Adjust**, in retention benchmarks published in 2025, put the median across all app categories at **26% on Day 1, 13% on Day 7 and 7% on Day 30**. iOS apps ran slightly higher (27%, 14% and 8%) and Android slightly lower (24% on Day 1, 6% on Day 30). Retention also varies widely by category, from 29% on Day 1 for games and social apps to 13% for food and drink, so a single median is a reference point, not a target.

Why retention pays

LTV (Lifetime Value) is the total value a user generates over their lifetime, and it grows the longer a user stays: a 2001 Bain & Company note by Frederick Reichheld observes that customers generate increasing profits each year they stay. A widely cited figure attributed to Reichheld, repeated in *Harvard Business Review* in 2014, holds that raising customer retention rates by **5%** increases profits by **25% to 95%**, and that acquiring a new customer costs five to 25 times more than keeping one. The figure describes company profits, not app LTV specifically, and the range varies by business. The direction is the lesson: small gains in retention compound, which is why retention is treated as more capital-efficient than paid acquisition.

Key terms

Aha Moment

The instant an app's core value becomes emotionally real — feeling the value, not finishing a tutorial. Facebook's was '7 friends in 10 days'; Twitter's was following 30 accounts. Onboarding should deliver every user here fast.

Push notification

The primary channel for reactivating users who have left the habit loop. The most effective ones are contextually timed, personalized to the user's state, and carry a curiosity or FOMO gap.

Investment (Hook)

The fourth Hook stage: users put something into the product — data, content, social connections, reputation. Investment makes the product more valuable on the next use and raises switching costs via the endowment effect: everything a user builds inside the app raises the cost of leaving.

Cohort analysis

Tracking the percentage of users from a given install cohort who return on Day 1, 7, 30, and 90. It is also how teams identify the Aha Moment — the early actions that correlate with long-term retention.

LTV (Lifetime Value)

The total value a user generates over their lifetime. Paid acquisition loops are sustainable only when it greatly exceeds CAC.

Key concepts

Facebook

- This social network located its Aha Moment as a specific social-density threshold new users had to hit early on.
- Reach that density and the feed becomes meaningful; miss it and the product feels like an empty room.
- Its famous benchmark: reaching 7 friends within the first 10 days of signup.

Twitter

- This microblogging platform defined its Aha Moment as reaching enough signal to make the timeline worth returning to.
- The threshold was about following enough sources to fill a feed.
- Its specific onboarding target was following 30 accounts.

Duolingo

- This language-learning app's Aha Moment is immediate and sensory rather than social.
- It hinges on finishing your very first exercise and getting an instant gamified payoff.
- New users feel the value the moment an animated XP celebration fires after lesson one — a dopamine hit that makes the habit feel attainable.

Key facts

> **Retention is won in the first session**
>
> Roughly **80% of users stop using an app after the third day** following install. The entire onboarding architecture exists to do one thing: deliver the user to the moment the app's value becomes real, before day three takes them.

When Value Feels Real

An app's Aha Moment is the instant its core value becomes emotionally real to the user — not the moment they finish a tutorial.

Twitter's Onboarding Number

Twitter's Aha-Moment onboarding threshold was following 30 accounts — enough signal to fill a timeline worth returning to.

Duolingo's Instant Payoff

Duolingo's Aha Moment is immediate and sensory: finishing the first lesson and getting the animated XP reward, a dopamine hit rather than a slow-building realization.

Hunting The Aha Moment

Product teams find an app's Aha Moment by analyzing cohort data for which early actions correlate with long-term retention, then re-engineering onboarding to steer every new user through that sequence.

Push: the re-engagement channel

Push notifications are the main way to reactivate users who left the habit loop. **Personalized** notifications — using the user's name and behavioral history — significantly outperform generic ones at driving people back.

Timed To Your Habits

The timing rule for push says notifications should land at moments a user has historically opened the app — not at a fixed interval sent regardless of context.

Copy That Pays Attention

Personalized push copy — referencing a user's name, streak, or behavioral history — outperforms generic copy because it signals the app is actually paying attention to them.

The Curiosity Gap Trick

Push copy that withholds just enough — like 'Your streak is at risk' — creates a curiosity gap and mild FOMO that motivates a tap, unlike copy that resolves everything upfront.

By the numbers

Share of users who stop using an app after day 3 following install

80 %

Median Day 1 retention across all apps (Adjust benchmark, 2025)

26 %

Median Day 7 retention across all apps (Adjust benchmark, 2025)

13 %

Median Day 30 retention across all apps (Adjust benchmark, 2025)

7 %

Upper end of the profit increase attributed to a 5% rise in customer retention (Bain)

95 %

Matched pairs

Each item on the left goes with the one on the right.

Facebook → 7 friends in 10 days

Twitter → follow 30 accounts

Duolingo → first lesson + animated XP

Timing → send at high-probability moments — post-commute, lunch, evening

Personalization → reference the user's specific state — '2 days from your longest streak'

Curiosity / FOMO gap → 'Your friend just overtook your rank' — competitive anxiety plus social proof

Duolingo → streak count

Step by step

Engineer onboarding to deliver every new user to the Aha Moment

1. Pull cohort data on users who stuck around long-term versus those who churned.
2. Find the early actions that correlate with long-term retention.
3. Define the Aha Moment as that exact action sequence (e.g. 7 friends in 10 days).
4. Re-engineer onboarding so every new user is driven to that action as fast as possible.
5. Confirm the value is felt emotionally, not just that a tutorial was completed.

Teams find the Aha Moment by analysis, not intuition — then build the funnel backward from it.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Facebook famously identified a single onboarding threshold as its Aha Moment. What was it?

A Follow 30 accounts

B 5 friends in the first session

C 10 friends in 30 days

D 7 friends in 10 days

2. What best defines an app's Aha Moment?

A. The day-3 point when most users churn
B. The instant the app's core value becomes emotionally real
C. The screen where a user grants push permission
D. The moment a user finishes the onboarding walkthrough

3. What was Twitter's Aha-Moment onboarding threshold?

A. Follow 30 accounts
B. 7 friends in 10 days
C. Add 5 topics of interest
D. Complete the first lesson for animated XP

4. Which describes Duolingo's Aha Moment?

A. Maintaining a 7-day streak
B. Reaching 7 friends in 10 days
C. Completing the first lesson and receiving the animated XP reward
D. Following 30 accounts

5. Which of these is NOT an example of an app's Aha Moment?

A. Duolingo's first lesson plus animated XP
B. Finishing the onboarding walkthrough
C. Facebook's 7 friends in 10 days
D. Twitter's follow 30 accounts

6. How do product teams identify an app's Aha Moment?

A. Copy whatever the market-leading competitor does
B. Pick the final screen of the onboarding tutorial
C. Analyze which early actions correlate with long-term retention in cohort data
D. Ask users in a survey what they enjoyed most

7. Roughly what share of users stop using an app after the third day following install?

A. 95%
B. 65%
C. 50%
D. 80%

8. A specific early behavior qualifies as the Aha Moment when it does what?

A. Predicts a user still being active about 30 days later
B. Matches a market-leading competitor's feature
C. Is rated most enjoyable in a user survey
D. Appears on the final onboarding screen

9. The ~80% day-3 drop-off reframes onboarding as which kind of problem?

A. A survival problem — prove value within two or three sessions
B. A tutorial-length problem — the walkthrough is too short
C. A paid-acquisition problem — not enough installs
D. A pricing problem — the app costs too much up front

10. Which is NOT a valid way to locate an app's Aha Moment?

A. Examining the early actions of users who stayed active
B. Choosing the last screen of the onboarding tutorial
C. Finding behaviors that predict 30-day retention
D. Analyzing which early actions correlate with long-term retention

11. Which is NOT one of the three rules for effective push notifications?

A. Time it to moments of high probability of action
B. Open a curiosity or FOMO gap
C. Send at the same fixed interval every day regardless of context
D. Personalize it to the user's specific state

12. What is a push notification's primary role?

A. A paid user-acquisition channel
B. A required step in the onboarding walkthrough
C. The Investment stage of the Hook Model
D. The primary channel for reactivating users who left the habit loop

13. The timing rule says push notifications should arrive when?

A. At the same fixed interval every day
B. At moments the user has historically opened the app
C. Only at midnight to avoid daytime noise
D. As often as possible to stay top of mind

14. Why does personalized push copy (name and behavioral history) outperform generic copy?

A. It is cheaper to send at scale
B. It bypasses app-store notification rules
C. It removes any need for good timing
D. It signals the app is paying attention to the user

15. Which push copy best uses the curiosity / FOMO gap?

A. 'Your streak is at risk'
B. 'Open the app'
C. 'Thanks for installing our app'
D. 'A new update is available'

16. In the Hook Model's Investment stage, what do users put into the product?

A. A one-time app download
B. Money for a subscription only
C. Data, content, social connections, and reputation
D. A single push-notification opt-in

17. A user has spent years building hundreds of professional connections and a detailed profile inside an app. Which Hook Model stage does this represent?

A. Action
B. Variable Reward
C. Trigger
D. Investment

18. Which Duolingo feature is the clearest example of accumulated investment?

A The Super Duolingo upgrade prompt
B The hearts (lives) system
C Streak count
D Push notifications

19. How does the Investment stage keep users coming back over time?

A Each investment makes the product more valuable next use and raises switching costs
B It happens before the user reaches the Aha Moment
C It sends the highest volume of notifications
D It lowers the cost of paid acquisition

20. Investment raises switching costs primarily through which psychological effect?

A Variable-ratio reinforcement
B The endowment effect
C The goal gradient effect
D The curiosity gap

21. In Adjust's 2025 benchmark, median Day 1 retention across all apps is roughly what?

A 7%
B 50%
C 13%
D 26%

22. In Adjust's 2025 benchmark, median Day 7 retention across all apps is roughly what?

A 7%
B 35%
C 13%
D 26%

23. In Adjust's 2025 benchmark, median Day 30 retention across all apps is roughly what?

A 7%
B 2%
C 13%
D 26%

24. Which correctly ranks Adjust's 2025 median retention figures from highest to lowest?

A Day 1 26% > Day 7 7% > Day 30 13%
B Day 1 26% > Day 7 13% > Day 30 7%
C Day 1 7% > Day 7 26% > Day 30 13%
D Day 1 13% > Day 7 7% > Day 30 26%

25. A figure attributed to Bain & Company says a 5% rise in customer retention can raise profits by 25–95%. What does it suggest?

A It only influences Day 1 numbers
B It is far more capital-efficient than paid acquisition
C It matters less than lowering CAC
D It has no effect on lifetime value

Go deeper

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LESSON 8 OF 11

Design Patterns & Ethics

Core loop & notifications · Social sequencing & onboarding · Ethical design guardrails · People, Places, Things, Events

WHAT YOU'LL BE ABLE TO DO

- Describe the four jobs of a core loop and the Doherty Threshold (sub-400ms feedback that feels instantaneous).
- Identify a state-triggered, personalized notification that references specific user investment.
- Apply progressive disclosure and the zero blank slate, and sequence social mechanics from asynchronous proof to cooperation to synchronous competition.
- Distinguish dark patterns from humane design and apply Fogg's maxims (help people do what they want; simplicity changes behavior).
- Apply the PPTE context framework (People, Places, Things, Events) to locate re-engagement levers.

Core loop & notifications

The core loop is the atomic unit of a sticky app — the repeatable action cycle that every retention mechanic eventually wraps around. Notifications exist to pull users back into it.

The four jobs of a core loop

Every sticky app has a **core loop** — the action a user repeats each session. A well-designed one satisfies four criteria simultaneously: it completes in **2–5 minutes** (fitting a micro-session between meetings or on a commute), it delivers **immediate feedback** below the **Doherty Threshold** of 400 ms (the sub-400 ms response time, from Doherty and Thadhani's 1982 IBM research, below which a user and system keep pace with each other and productivity soars), it ends with a **variable reward** to drive anticipation, and it plants a setup condition for the next session. Strip any one of these and the loop either feels slow, pointless, or terminal.

End on an open loop

The best core loops don't end clean — they end with a **Zeigarnik open loop**. The Zeigarnik effect — Bluma Zeigarnik's finding that interrupted tasks were better remembered — has proved hard to replicate (a 2025 meta-analysis found no memory advantage), but the closely related Ovsiankina effect, the tendency to resume interrupted tasks, is well supported. App designers exploit this deliberately: an unfinished lesson, a half-built streak, a "come back tomorrow for your result" hook leaves a small cognitive itch the user wants to scratch. The loop never truly closes — it just resets with new stakes.

Notifications: trigger on state, not the clock

Effective notifications are **contextually triggered**, not time-scheduled. Firing at 9 AM every day regardless of user state is the weakest possible signal — the brain habituates to a predictable signal and starts ignoring it. The pattern that works: fire when the user **breaks their streak pattern** or crosses a

behaviorally meaningful threshold. A **personalized notification** such as "Your 14-day streak is at risk" outperforms a generic reminder because it references the user's specific investment. Social triggers — "Alex just passed your score" — layer in competitive loss aversion on top. Treating a fixed daily schedule as best practice therefore misses the point.

The streak + freeze pattern

Any app usable daily should have a **streak counter** — a running tally of consecutive-day sessions that converts a single daily habit into compounding psychological investment. The **freeze** mechanic extends this without breaking it: a missed day passes without streak loss, via a purchased or earned freeze token. This converts the streak from a fragile anxiety driver into a **resource-management meta-game**. Users now manage their freeze inventory, not just their calendar — a meaningful decision that deepens engagement beyond the primary content.

Social sequencing & onboarding

Onboarding is the highest-leverage minute in any app's lifecycle — users who don't reach value fast leave permanently. Social mechanics work best when sequenced to match where a user's trust actually sits.

Instrument the Aha Moment

The **Aha Moment** is the specific action most correlated with 7-day retention in your cohort data — not the action product managers assume is meaningful, but the one analytics surfaces. Onboarding has one job: deliver users to that moment as fast as possible. Everything before it is overhead to be eliminated. **Progressive disclosure** is the key onboarding principle here: reveal complexity gradually rather than dumping every feature on screen at once. New users lack the context to evaluate features they haven't experienced, so showing them all upfront creates overwhelm, not excitement. A common rule of thumb is to aim for a first quick win within about **60 seconds**.

The **zero blank slate** principle handles the empty-screen problem: pre-populate a new user's experience with suggested friends, example content, or seeded data, because an empty screen signals no value. A social app that shows zero connections on signup is communicating that nobody uses it.

Social mechanics follow a deliberate sequence. **Asynchronous social proof** — leaderboards, follower counts, visible activity feeds — comes first because it requires no mutual timing; a user can experience it alone. **Cooperative features** (shared quests, collaborative challenges) come next, once the user has a stake in the product. **Synchronous competition** — live battles, real-time leaderboards requiring matched opponents — lands last, because forcing real-time multiplayer on users who barely know the app destroys more sessions than it creates. Introducing synchronous competition early is therefore a sequencing mistake.

Ethical design guardrails

The mechanisms that make apps sticky are morally neutral tools — they can serve the user's goals or work against them. The distinction is what separates humane design from manipulation.

Same mechanism, opposite intent

Every engagement mechanic has a humane and a dark version. **Dark patterns** are design choices that work against the user's own goals: shaming copy ("No, I don't want to be smart"), **impossible cancellation flows**, manufactured scarcity, and infinite scroll without session-end cues. These produce short-term engagement metrics and long-term churn and resentment. An impossible-to-find cancellation flow is the canonical example of a dark pattern — it exploits friction asymmetry to trap users rather than retain them.

Fogg's first maxim is the counter-principle: *help people do what they already want to do*. B.J. Fogg's behavior model, developed at Stanford's Persuasive Tech Lab, starts from the premise that lasting behavior change requires motivation alignment — you can't sustainably push users toward goals they don't hold. Fogg's companion maxim on behavior change is that **simplicity changes behavior**: removing friction from a desired action is more reliably effective than increasing motivation for a reluctant one. Streak freezes, gentle session-end cues, and user controls over notification frequency are the practical outputs of designing from these maxims.

The difference is alignment: humane design makes it easy for users to do what they said they wanted to do, then gets out of the way. Dark patterns manufacture wants or obstruct exits. Trust, once destroyed by a dark pattern, rarely recovers — and the most-retained users are eventually the ones who chose to stay.

People, Places, Things, Events

Context is not a background condition — it is a first-class design variable. The **PPTE framework** organizes every contextual lever a designer can pull into four axes.

People, Places, Things, Events

People asks: who is in the user's social graph, and how does the app surface them? Social graphs create mutual accountability, competitive stakes, and belonging — three distinct retention mechanisms that don't require any new content. **Places** asks: where is the user when they engage? A commute app behaves differently from a bedtime app; designing for the actual physical and cognitive context of use is more effective than designing for a generic "user session." **Things** covers the artifacts a user accumulates. **Events** covers recurring real-world moments that open re-engagement windows. Each axis is a distinct design question, not an afterthought.

Every 'Thing' is a sunk cost

Under **Things**, the artifacts a user accumulates — streaks, badges, followers, portfolio items, content they've created — each function as a **sunk cost** that raises the **switching cost** of leaving. A user with a 200-day streak, 500 followers, and a completed course library has built something real inside the app.

The pain of abandonment scales with accumulation. This is not manipulation — it's the natural consequence of genuine value created inside the product. The design implication: build Things that are meaningful, not cosmetic, so the switching cost reflects actual loss rather than manufactured lock-in.

Events: the New Year's spike

Events are recurring real-world moments — New Year's resolutions, back-to-school seasons, sports seasons, holidays — that predictably open re-engagement windows. Duolingo's record DAU additions in **Q1 2025** (more than in any earlier quarter, per its Q1 2025 results) are plausibly attributable in part to resolution-makers picking up language learning in January. Designing for Events means having a re-engagement surface ready when the cultural moment arrives: a targeted notification, a seasonal challenge, a lower barrier to restart for lapsed users.

Key terms

Core loop

The fundamental action cycle a user repeats every session. A good one is completable in 2–5 minutes, gives feedback under the Doherty Threshold, ends with a variable reward, and sets up the next session via an open loop.

Doherty Threshold

The sub-400ms response time below which a system feels instantaneous and keeps a user productively engaged. A tight core loop should provide feedback under this threshold.

Progressive disclosure

An onboarding principle of revealing complexity gradually rather than exposing every feature at once, so new users aren't overwhelmed before they reach the Aha Moment.

Zero blank slate

Pre-populating a new user's experience with data, suggested friends, or example content, because an empty screen signals no value.

Dark pattern

A manipulative design that works against the user's own goals — shaming language ('No, I don't want to be smart'), impossible cancellation flows, manufactured scarcity. Dark patterns destroy long-term trust.

Key concepts

People

- One of the four PPTE context axes, this one treats the user's social graph as a first-class design variable.
- It asks who is in a user's network and how the app surfaces them.
- It drives three retention mechanisms at once — mutual accountability, competitive stakes, and belonging — without adding any new content.

Places

- One of the four PPTE axes, this one treats the physical and cognitive context of use as a design variable.
- It asks where a user is when they engage — designing for actual context beats designing for a generic session.
- A commute app behaves differently from a bedtime app precisely because of this axis: the user's location and situation.

Things

- One of the four PPTE axes, this one covers the artifacts a user piles up inside an app.
- Streaks, badges, followers, and created content each function as a sunk cost that raises the switching cost of leaving.
- A user with a 200-day streak, 500 followers, and a full course library has built real value here — the pain of abandonment scales with what they've accumulated.

Events

- One of the four PPTE axes, this one covers recurring real-world moments that predictably open re-engagement windows.
- New Year's resolutions, back-to-school seasons, and holidays are the openings this axis tells you to prepare for.
- Duolingo's record quarterly DAU additions, in Q1 2025, are plausibly credited partly to resolution-makers — a textbook case for this axis.

Key facts



AI-generated (gpt-image-1.5)

The four jobs of a core loop

Every sticky app has a **core loop** — the action a user repeats each session. A good one does four things: it's **completable in 2–5 minutes** (micro-session compatible), it gives **immediate feedback**, it **ends with a variable reward**, and it **sets up the next session** through an open loop.

> ### End on an open loop
>
> The best core loops don't end clean — they end with a **Zeigarnik open loop**, a setup condition for the *next* session. An unfinished lesson, a half-built streak, a 'come back tomorrow' hook leaves a small itch the brain wants to close.

Notifications: trigger on state, not the clock

Effective notifications are **contextually triggered**, not time-scheduled — fire when the user breaks their streak pattern, not at 9 AM daily. They're **personalized** to state ('Your 14-day streak is at risk' beats 'Don't forget to practice'), and **social** wherever possible ('Alex just passed your score').



Don Komarechka (Openverse) · cc0 1.0

The streak + freeze pattern

Any app usable daily should have a **streak counter**. The **freeze** mechanic — letting a missed day pass without losing the streak, purchased or earned — converts the streak from attrition-driving anxiety into a resource-management meta-game that deepens investment.

The 400ms Ceiling

A core loop needs to deliver feedback in under roughly 400 milliseconds — the Doherty Threshold below which an interaction feels immediate and responsive, rather than sluggish.



AI-generated (gpt-image-1.5)

Instrument the Aha Moment

The **Aha Moment** is the action most correlated with 7-day retention in your cohort data. Use product analytics to find it, then orient all of onboarding to deliver users there as fast as possible. Everything before the Aha Moment is overhead.



AI-generated (gpt-image-1.5)

The Social Onboarding Order

Social mechanics should be introduced in sequence: asynchronous social proof first since it needs no mutual timing, cooperative features once the user has a stake, then synchronous competition last, since forcing real-time play too early destroys sessions.

Why Real-Time Waits

Synchronous competition, like live battles or real-time leaderboards, is saved for last in onboarding because forcing real-time play on users who barely know the app destroys more sessions than it creates.

Reveal, Don't Dump

Progressive disclosure means revealing an app's complexity gradually instead of dumping every feature on a new user at once — without context, seeing it all creates overwhelm, not excitement.

Never Start From Empty

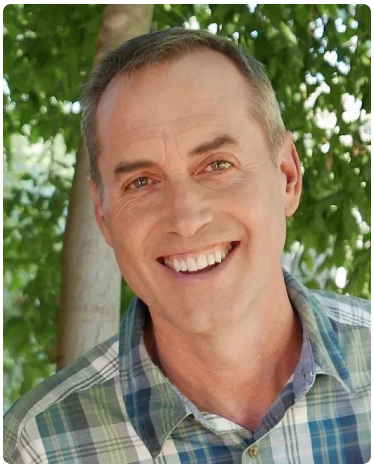
The zero blank slate principle pre-populates a new user's experience with suggested friends or seeded content, because an empty screen signals that nobody uses the app.

Same mechanism, opposite intent

The mechanisms that build habits can also build dependencies; the distinction lies in **alignment with the user's goals**. **Dark patterns** — shaming copy, impossible cancellation, manufactured scarcity — destroy trust. Humane design uses streak freezes, gentle session-end cues, transparency, and user controls instead.

Impossible To Cancel

An impossible-to-find cancellation flow is a classic dark pattern rather than a humane design choice — it destroys the user's trust in the app.



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What People Already Want

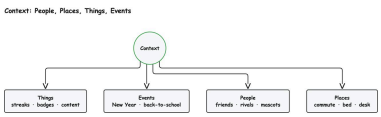
Fogg's first maxim tells designers to help people do what they already want to do — lasting behavior change comes from aligning with existing motivation, not pushing users toward goals they don't hold.

Friction Beats Motivation

Fogg's companion maxim holds that removing friction from a desired action changes behavior more reliably than trying to raise motivation for a reluctant one — simplicity wins.

Guilt-Tripping The Decline Button

A decline button labeled 'No, I don't want to be smart' is shaming copy — a dark pattern that works against the user's own goals and erodes long-term trust.



FlashFeed original diagram · CC-BY-4.0

People, Places, Things, Events

Sticky design treats **context** as a first-class variable across four axes — **People** (the social graph), **Places** (where the user engages), **Things** (artifacts they accumulate), and **Events** (recurring real-world moments). Each axis is a design question, not an afterthought.

> **Every 'Thing' is a sunk cost**
>
> Under **Things**, the artifacts a user accumulates — streaks, badges, followers, portfolio items, content — each act as a sunk cost that raises the **switching cost** of leaving. The more a user has built, the more it hurts to abandon.



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Events: the New Year's spike

Events are recurring real-world moments — resolutions, back-to-school, sports seasons, holidays — that open re-engagement windows. Duolingo's record DAU additions in **Q1 2025** (more than in any earlier quarter) are plausibly attributable in part to New Year's resolution-makers.

> **The People Question**
>
> The 'People' axis of the PPTE framework asks who is in a user's social graph and how the app surfaces them — building mutual accountability, competitive stakes, and belonging without adding any new content.

> **Where You Open It**
>
> The 'Places' axis asks where a user physically and mentally is when they engage — a commute app should behave differently from a bedtime app, designed for real context rather than one generic session.

By the numbers

Response time below which core-loop feedback feels immediate (the Doherty Threshold)

400 ms

Upper bound on how long a micro-session-compatible core loop should take to complete

5 minutes

Common rule-of-thumb window for onboarding to deliver the first quick win

60 seconds

Matched pairs

Each item on the left goes with the one on the right.

Personalized notification → 'Your 14-day streak is at risk'

Asynchronous social proof → Leaderboards, follower counts

Cooperative features → Shared quests, collaborative challenges

Synchronous competition → Live battles, real-time leaderboards

Fogg's first maxim → Help people do what they already want to do

Fogg's maxim on behavior change → Simplicity changes behavior

People → Who is in the user's social graph?

Places → Where is the user when they engage?

Things → What artifacts does the user accumulate?

Events → What recurring real-world moments or occasions re-engage the user?

Step by step

Sequence an app's social features in the right build order

1. Asynchronous social proof — leaderboards and follower counts; low friction, immediately reinforcing.
2. Cooperative features — shared quests and collaborative challenges; medium investment, once the user has a stake in the product.
3. Synchronous competition — live battles and real-time leaderboards; high friction, high reward, best for power users.

Don't force synchronous features early — a user who can't find a match or partner abandons.

Engineer onboarding to deliver every new user to the Aha Moment

1. Pull cohort data on users who stuck around long-term versus those who churned.
2. Find the early actions that correlate with long-term retention.
3. Define the Aha Moment as that exact action sequence (e.g. 7 friends in 10 days).
4. Re-engineer onboarding so every new user is driven to that action as fast as possible.
5. Confirm the value is felt emotionally, not just that a tutorial was completed.

Teams find the Aha Moment by analysis, not intuition — then build the funnel backward from it.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Why must a core loop deliver feedback in under ~400ms?

- A It matches the average human blink duration
- B It is the time a typical user needs to read an on-screen prompt before tapping
- C It is the delay that makes a variable reward feel most exciting
- D Below the Doherty Threshold the interaction feels immediate and responsive

2. Which is NOT one of the four jobs a well-designed core loop must do?

- A End with a variable reward
- B Require an in-app purchase to complete
- C Set up the next session via an open loop
- D Complete in 2–5 minutes

3. The Doherty Threshold — below which a user and system keep pace and productivity soars — is what response time?

- A 100 ms
- B 250 ms
- C 400 ms
- D 1000 ms

4. To fit a micro-session, how long should a core loop take to complete?

- A 2–5 minutes
- B 10–15 minutes
- C 20–30 minutes
- D 30–60 seconds

5. A core loop that ends with a 'come back tomorrow for your result' hook is applying which principle?

- A Progressive disclosure
- B Doherty Threshold
- C Zeigarnik open loop
- D Zero blank slate

6. Why is firing a notification at 9 AM every day, regardless of user state, the weakest signal?

- A It closes the Zeigarnik open loop before the user feels a pull to return
- B The brain habituates to a predictable signal and starts ignoring it
- C It skips the variable reward that keeps anticipation high
- D It triggers loss aversion before the streak feels earned

7. Which notification best references a user's specific investment in the app?

- A Your 14-day streak is at risk
- B Practice makes perfect!
- C New features are now available
- D Don't forget to practice today

8. An effective notification should fire when the user...

- A Has been inactive for precisely 24 hours
- B Installs a competing app
- C Reaches exactly 9 AM local time
- D Breaks their streak pattern or crosses a meaningful threshold

9. A notification reading 'Alex just passed your score' layers in which additional force?

A. Progressive disclosure
B. The Doherty Threshold
C. Competitive loss aversion
D. Manufactured scarcity

10. Rank these notification strategies from weakest to strongest signal.

A. Fixed daily clock alert → personalized streak alert → social 'a friend passed you' trigger
B. Social 'a friend passed you' trigger → personalized streak alert → fixed daily clock alert
C. Fixed daily clock alert → social 'a friend passed you' trigger → personalized streak alert
D. Personalized streak alert → fixed daily clock alert → social 'a friend passed you' trigger

11. In the recommended social onboarding sequence, why does synchronous competition (live battles, real-time leaderboards) belong last?

A. Real-time features are the most expensive to build, so they ship last
B. Forcing real-time multiplayer on users who barely know the app destroys more sessions than it creates
C. Synchronous features require push permissions that new users rarely grant
D. Live competition only works once an app has millions of users for matchmaking

12. What is the correct order for introducing social mechanics in onboarding?

A. Asynchronous social proof → synchronous competition → cooperative features
B. Synchronous competition → cooperative features → asynchronous social proof
C. Cooperative features → asynchronous social proof → synchronous competition
D. Asynchronous social proof → cooperative features → synchronous competition

13. What does progressive disclosure mean as an onboarding principle?

A. Delaying all features until the user pays
B. Revealing complexity gradually rather than dumping every feature at once
C. Pre-filling the screen with seeded example content
D. Showing every feature upfront so users learn all capabilities

14. The zero blank slate principle exists to solve which problem?

A. Real-time matchmaking needs many users
B. Notifications habituate over time
C. An empty screen signals that the app is worthless
D. Users forget which features exist

15. Which is NOT a form of asynchronous social proof?

A. A live real-time battle against a matched opponent
B. A visible activity feed
C. A follower count
D. A leaderboard

16. Which is a dark pattern rather than a humane design choice?

A. User controls over notification frequency
B. A gentle session-end cue
C. A streak freeze that absorbs a missed day
D. An impossible-to-find cancellation flow

17. What does Fogg's first maxim tell designers to do?

A. Add friction to keep users from leaving
B. Increase motivation for goals users don't hold
C. Help people do what they already want to do
D. Manufacture new wants users didn't have

18. Per Fogg's companion maxim, what changes behavior more reliably than raising motivation?

A. Sending more frequent reminders
B. Removing friction from a desired action (simplicity)
C. Applying social pressure
D. Adding more variable rewards

19. Which trio are the practical humane outputs of designing from Fogg's maxims?

A. Fixed 9 AM pushes, variable rewards, and open loops
B. Infinite scroll, autoplay, and streak-loss anxiety
C. Manufactured scarcity, shaming copy, and hard-to-find cancellation
D. Streak freezes, gentle session-end cues, and notification-frequency controls

20. A decline button labeled 'No, I don't want to be smart' is an example of what?

A. Shaming copy, a dark pattern
B. A Zeigarnik open loop
C. Progressive disclosure
D. Fogg's first maxim

21. In the PPTE framework, which axis covers accumulated artifacts like streaks, badges, and followers?

A. People
B. Events
C. Places
D. Things

22. The PPTE context framework stands for which four axes?

A. Places, People, Tools, Emotions
B. People, Places, Things, Events
C. Personas, Places, Triggers, Events
D. People, Products, Time, Engagement

23. In PPTE, the 'People' axis asks which question?

A. What artifacts does the user accumulate?
B. What recurring real-world moments re-engage the user?
C. Who is in the user's social graph, and how does the app surface them?
D. Where is the user when they engage?

24. The 'Places' axis of PPTE is concerned with...

A. Where the user is (physical and cognitive context) when they engage
B. Holidays and seasonal spikes
C. Badges and streaks the user has earned
D. Who is in the user's social graph

25. Duolingo added more daily active users in Q1 2025 than in any earlier quarter. Which Events lever is plausibly part of the reason?

A. A major redesign of the lesson interface
B. The launch of a new subscription tier
C. A viral referral marketing campaign
D. New Year's resolution-makers picking up language learning

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/sticky-apps/design-patterns-and-ethics

STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 9 OF 11

Case Studies in Stickiness

Duolingo: the gamification benchmark · TikTok & Instagram · Snapchat & FarmVille

WHAT YOU'LL BE ABLE TO DO

- Explain Duolingo's demotion threat and variable XP as loss-aversion and variable-ratio mechanics, and how AI scaled its content.
- Cite Duolingo's DAU/MAU ratio versus the industry average, its day-over-day retention, and its market-cap growth.
- Contrast TikTok's interest graph and completion signal with Instagram's social-graph moat.
- Explain Snapchat's ephemeral content and Group Streaks as FOMO and loss-aversion engines.
- Explain FarmVille's social-obligation gift-sending loops and cite its peak monthly active users.

Duolingo: the gamification benchmark

Duolingo didn't invent gamification, but it operationalized it at a scale that is now the reference case. The mechanics below are straightforward; what is instructive is how precisely each one maps to a known psychological lever.

The fire and the hourglass

The **streak** counter is a number that grows by one each day you open the app. Duolingo then threatens to zero it: the fire icon dims, an hourglass appears, and a push notification warns that your streak dies at midnight. The mechanism is **loss aversion** — people feel losses roughly twice as intensely as equivalent gains — so the dread of losing a 47-day streak outweighs the mild satisfaction of extending it. The counter does not measure fluency; it measures the strength of a daily habit loop. That is precisely the point.

Leagues and the fear of dropping

Duolingo's weekly **leaderboards** sort users into named tiers and promote or demote them based on XP. The fear of demotion reliably outweighs the desire to advance — users who sit near the cutoff line earn far more XP than users safely in the middle. Loss aversion, again. Duolingo's **DAU/MAU ratio** — the fraction of monthly users who open the app daily — reached **36%**, roughly double the **20%** industry average, which is the metric most analysts credit to these retention mechanics. Day-over-day retention of daily active users sits at **55%**. The company's market cap grew from **5 billion at IPO** to **22 billion by Q1 2025**. When generative AI landed, Duolingo used it to compress course production from 12+ months per course down to weeks, launching **148 new courses in under a year** — proof that the content engine now scales as fast as the engagement model.

XP that isn't fixed

Flat rewards train users to expect a predictable payout and, eventually, to stop caring. **Variable XP** — bonus rounds, surprise multipliers, Perfect Lesson celebrations — keeps the distribution uncertain.

Variable-ratio reinforcement produces the most durable behavior: the next lesson might yield double XP, or nothing extra, and you won't know until you finish. That unpredictability is what makes starting the next lesson worth the cost of opening the app.

TikTok & Instagram

These two platforms made opposite bets about what keeps users — one on the social web, one on a machine-built model of individual taste — and both won, which is why the distinction matters.

What you're drawn to

Every feed algorithm makes a structural choice: organize content around **who you know** (the social graph) or around **what you consume** (the interest graph). TikTok chose the latter. The **For You Page** is cold to strangers — a new account with zero followers sees a fully personalized feed within hours, assembled entirely from behavioral signals. The signals the algorithm weights are completion rate, shares, comments, follows, and re-watches. **Completion and sharing** rank highest. The result is a feed that reflects your revealed preferences rather than your social identity, which is why it consistently surfaces content from creators you have never encountered.

Watched to the last second

Completion rate — the fraction of a video watched to the final second — is TikTok's dominant ranking signal, weighted above likes, comments, and follower count. This creates a structural incentive for creators: a video that hooks but doesn't hold is actively penalized. The underlying recommendation engine uses **matrix factorization**, a technique that finds latent patterns across millions of user-video interactions to predict which unseen video a given user is most likely to finish. Each swipe updates the model. The result is a **variable-ratio** delivery schedule: most videos are ordinary; occasionally one lands exactly right, which is enough to keep swiping.

The graph is the moat

Instagram copied short-form video with Reels and matched TikTok's content quality. It did not close the gap, and the reason is structural. Research found that users value connections with **family and close friends** at a qualitatively different level than content-only connections. The **social graph** — years of accumulated relationships, shared photos, and mutual follows — cannot be ported. It is the moat that content quality alone cannot breach, and it is why Instagram remained the second-largest short-form platform despite replicating the surface mechanics of its rival.

Snapchat & FarmVille

Two case studies in obligation-based retention. One built its entire product thesis on content that vanishes; the other was a browser game that held 74 million people not through enjoyment but through reciprocal social debt.

Disappearing by design

Ephemeral content — posts that auto-delete after viewing or a set time window — is often described as a privacy feature. It was always primarily a behavioral one. When a Snap disappears, it creates two effects: **FOMO** (the recipient must open it now, not later) and reduced social anxiety (low-quality posts cost nothing to send because no permanent record exists). Disappearing makes posting feel cheap, which makes it frequent, which feeds the habit loop. Snapchat's streak mechanic then converts that frequency into a loss-aversion engine — you're not protecting quality content, you're protecting a number. Ephemeral content was the mechanism; the daily open was the goal.

Streaks go collective

Individual streaks require only two users. In September 2025 Snapchat launched **Group Streaks**, which extended the obligation to multi-person chains: most members of the group must Snap for the collective streak to survive. Non-participation now costs you the group's streak, not just a single friendship. This multiplies social pressure by the size of the group — a well-understood principle that FOMO and social obligation scale with the number of relationships implicated. The architecture is the same loss-aversion loop; the blast radius is larger.

The proof of concept

FarmVille (2009, peak **74 million monthly active users**) was the earliest mass demonstration that obligation loops, not fun, could sustain engagement. Players needed **gifts** from real Facebook friends to unlock crops and buildings; those friends needed gifts in return. Progress was structurally coupled to other people's participation. The game wasn't particularly enjoyable — most players described it as a chore — but the **social-obligation loop** and loss aversion over planted crops kept them returning. FarmVille proved that reciprocal mechanics could hold millions of users without the product being intrinsically rewarding.

Key terms

Demotion threat

A league mechanic where falling below a tier's cutoff drops you a rank — the fear of dropping is engineered to motivate more than the desire to advance.

Interest graph

A machine-curated map of what you are drawn to rather than who you know. TikTok's For You Page replaced the social graph with an interest graph, letting a follower-less user get viral distribution in 24 hours.

Ephemeral content

Posts that auto-delete after viewing or a set window — engineered to create urgency and to lower the social anxiety of sharing imperfect moments.

Key concepts

Instagram

- This platform copied short-form video and matched its rival's content quality — but still couldn't close the gap.
- The reason is structural: its moat is the social graph, years of accumulated real-world relationships that can't be ported.
- It launched Reels to counter its rival and stayed the second-largest short-form platform on the strength of family and close-friend ties.

Snapchat

- This app built its thesis on ephemeral content — posts that auto-delete after viewing or a set window.
- Disappearing posts create FOMO and lower social anxiety, making posting feel cheap and frequent — feeding a daily-open habit.
- Its streak mechanic turns that frequency into a loss-aversion engine; in September 2025 it launched Group Streaks to extend the obligation to whole chat groups.

Key facts

> **The fire and the hourglass**
> Duolingo's **streak** turns a counter into a daily anxiety. The fire emoji and the hourglass warning create a low-grade dread that resolves only one way: opening the app. The mechanism is **loss aversion** — you log in to avoid losing what you've built.

> **Leagues and the fear of dropping**
> Duolingo's weekly **leaderboards** promote and demote players between tiers. The design exploits a known asymmetry: the fear of dropping a league tier is more motivating than the desire to climb one. Loss aversion, dressed as competition.

> **XP that isn't fixed**
> Lesson completion yields **variable XP** — bonus rounds, surprise multipliers, and 'Perfect Lesson' celebrations. The reward isn't a flat payout; it's unpredictable, which is exactly what keeps the next lesson worth starting.

> **AI Collapsed The Timeline**
> Generative AI let Duolingo launch 148 new courses in under a year, down from more than 12 months of production time per course — a step-change in content breadth that feeds retention.

> **Double The Industry Average**
> Duolingo's DAU/MAU ratio reached 36% — roughly double the 20% industry average, and the number analysts point to as evidence its retention mechanics are working.

What you're drawn to

TikTok swapped the human-curated **social graph** for a machine-curated **interest graph**. The For You Page reads completion rate, shares, comments, follows, and re-watches — weighting **completion and sharing** most heavily.

Watched to the last second

TikTok's algorithm weighs **completion rate** — watch-through to the final second — above almost every other signal. That single weighting creates a race among creators to hold attention to the end, and a per-user model refined by **matrix factorization** with every swipe.

The graph is the moat

Even as Instagram chased content, the **social graph** stayed its moat. Research found users value connections with family and close friends far above content-only connections — so the graph is functionally irreplaceable even when a competitor clones the content quality.

Family Ties Hit Different

Research behind the Instagram case study found that users value connections with family and close friends at a qualitatively different level than purely content-based follows.

Sharing Beats Social Proof

TikTok's ranking weighs completion and sharing above comments, follows, and re-watches — a bet on revealed preference, what you actually finish and pass on, over social signals like who you follow.

Disappearing by design

Snapchat built around **ephemeral content** — but that wasn't a privacy feature, it was behavioral design. Disappearing Snaps create urgency (FOMO) and lower the social anxiety of sharing imperfect content. Vanishing makes posting feel cheap, which makes it frequent.

Streaks go collective

Snapchat's September 2025 **Group Streaks** extend the obligation to multi-person relationships: collective Snapping from most of a group keeps the streak alive. Now non-participation costs you the group, not just a friend — multiplying the social pressure.

The proof of concept

FarmVille (2009) was the prototype for social-obligation loops. Its **gift-sending** mechanics required other players to participate — your progress depended on theirs, and theirs on yours. The loop ran on social obligation and loss aversion, not on the game being fun.

Protecting A Number

Snapchat's streak mechanic turns posting frequency into a loss-aversion engine: users keep opening the app to protect a number, not because that day's content matters.

74 Million Farmers

FarmVille peaked at 74 million monthly active users in 2009 — the earliest mass demonstration that an obligation loop could sustain engagement at that scale.

By the numbers

New Duolingo courses launched in under a year using generative AI (vs. 12+ months each before)
148 courses

Duolingo's DAU/MAU ratio
36 %

Industry-average DAU/MAU ratio (Duolingo sits well above this)
20 %

Duolingo's day-over-day retention of daily active users
55 %

Duolingo's market cap at IPO
5000000000 USD

Duolingo's market cap by Q1 2025
22000000000 USD

FarmVille's peak monthly active users (2009-era)
74 million-users

Matched pairs

Each item on the left goes with the one on the right.

TikTok → Interest graph + variable-ratio For You Page

Instagram → Social graph moat + algorithmic Reels broadcast

Snapchat → Ephemeral content + loss-aversion streaks

FarmVille → Social-obligation gift-sending loops

Self-test

Answer each question from memory, then check your work against the answer key.

1. Lesson completion yields **variable XP** — bonus rounds, surprise multipliers, and '___' celebrations. The reward isn't a flat payout; it's unpredictable, which is exactly what keeps the next lesson worth starting.

A. Combo Bonus
B. Legendary Level
C. Perfect Lesson
D. Lightning Round

2. What did generative AI change about Duolingo's content production?

A) It removed the need for leaderboards
B) It let them launch 148 new courses in under a year, instead of 12+ months per course
C) It replaced the streak with an AI tutor
D) It auto-translated user posts

3. Duolingo's league demotion threat works because of which psychological lever?

A) Loss aversion — the fear of dropping a tier outweighs the desire to climb
B) Anchoring — the first XP number sets expectations
C) Reciprocity — users feel obliged to repay the app
D) Social proof — users copy what top-ranked players do

4. Duolingo's variable XP (bonus rounds, surprise multipliers) is an example of which reinforcement schedule?

A) Continuous reinforcement
B) Fixed-ratio reinforcement
C) Fixed-interval reinforcement
D) Variable-ratio reinforcement

5. How did generative AI change Duolingo's course production timeline?

A) It compressed course-building from 12+ months each down to weeks
B) It slowed launches to ensure higher quality
C) It eliminated the need for human course designers entirely
D) It doubled the length of each course

6. What is Duolingo's DAU/MAU ratio, the metric analysts credit to its retention mechanics?

A) 55%
B) 20%
C) 74%
D) 36%

7. Duolingo's 36% DAU/MAU ratio is roughly double what industry average?

A) 10%
B) 20%
C) 55%
D) 30%

8. What is Duolingo's day-over-day retention of its daily active users?

A) 20%
B) 22%
C) 55%
D) 36%

9. How did Duolingo's market cap change from its IPO to Q1 2025?

A) From $5 billion to $12 billion
B) From $2 billion to $10 billion
C) From $5 billion to $22 billion
D) From $10 billion to $22 billion

10. Which figure is NOT one of Duolingo's reported metrics?

A) An 80% DAU/MAU ratio
B) A 55% day-over-day retention rate
C) A $22 billion market cap by Q1 2025
D) A 36% DAU/MAU ratio

11. Which signal does TikTok's algorithm weight above almost all others?

A. Number of followers a creator has
B. Completion rate — watch-through to the final second
C. How recently the video was posted
D. Whether you follow the creator

12. TikTok's For You Page is built around which organizing principle?

A. The location graph — where you are
B. The social graph — who you know
C. The follower graph — who follows you
D. The interest graph — what you consume

13. Research cited in the Instagram case found users value which connections at a qualitatively different level?

A. Connections with creators discovered algorithmically
B. Connections with brands and advertisers
C. Connections with the highest-follower accounts
D. Connections with family and close friends

14. Why did Instagram fail to close the gap with TikTok despite matching content quality with Reels?

A. It did not weight completion rate
B. Its recommendation algorithm was technically inferior
C. The social graph — years of accumulated relationships — cannot be ported
D. It had far fewer monthly users to learn from

15. Which two signals does TikTok's algorithm weight most heavily?

A. Completion and sharing
B. Likes and follower count
C. Comments and posting recency
D. Follows and re-watches

16. According to the case study, when a Snap disappears it produces two behavioral effects. Which pair?

A. Competitiveness and a fear of losing streaks
B. FOMO for the recipient and reduced social anxiety for the sender
C. Nostalgia and a sense of exclusivity
D. Trust in the app's privacy and reduced screen-time guilt

17. How does the case study characterize Snapchat's ephemeral content?

A. A moderation tool to limit harmful posts
B. A monetization feature for ads
C. Purely a privacy feature with no behavioral aim
D. Primarily behavioral design, not a privacy feature

18. What did Snapchat's September 2025 Group Streaks change about the streak mechanic?

A. They capped streaks at a fixed number of days
B. They removed streaks to reduce user anxiety
C. They extended the obligation to multi-person chains, multiplying social pressure
D. They made streaks purely individual again

19. Snapchat's streak mechanic converts posting frequency into an engine driven by which lever?

A Loss aversion — protecting a number, not the content
B Scarcity of storage space
C Novelty — always showing fresh content
D Social proof — mimicking popular users

20. Which principle explains why Group Streaks increase pressure more than individual streaks?

A Streaks reset faster with more participants
B FOMO and social obligation scale with the number of relationships implicated
C Group members can see each other's private messages
D Larger groups earn more in-app currency

21. What was FarmVille's peak monthly active users?

A 36 million
B 22 million
C 148 million
D 74 million

22. What mechanic structurally coupled a FarmVille player's progress to other people's participation?

A Ephemeral crops that vanished after viewing
B A shared leaderboard that reset weekly
C Needing gifts from real Facebook friends to unlock crops and buildings
D A subscription that friends had to co-sign

23. What did FarmVille prove about what sustains engagement?

A Variable rewards are the sole driver of retention
B Reciprocal obligation loops can hold millions without the product being intrinsically rewarding
C Only genuinely fun games can retain large audiences
D Content quality always beats social mechanics

24. In what year did FarmVille launch and reach its mass-engagement peak?

A 2009
B 2012
C 2005
D 2015

25. Which statement about FarmVille is NOT supported by the case study?

A It peaked at 74 million monthly active users
B Players returned mainly because the game was intrinsically fun
C Loss aversion over planted crops helped retain players
D Progress depended on friends sending gifts

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/sticky-apps/case-studies-in-stickiness

STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 10 OF 11

Who's Who & What's What of Stickiness

The people behind the playbook · The frameworks and effects · Right or Wrong: spot the mechanic

WHAT YOU'LL BE ABLE TO DO

- Recognize the academic pioneers of persuasive design (BJ Fogg, Nir Eyal, B.F. Skinner) from clues about their contributions.
- Recognize the neuroscience and behavioral-economics figures (Kent Berridge, Wolfram Schultz, Daniel Kahneman) by the idea they established.
- Recognize the designers and critics (Csikszentmihalyi, Yu-kai Chou, Aza Raskin, Anna Lembke) by the concept they are welded to.
- Recognize the core frameworks and effects by description (Hook Model, B=MAP, variable-ratio, loss aversion, Zeigarnik, goal gradient).
- Recognize the social/growth and neuro frameworks (network effects, K-factor, Octalysis, Default Mode Network) and spot the Zeigarnik pattern.

Every mechanic in this pack traces back to a name — a researcher who ran the experiment, a designer who shipped the pattern, or a framework that gave it a shape. This lesson is recognition practice. Given a few clues, can you name the **person** behind an idea, or the **framework** behind a description? Once the cast and the concepts are second nature, the whole playbook reads as one connected system rather than a grab-bag of tricks.

The people behind the playbook

The discipline starts in academia. **BJ Fogg** proved at Stanford that computers could change behavior, coined *captology*, and gave the field its formula. **Nir Eyal** translated the research into a practitioner's loop that product teams everywhere now follow. Reaching further back, **B.F. Skinner**'s mid-century rats — pressing levers on unpredictable schedules — are still the single most cited body of work in product design.

The neuroscience has its own pioneers. **Kent Berridge** split *wanting* from *liking*, showing dopamine is about pursuit, not pleasure. **Wolfram Schultz** mapped the reward-prediction-error signal that makes uncertainty so compelling. And **Daniel Kahneman**, with Amos Tversky, established that losses hurt about twice as much as equivalent gains — the bedrock of every streak.

Then the designers and critics. **Mihaly Csikszentmihalyi** named the absorbed "flow" state that dynamic-difficulty systems chase. **Yu-kai Chou** mapped eight "Core Drives" of motivation into a single framework. **Aza Raskin** invented the bottomless feed that erased the natural stopping point — and later became one of its loudest critics. And **Anna Lembke**, a Stanford psychiatrist, gave us the language of "digital

dopamine" and the smartphone as a "modern-day hypodermic needle." Recognize each by the idea they're welded to.

The frameworks and effects

The ideas themselves deserve names on sight. **The Hook Model** is Eyal's Trigger → Action → Variable Reward → Investment loop. **The Fogg Behavior Model (B=MAP)** is the equation B = Motivation × Ability × Prompt — the conditions for a behavior to fire. **Variable-Ratio Reinforcement** is the slot-machine schedule: rewards after an unpredictable number of actions, the most extinction-resistant pattern there is.

From behavioral economics comes **Loss Aversion** — losses felt roughly twice as strongly as gains, the engine of the streak — and **The Zeigarnik Effect**, our pull toward unfinished tasks, exploited by progress bars stuck at 95%. From the social layer come **Network Effects** (more users, more value, modeled by Metcalfe's Law) and **The K-Factor**, the viral coefficient i × c that, above 1, turns growth exponential. From gamification comes **The Octalysis Framework**'s eight Core Drives and **The Goal Gradient Effect**, our acceleration toward a nearing reward. And from neuroscience, **The Default Mode Network** — the "zoning-out" brain state that infinite scroll is built to induce. Learn to spot each from a sentence of description, and the entire stack is at your command.

Key concepts

BJ Fogg

- A Stanford researcher who, in the 1990s, proved computers could deliberately change human attitudes and behavior.
- He coined a term for the study of computers as persuasive technologies and founded a Stanford lab to pursue it.
- His model — Behavior = Motivation × Ability × Prompt — became the product-design bible of the mobile era.

Nir Eyal

- A product-design writer who distilled the industry's habit-forming techniques into one practitioner framework.
- His 2014 book taught teams at Snapchat, Instagram, and Twitter to build products people return to instinctively.
- His four-stage loop runs Trigger, Action, Variable Reward, and Investment.

B.F. Skinner

- A mid-20th-century behaviorist whose rat experiments remain the most cited research in product design.
- He showed that rewarding a behavior on an unpredictable schedule makes it far more frequent and persistent.
- His lever-pressing rats on a variable-ratio schedule are the blueprint for the slot machine and the notification.

Kent Berridge

- A neuroscientist who overturned the popular idea that one brain chemical is simply about pleasure.
- He separated 'wanting' — seeking and motivation — from 'liking' — satisfaction — as two distinct neural systems.
- His work explains why scrolling a feed stays compulsive even when the content barely satisfies.

Wolfram Schultz

- A neuroscientist who mapped how dopamine neurons respond to rewards versus expectations.
- He described the signal that fires when an outcome beats expectations and is suppressed when it falls short.
- That 'reward prediction error' in the ventral tegmental area is driven by uncertainty, not certainty.

Daniel Kahneman

- A psychologist who won a Nobel Prize in economics for his work on human judgment and decision-making.
- With his collaborator Amos Tversky, he showed people weigh losses far more heavily than equivalent gains.
- Their Prospect Theory is the engine behind the streak: breaking it hurts more than keeping it ever helped.

Mihaly Csikszentmihalyi

- A Hungarian-American psychologist and a founder of positive psychology.
- He described the state of total absorption that appears when a task's challenge matches the user's skill.
- Apps chase his 'channel' with dynamic difficulty — too easy bores, too hard breeds anxiety.

Yu-kai Chou

- A gamification designer who argues points and badges are only the shallow surface of motivation.
- He cataloged eight 'Core Drives' behind human behavior, from Epic Meaning to Ownership.
- His framework, named for its eight-sided shape, says durable apps engage several drives at once.

Aza Raskin

- An interface designer who later became a prominent critic of the attention economy he helped build.
- In 2006 he created a design feature that removed the natural stopping point from digital consumption.
- His invention — the bottomless feed — keeps content loading so a session never has to end.

Anna Lembke

- A Stanford psychiatrist who studies addiction and modern compulsion.
- She calls the smartphone 'the modern-day hypodermic needle,' delivering its reward to a wired generation.
- Her book frames our constant scrolling as a problem of 'digital dopamine' and overconsumption.

The Hook Model

- A practitioner framework from a 2014 book, now standard at the major social apps.
- It describes a four-stage loop that converts first-time users into habitual ones.
- Its stages run Trigger, Action, Variable Reward, and Investment.

The Fogg Behavior Model (B=MAP)

- A formula, from a Stanford researcher, for when a behavior will actually happen.
- It says three ingredients must converge at the same moment for an action to occur.
- Written B = M × A × P, it multiplies Motivation, Ability, and a Prompt.

Variable-Ratio Reinforcement

- A reinforcement schedule first studied in mid-century rat experiments.
- It delivers a reward only after an unpredictable number of actions.
- It produces the highest, most extinction-resistant response rates — the slot-machine pattern.

Loss Aversion

- A principle from Prospect Theory about how people value gains and losses unequally.
- Losing something feels roughly twice as powerful as gaining the same thing.
- It is the psychology that makes breaking a 100-day streak feel devastating.

The Zeigarnik Effect

- A memory phenomenon weaponized by progress bars left stuck at 95%.
- People remember and are pulled back toward incomplete tasks more than finished ones.
- Apps open a loop — 'just 2 more cards' — then fire a notification to close it.

Network Effects

- A property that makes a product more valuable to each user as more people join it.
- Metcalfe's Law models its value as scaling with the square of the user count.
- It is the moat behind Facebook's six concentric 'walls' of defensibility.

The K-Factor (Viral Coefficient)

- A single number that measures how virally a product grows.
- It equals the invitations sent per user times the conversion rate of those invitations.
- Above 1, growth becomes exponential and self-sustaining.

The Octalysis Framework

- A gamification model built around an eight-sided diagram.
- Each side is one of eight 'Core Drives' of human motivation, such as Epic Meaning.
- It argues the stickiest apps engage several of those drives at the same time.

The Goal Gradient Effect

- A behavioral pattern about effort and proximity to a reward.
- People accelerate as they get closer to a finish line or milestone.
- It's why a punch card with two pre-stamped holes outperforms a blank one.

The Default Mode Network

- A brain network that takes over during easy, habitual, mind-wandering activity.
- When it dominates, the prefrontal cortex's top-down executive control goes offline.
- Users call it 'zoning out' — and it is the state infinite scroll is designed to induce.

Self-test

Answer each question from memory, then check your work against the answer key.

1. Which researcher proved at Stanford that computers could change behavior and coined the term 'captology'?

A BJ Fogg
B B.F. Skinner
C Nir Eyal
D Kent Berridge

2. Whose mid-century experiments with rats pressing levers on unpredictable schedules remain the single most cited body of work in product design?

A BJ Fogg
B Nir Eyal
C Kent Berridge
D B.F. Skinner

3. Who translated academic persuasion research into a practitioner's loop that product teams everywhere now follow?

A BJ Fogg
B Nir Eyal
C Daniel Kahneman
D B.F. Skinner

4. Which of the following is NOT associated with BJ Fogg?

A Proving computers can change behavior
B Working at Stanford
C Creating the Hook Model loop
D Coining the term captology

5. The 'formula' that gave persuasive design its shape (later expressed as B=MAP) is credited to which researcher?

A B.F. Skinner
B Nir Eyal
C Wolfram Schultz
D BJ Fogg

6. Who split 'wanting' from 'liking,' showing dopamine is about pursuit rather than pleasure?

A Daniel Kahneman
B Kent Berridge
C Wolfram Schultz
D BJ Fogg

7. Which neuroscientist mapped the reward-prediction-error signal that makes uncertainty so compelling?

A Wolfram Schultz
B Kent Berridge
C B.F. Skinner
D Daniel Kahneman

8. Who, working with Amos Tversky, established that losses hurt about twice as much as equivalent gains?

A B.F. Skinner
B Kent Berridge
C Daniel Kahneman
D Wolfram Schultz

9. The bedrock finding behind every streak mechanic — that losing stings roughly twice as much as gaining — comes from which figure?

A Kent Berridge
B Mihaly Csikszentmihalyi
C Wolfram Schultz
D Daniel Kahneman

10. Which figure is correctly paired with their contribution?

A Skinner — the flow state
B Schultz — loss aversion
C Berridge — wanting vs. liking
D Kahneman — reward-prediction error

11. Who named the absorbed 'flow' state that dynamic-difficulty systems try to chase?

A Anna Lembke
B Mihaly Csikszentmihalyi
C Yu-kai Chou
D Aza Raskin

12. Who mapped eight 'Core Drives' of motivation into a single gamification framework?

A Yu-kai Chou
B BJ Fogg
C Aza Raskin
D Mihaly Csikszentmihalyi

13. Who invented the bottomless feed that erased the natural stopping point, then later became one of its loudest critics?

A Nir Eyal
B Aza Raskin
C Anna Lembke
D Yu-kai Chou

14. Which Stanford psychiatrist gave us 'digital dopamine' and called the smartphone a 'modern-day hypodermic needle'?

A Kent Berridge
B Mihaly Csikszentmihalyi
C Aza Raskin
D Anna Lembke

15. Which designer or critic is NOT correctly matched to their concept?

A Yu-kai Chou — eight Core Drives
B Aza Raskin — the infinite feed
C Anna Lembke — reward-prediction error
D Csikszentmihalyi — the flow state

16. The Hook Model is Nir Eyal's four-stage loop. What is the correct order of its stages?

A Trigger → Action → Variable Reward → Investment
B Motivation → Ability → Prompt → Reward
C Action → Trigger → Investment → Variable Reward
D Trigger → Variable Reward → Action → Investment

17. The Fogg Behavior Model says a behavior fires only when three factors converge. Which equation captures it?

A B = Cue then Routine then Reward
B B = invites × conversion
C B = Trigger + Action + Reward
D B = Motivation × Ability × Prompt

18. Which schedule delivers rewards after an unpredictable number of actions and is the most extinction-resistant pattern known?

A Fixed-Ratio Reinforcement
B Variable-Ratio Reinforcement
C The Goal Gradient Effect
D Loss Aversion

19. Which effect — losses felt roughly twice as strongly as gains — is described as the engine of the streak?

A Loss Aversion
B Network Effects
C The Zeigarnik Effect
D The Goal Gradient Effect

20. Which effect describes our tendency to accelerate as we get closer to a reward?

A The Zeigarnik Effect
B Loss Aversion
C The Goal Gradient Effect
D Variable-Ratio Reinforcement

21. Which design pattern correctly exploits the Zeigarnik effect?

A Pre-populating a new account with suggested friends
B A reward delivered after an unpredictable number of pulls
C A progress bar left stuck at 95% complete
D A leaderboard showing your rank among followers

22. Which effect describes a product becoming more valuable as more people use it, and is modeled by Metcalfe's Law?

A Network Effects
B The Default Mode Network
C The K-Factor
D The Goal Gradient Effect

23. The metric computed as invites × conversion (i × c), which turns growth exponential when it exceeds 1, is called what?

A The Octalysis Framework
B The K-Factor
C Network Effects
D Metcalfe's Law

24. Which framework organizes motivation into eight 'Core Drives'?

A The Default Mode Network
B Network Effects
C The Hook Model
D The Octalysis Framework

25. Which 'zoning-out' brain state is infinite scroll specifically built to induce?

A Variable-Ratio Reinforcement
B The Goal Gradient Effect
C The flow state
D The Default Mode Network

Go deeper

ONLINE This lesson on the web flashfeedlearningapp.com/study-guides/sticky-apps/who-s-who-and-what-s-what-of-stickiness

STUDY The Science of Sticky Apps in the FlashFeed app flashfeedlearningapp.com/packs/sticky-apps

LESSON 11 OF 11

Essential Vocabulary & Quick Recall

Brain & behavior terms · Framework & gamification terms · Social & growth terms · Retention & metrics terms · Quick recall (mixed)

WHAT YOU'LL BE ABLE TO DO

- Recall the core brain and behavioral-economics terms: dopamine, RPE, variable-ratio, DMN, and the biases (loss aversion, endowment, sunk cost, goal gradient).
- Recall the framework and gamification terms: captology, B=MAP, the Hook Model and its stages, and Octalysis.
- Recall the social and growth terms: network effect, Metcalfe's Law, social graph, interest graph, FOMO, viral coefficient, and viral loop.
- Recall the retention and metrics terms: cohort analysis, DAU/MAU, CAC, LTV, Aha Moment, churn, and push notifications.
- Quickly recall mixed pack facts across frameworks, neurochemicals, growth, and retention.

Brain & behavior terms

The neuroscience and behavioral economics behind why apps are hard to put down.

At the center is **dopamine**, the neurochemical that governs wanting and seeking — not liking or satisfaction. It fires during anticipation, not fulfillment, which is why scrolling stays compulsive even when the content disappoints. The mechanism that drives this is **Reward Prediction Error (RPE)**, first described by Wolfram Schultz: dopamine surges when an outcome exceeds expectations and is suppressed when it falls short. Because the system runs on uncertainty rather than certainty, apps that deliver inconsistent payoffs are more compelling than ones that are reliably good.

That uncertainty is formalized in **variable-ratio reinforcement**, from B.F. Skinner's rat experiments — rewards arrive after an unpredictable number of actions. This schedule produces the highest response rates and the greatest resistance to extinction. It is the slot-machine model behind infinite scroll. Meanwhile, **flow state** — Mihaly Csikszentmihalyi's channel where challenge matches skill — describes the engagement zone apps are trying to hit: too easy breeds boredom; too hard breeds anxiety; both drive churn.

When a habit is well-worn and requires little attention, the **Default Mode Network (DMN)** — the brain network associated with mind-wandering and self-referential thought — takes over as prefrontal executive control recedes. Users describe it as zoning out. The **Zeigarnik effect** keeps them returning: incomplete tasks are remembered and craved more than completed ones, which is why apps use progress bars stuck at 95% and "2 more cards" prompts.

Behavioral economics supplies the rest. **Loss aversion**, from Kahneman and Tversky's Prospect Theory, holds that losses feel roughly twice as painful as equivalent gains — the engine behind streak anxiety.

The **endowment effect** means users value things more simply because they own them; data, content, and reputation built inside an app raise switching costs. The **sunk cost fallacy** compounds this: people keep investing because of what they've already put in, even when quitting is rational. A 100-day streak is accumulated sunk cost. Finally, the **goal gradient effect** describes the tendency to accelerate effort near a milestone — which is why pre-stamped punch cards and progress maps lift completion rates as the next reward comes into view.

Framework & gamification terms

The named models and systems designers use to engineer habit-forming products.

Captology — coined by BJ Fogg in 1996 — is the study of Computers As Persuasive Technologies: how computers can be designed to change human thoughts and behaviors. Fogg also gave us the **Fogg Behavior Model (B = MAP)**, which states that Behavior = Motivation × Ability × Prompt. A behavior happens only when all three converge at the same moment, encoding friction reduction into a single equation.

Nir Eyal's **Hook Model** is a four-stage habit loop from his 2014 book *Hooked*: Trigger → Action → Variable Reward → Investment. Each pass makes the product harder to leave. The **trigger** starts the loop — external triggers are notifications, badges, and emails; internal triggers are emotions like boredom or loneliness. The goal is to graduate users from external to internal. The **variable reward** — an unpredictable payoff of the tribe (social validation), the hunt (information), or the self (mastery) — is stage three; predictable rewards habituate and lose pull. **Investment** is stage four: users put something into the product — data, content, connections, reputation — making it more valuable on the next use and raising switching costs via the endowment effect.

PBL (Points, Badges, Leaderboards) is the surface layer of gamification — visible and legible but easy to habituate to. Yu-kai Chou's **Octalysis** goes deeper, identifying eight Core Drives (from Epic Meaning to Ownership to Social Influence) that motivate behavior; the most durable apps engage multiple drives simultaneously.

In execution, **Dynamic Difficulty Adjustment (DDA)** keeps users in the flow channel by analyzing performance in real time and modulating challenge accordingly — Duolingo tests how quickly users learn sections and adjusts course structure. **Streak Freeze** converts streak anxiety into a resource-management meta-game, deepening investment. And the **Doherty Threshold** — sub-400ms response time — is the technical floor: a core loop must provide feedback under this threshold for the system to feel instantaneous and keep users productively engaged.

Social & growth terms

The mechanics that govern how apps spread and why users recruit other users.

The foundation is the **network effect**: a product becomes more valuable to each user as more people use it. Effects can be direct (more users helps you) or indirect (more users improves the content or

infrastructure you rely on). **Metcalfe's Law** models this by stating a network's value scales with the square of its user count (n^2) — though real-world dynamics are more nuanced, since not every connection is equally valuable.

Two different maps define what kind of network a product builds. A **social graph** is a map of real-world, identity-based relationships — who you know. Facebook's early dominance rested on it; it is hard for rivals to replicate. An **interest graph** is a machine-curated map of what you are drawn to rather than who you know. TikTok's For You Page replaced the social graph with an interest graph, letting a follower-less user achieve viral distribution in 24 hours.

Social psychology does a lot of the retention work. **FOMO (Fear of Missing Out)** is anxiety driven not by missing content but by the social cost of non-participation — Instagram Stories' 24-hour expiry works because skipping carries a perceived social penalty. **Parasocial bonds** are oxytocin-mediated emotional attachments to non-reciprocating entities such as Duolingo's Duo owl; the mascot becomes a relationship users don't want to disappoint.

Growth is formalized in a few key metrics. The **viral coefficient (K-factor)** measures how many new users each existing user generates: K = invitations sent × conversion rate. K above 1 means exponential, self-sustaining growth. A **viral loop** is the growth mechanism — users recruit others through sharing or social artifacts intrinsic to the core value loop, not a bolted-on Share button. **Shareable artifacts** are the content users want to share because it reflects well on them (Spotify Wrapped, a "Top 1% of learners" badge) — users promote themselves, the app is the medium. A **referral program** is the explicit invite mechanic; double-sided versions where both referrer and new user receive value outperform single-sided ones by exploiting reciprocity norms.

Retention & metrics terms

The measurements and design principles that determine whether users come back.

Every retention strategy aims at the **Aha Moment** — the instant a product's core value becomes emotionally real. Facebook's was "7 friends in 10 days"; Twitter's was following 30 accounts. Onboarding should deliver every user to this point as fast as possible, since **churn** is the relentless counterforce: a widely cited 2015 analysis by Andrew Chen with Quettra found the average Android app loses about 77% of its daily active users within three days of install. **Progressive disclosure** is the onboarding principle that helps prevent early dropout — reveal complexity gradually rather than exposing every feature at once, so new users aren't overwhelmed before they reach the Aha Moment.

Two metrics govern how health is tracked. **Cohort analysis** tracks the percentage of users from a given install cohort who return on Day 1, 7, 30, and 90 — it is also how teams locate the Aha Moment by finding which early actions correlate with long-term retention. **DAU/MAU ratio** (daily active users as a share of monthly active users) measures habitual return; industry average sits well below 20%; Duolingo reached 36%.

The business metrics connect directly to these. **CAC (Customer Acquisition Cost)** is the cost to acquire one new user — a K-factor above 1 lowers it because users recruit each other. **LTV (Lifetime Value)** is

the total value a user generates over their lifetime. A widely cited figure attributed to Bain & Company holds that raising customer retention rates by 5% increases profits by 25–95%, which is why retention is treated as far more capital-efficient than paid acquisition. Paid loops are sustainable only when LTV greatly exceeds CAC.

Bringing lapsed users back is the job of **push notifications** — the primary channel for reactivation. The most effective ones are contextually timed, personalized to the user's state, and carry a curiosity or FOMO gap. The **core loop** is what those notifications are calling users back to: the fundamental action cycle repeated every session, completable in 2–5 minutes, ending with a variable reward and leaving an open loop that sets up the next visit. What the core loop must never do is deploy **dark patterns** — manipulative design that works against the user's own goals, such as shaming language or impossible cancellation flows. Dark patterns may retain users short-term but destroy long-term trust.

Key terms

Dopamine

The neurochemical that governs wanting and seeking — not liking or satisfaction. It is released during the anticipation of a reward, which is why scrolling stays compulsive even when the content barely satisfies.

Reward Prediction Error (RPE)

The mechanism, first described by Wolfram Schultz, in which dopamine fires strongly in the VTA when an outcome exceeds expectations and is suppressed when it falls below — meaning the system runs on uncertainty, not certainty.

Variable-ratio reinforcement

An operant schedule, from B.F. Skinner's rat experiments, where rewards arrive after an unpredictable number of actions. It produces the highest response rates and the greatest resistance to extinction — the slot-machine model behind infinite scroll.

Default Mode Network (DMN)

The brain network associated with mind-wandering and self-referential thought. When scrolling becomes habitual and easy, the DMN dominates and prefrontal executive control goes offline — users describe it as 'zoning out.'

Loss aversion

From Kahneman and Tversky's Prospect Theory: losses feel roughly twice as psychologically powerful as equivalent gains. It is the engine behind streaks — breaking one triggers pain disproportionate to what was actually lost.

Endowment effect

The tendency to value something more highly simply because you own it. Investment inside an app (data, content, reputation) activates this effect, making the product feel more valuable and raising switching costs.

Sunk cost fallacy
The bias to keep investing in something because of what you have already put in, even when quitting would be rational. A 100-day streak is accumulated sunk cost; abandoning it feels like wasting the prior effort.

Zeigarnik effect
The finding that people remember and are drawn back to incomplete tasks more strongly than completed ones. Apps weaponize it with progress bars stuck at 95%, '2 more cards' prompts, and chapters that unlock but don't let you start.

Flow state
Mihaly Csikszentmihalyi's channel of optimal engagement where challenge matches skill. Too easy breeds boredom; too hard breeds anxiety; both drive churn. The design goal is to keep users inside the flow channel.

Goal gradient effect
The tendency to accelerate effort as you approach a milestone. It explains why a punch card with 2 of 10 holes pre-stamped outperforms a blank one, and why progress maps lift completion near checkpoints — always show how close the next reward is.

Captology
The study of Computers As Persuasive Technologies — how computers can be designed to change human thoughts and behaviors. BJ Fogg coined the term in 1996.

Fogg Behavior Model (B = MAP)
BJ Fogg's formula stating that Behavior = Motivation × Ability × Prompt. A behavior occurs only when motivation, ability, and a prompt converge at the same moment — encoding friction reduction into a single equation.

Hook Model
Nir Eyal's four-stage habit loop from his 2014 book Hooked: Trigger → Action → Variable Reward → Investment. Each pass through the loop makes the product harder to leave and more likely to be opened again.

Trigger
The cue that starts a Hook loop. External triggers are notifications, emails, and badges; internal triggers are emotions like boredom or loneliness. The goal is to graduate users from external to internal triggers over time.

Variable reward
The third Hook stage: an unpredictable payoff of the tribe (social validation), the hunt (information), or the self (mastery). Variability is essential — predictable rewards habituate and lose their pull.

Investment (Hook)
The fourth Hook stage: users put something into the product — data, content, social connections, reputation. Investment makes the product more valuable on the next use and raises switching costs via the endowment effect: everything a user builds inside the app raises the cost of leaving.

PBL (Points, Badges, Leaderboards)

The surface layer of gamification: visible, legible reward elements that are also easy to habituate to. Durable engagement requires deeper mechanics at the level of narrative, identity, and social positioning.

Octalysis

Yu-kai Chou's framework identifying eight Core Drives that motivate behavior — from Epic Meaning to Ownership to Social Influence. The most durable apps engage multiple core drives at once.

Streak Freeze

A purchasable or earnable item that protects a streak during an absence. It converts the streak from a source of attrition-driving anxiety into a resource-management meta-game that deepens investment.

Dynamic Difficulty Adjustment (DDA)

Systems that analyze a user's performance in real time and modulate challenge to keep them inside the flow channel. Duolingo tests how quickly users learn sections and adjusts course structure accordingly.

Doherty Threshold

The sub-400ms response time below which a system feels instantaneous and keeps a user productively engaged. A tight core loop should provide feedback under this threshold.

Network effect

The dynamic where a product becomes more valuable to each user as more people use it. Effects can be direct (more users helps you) or indirect (more users improves the content or infrastructure you rely on).

Metcalfe's Law

A model stating that a network's value scales with the square of its number of users (n^2). Real-world dynamics are more nuanced, since not every connection is equally valuable.

Social graph

A map of real-world, identity-based relationships — who you know. Facebook's early dominance was built on the social graph, which made the platform uniquely defensible and is hard for rivals to replicate.

Interest graph

A machine-curated map of what you are drawn to rather than who you know. TikTok's For You Page replaced the social graph with an interest graph, letting a follower-less user get viral distribution in 24 hours.

FOMO (Fear of Missing Out)

Anxiety driven not by missing content but by the social consequences of missed bonding opportunities. Instagram Stories' 24-hour expiry works because it imposes a social cost for non-participation.

Parasocial bond

An oxytocin-mediated emotional attachment to a non-human or non-reciprocating entity, such as Duolingo's Duo owl. The mascot becomes a relationship the user does not want to disappoint.

Viral coefficient (K-factor)

A measure of how many new users each existing user generates, calculated as K = i × c (invitations sent × conversion rate). K greater than 1 means exponential, self-sustaining growth.

Viral loop
A growth loop in which users naturally recruit others through sharing, invitations, or social artifacts. It works best when sharing is intrinsic to the core value loop, not a bolted-on 'Share' button.

Shareable artifact
Content a user wants to share because it reflects well on them — Spotify Wrapped, a 'Top 1% of learners' badge. The user is promoting themselves, not the app; the app is merely the medium.

Referral program
An invite mechanic for acquisition. Double-sided versions, where both referrer and new user get value, outperform single-sided ones by exploiting reciprocity norms — as in Uber's early 'give a ride, get a ride.'

Aha Moment
The instant an app's core value becomes emotionally real — feeling the value, not finishing a tutorial. Facebook's was '7 friends in 10 days'; Twitter's was following 30 accounts. Onboarding should deliver every user here fast.

Push notification
The primary channel for reactivating users who have left the habit loop. The most effective ones are contextually timed, personalized to the user's state, and carry a curiosity or FOMO gap.

Cohort analysis
Tracking the percentage of users from a given install cohort who return on Day 1, 7, 30, and 90. It is also how teams identify the Aha Moment — the early actions that correlate with long-term retention.

DAU/MAU ratio
Daily active users as a share of monthly active users — a measure of how habitually people return. Industry average sits well below 20%; Duolingo has reported figures in the mid-30s% range in recent shareholder letters.

CAC (Customer Acquisition Cost)
The cost to acquire one new user. A K-factor above 1 lowers CAC because users recruit each other, cutting the paid-acquisition spend needed to hit growth targets.

LTV (Lifetime Value)
The total value a user generates over their lifetime. Paid acquisition loops are sustainable only when it greatly exceeds CAC.

Churn
The loss of users over time. A widely cited 2015 analysis by Andrew Chen with Quettra found the average Android app loses about 77% of its daily active users within three days of install, which is why the onboarding-to-Aha pipeline is a high-leverage place to fight churn.

Dark pattern
A manipulative design that works against the user's own goals — shaming language ('No, I don't want to be smart'), impossible cancellation flows, manufactured scarcity. Dark patterns destroy long-term trust.

Progressive disclosure
An onboarding principle of revealing complexity gradually rather than exposing every feature at once, so new users aren't overwhelmed before they reach the Aha Moment.

Core loop

The fundamental action cycle a user repeats every session. A good one is completable in 2–5 minutes, gives feedback under the Doherty Threshold, ends with a variable reward, and sets up the next session via an open loop.

Key concepts

Reward Prediction Error

- First described by Wolfram Schultz, this is the signal at the core of the brain's wanting system.
- Dopamine surges when an outcome beats expectations and is suppressed when it falls short.
- Because it runs on the gap between expected and actual payoff, apps with uncertain outcomes are more compelling than reliably good ones.

Flow state

- Named by the psychologist Mihaly Csikszentmihalyi, this is the engagement zone apps are trying to hit.
- It is the channel where the challenge presented exactly matches the user's skill.
- Too easy breeds boredom and too hard breeds anxiety — both drive churn, so apps aim for this balanced zone.

The sunk cost fallacy

- This reasoning error keeps people committed to something long after quitting would be the rational move.
- It means continuing to invest because of what you've already put in, not because of future value.
- A 100-day streak is the classic example — abandoning it feels like wasting everything already accumulated.

Key facts

> **Rewards Of The Self**
> One of the Hook Model's variable-reward types is 'rewards of the self' — the mastery hit from finishing something, leveling up, or hitting a personal milestone.

> **Retention's Big Profit Payoff**
> A figure attributed to Bain & Company's Frederick Reichheld says raising customer retention rates by 5% increases profits by 25 to 95 percent — one reason retention is treated as a more capital-efficient lever than paid acquisition.

Matched pairs

Each item on the left goes with the one on the right.

Rewards of the tribe → Social validation — likes, comments, recognition

Rewards of the hunt → Information seeking — scrolling a feed for the next good thing

Rewards of the self → Mastery and progress — completion, leveling up, personal accomplishment

BJ Fogg → Coined captology; founded the Stanford Persuasive Technology Lab

Oxytocin → Social bonding & trust

Variable Reward → An unpredictable outcome — a funny post, a good trade, a match

Challenge far below skill → Boredom — the user disengages and churns

Variable-interval reinforcement → When will the next match arrive?

Parasocial bond (Duo owl) → Oxytocin — bonding with a non-human entity

Content/ASO loop → User activity becoming content that lifts App Store visibility

Personalized notification → 'Your 14-day streak is at risk'

Self-test

Answer each question from memory, then check your work against the answer key.

1. According to neuroscience, dopamine is primarily responsible for what?

- A Liking — the pleasure and satisfaction felt when a reward actually arrives
- B Wanting and seeking — it fires during the anticipation of a reward, not its delivery
- C Calm — the relief that shuts down craving once a habit is satisfied
- D Memory — encoding after the fact which rewards were worth pursuing

2. Which mechanism, first described by Wolfram Schultz, has dopamine surge when an outcome beats expectations and drop when it falls short?

- A Reward Prediction Error (RPE)
- B Variable-ratio reinforcement
- C Loss aversion
- D The goal gradient effect

3. Which reward schedule, from B.F. Skinner's experiments, pays out after an unpredictable number of actions and is the model behind infinite scroll?

- A Reward Prediction Error
- B Fixed-interval reinforcement
- C Progressive disclosure
- D Variable-ratio reinforcement

4. When scrolling becomes habitual and users describe 'zoning out,' which network takes over as prefrontal executive control recedes?

- A Ventral tegmental area
- B The flow channel
- C Default Mode Network (DMN)
- D The reward prediction system

5. A punch card with 2 of 10 holes pre-stamped drives more completion than a blank 8-hole card. Which bias best explains this?

A Goal gradient effect
B Sunk cost fallacy
C Zeigarnik effect
D Endowment effect

6. In Nir Eyal's Hook Model, what is the correct order of the four stages that form the habit loop?

A Action → Trigger → Investment → Variable Reward
B Trigger → Action → Investment → Variable Reward
C Trigger → Variable Reward → Action → Investment
D Trigger → Action → Variable Reward → Investment

7. In Nir Eyal's Hook Model, which is an example of an INTERNAL trigger rather than an external one?

A A push notification
B Boredom or loneliness
C A reminder email
D A badge shown in the app

8. Captology, coined by BJ Fogg in 1996, is the study of what?

A Consumer purchase psychology
B Cognitive load in app design
C Computers As Persuasive Technologies
D Compulsive scrolling behavior

9. The Fogg Behavior Model says a behavior occurs only when which three factors converge at the same moment?

A Motivation, Ability, and Payoff
B Motivation, Ability, and a Prompt
C Points, Badges, and Leaderboards
D Trigger, Action, and Reward

10. Yu-kai Chou's Octalysis framework maps how many Core Drives that motivate behavior?

A Eight
B Three
C Ten
D Four

11. Metcalfe's Law models the value of a network as proportional to what?

A The cube of its number of users (n^3)
B The logarithm of its number of users (log n)
C The square of its number of users (n^2)
D Its number of users (n)

12. What is the dynamic in which a product becomes more valuable to each user as more people use it?

A A viral loop
B A referral program
C The endowment effect
D The network effect

13. TikTok's For You Page let follower-less users go viral in 24 hours by replacing the social graph with what?

A Metcalfe's Law
B A larger social graph
C A referral program
D An interest graph

14. In this pack, FOMO is described as anxiety driven mainly by what — not by missing the content itself?

A The social cost of non-participation
B Falling behind on notifications
C The loss of a login streak
D The fear of overspending

15. The metric computed as invites × conversion (i × c), which turns growth exponential when it exceeds 1, is called what?

A Metcalfe's Law
B Network Effects
C The K-Factor
D The Octalysis Framework

16. Facebook's classic Aha Moment — the point where its core value became emotionally real — was quantified as which early milestone?

A Posting 3 status updates on day one
B Adding 7 friends in 10 days
C Sending 5 messages within 24 hours
D Following 30 accounts in the first week

17. Which is NOT one of the three rules for effective push notifications?

A Open a curiosity or FOMO gap
B Personalize it to the user's specific state
C Time it to moments of high probability of action
D Send at the same fixed interval every day regardless of context

18. According to the pack, roughly what share of users stop using an app within three days of install?

A About 20%
B About 36%
C About 80%
D About 50%

19. The ratio that measures habitual return divides daily active users by what?

A Monthly active users
B Lifetime users
C New installs this month
D Total registered users

20. A K-factor above 1 lowers which business metric, because existing users recruit new ones for free?

A Churn rate
B CAC (Customer Acquisition Cost)
C DAU/MAU ratio
D LTV (Lifetime Value)

21. Why do double-sided referral programs outperform single-sided ones?

A They swap the user's social graph for a machine-curated interest graph
B They exploit reciprocity norms by rewarding both the referrer and the new user
C They pay rewards in cash only, which users value more than app credit
D They guarantee a K-factor above 1, whatever the conversion rate

22. What are the four stages of Nir Eyal's Hook Model, in order?

A Motivation → Ability → Prompt → Reward

B Acquisition → Activation → Retention → Referral

C Action → Trigger → Investment → Reward

D Trigger → Action → Variable Reward → Investment

23. How do product teams identify an app's Aha Moment?

A Analyze which early actions correlate with long-term retention in cohort data

B Pick the final screen of the onboarding tutorial

C Ask users in a survey what they enjoyed most

D Copy whatever the market-leading competitor does

24. A parasocial bond with Duolingo's Duo owl, a relationship users don't want to disappoint, is mediated primarily by which neurochemical?

A Cortisol

B Dopamine

C Oxytocin

D Serotonin

25. Why is the PBL (Points, Badges, Leaderboards) layer considered shallow gamification?

A It rewards only the top-ranked users and ignores everyone else

B It depends entirely on real-money purchases to work

C It's visible and legible but easy to habituate to

D It cannot be layered with any other game mechanic

Go deeper

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Answer key

Lesson 1: How We Got Here

1. D Stanford Persuasive Technology Lab

2. A Persuasive technologies

Captology stands for Computers As Persuasive Technologies — the study of how computers can be designed to change human thoughts and behaviors.

3. C BJ Fogg

BJ Fogg coined captology in 1996. Eyal wrote Hooked, Raskin patented infinite scroll, and Lembke wrote Dopamine Nation.

4. B Coining captology and founding the Stanford Persuasive Technology Lab

Fogg both coined captology (1996) and founded the Stanford Persuasive Technology Lab (1998). The other pairs belong to Raskin/Eyal, Zynga, and TikTok/Lembke.

5. C It was coined by Nir Eyal in his book Hooked

Captology was coined by BJ Fogg in 1996, not by Nir Eyal. The other three statements are all accurate.

6. B 1993

The Charismatic Computers dissertation was 1993. Captology was coined in 1996, the lab founded in 1998, and the Persuasive Technology book published in 2003.

7. A 1996

Captology was coined in 1996 — three years after the 1993 dissertation and two years before the 1998 lab.

8. D 1998

Fogg founded the Stanford Persuasive Technology Lab in 1998, after coining captology in 1996 and before his 2003 book.

9. C 2003

The book was published in 2003, five years after the 1998 lab founding. It predated the iPhone (2007).

10. A Dissertation → coining captology → founding the lab → publishing the book

The order is dissertation (1993) → captology coined (1996) → Stanford lab (1998) → Persuasive Technology book (2003).

11. B Facebook Developer Platform

12. D Direct access to users' social graph, so friends could see and affect each other's games

The platform opened Facebook's social graph to outside teams, so friends could see and affect each other's games — making social obligation the core mechanic. Reinforcement-learning feeds came later with TikTok.

13. A 1 million

FarmVille hit 1 million DAU in four days and 30 million in six months — figures with no precedent in consumer software.

14. D 30 million

FarmVille grew to 30 million DAU in six months, up from 1 million in its first four days.

15. C An engineered viral loop of social proof, gifting, and 'friend needs help' notifications

Growth came from a tightly engineered viral loop — visible farms as social proof, resource-gifting requiring friends, and lapsed-user notifications — not gameplay depth.

16. B App Store

17. B Aza Raskin

Aza Raskin patented infinite scroll in 2006. Fogg coined captology, Eyal wrote Hooked, and Lembke coined 'digital dopamine'.

18. C A feed that loads content endlessly as you scroll

Infinite scroll is a feed design with no natural stopping point that loads content endlessly, removing the cues that told you to stop.

19. D Anna Lembke

Anna Lembke, Stanford psychiatrist and author of Dopamine Nation, used the hypodermic-needle metaphor for digital dopamine.

20. A A conditioning chamber you carry everywhere

The portable Skinner box metaphor casts the smartphone as a conditioning chamber that travels with you, able to condition users in every idle moment.

21. C Trigger → Action → Variable Reward → Investment

The Hook Model loops through Trigger, Action, Variable Reward, and Investment. Motivation × Ability × Prompt is Fogg's separate B=MAP equation.

22. A Nir Eyal

Nir Eyal wrote Hooked (2014) and synthesized practitioner knowledge into the Hook Model. Fogg's separate framework is B=MAP.

23. D 2014

Hooked was published in 2014 — after the iPhone (2007) and App Store (2008) had primed a cohort of mobile teams for the synthesis.

24. B 2018

TikTok launched globally in 2018, four years after Hooked (2014), shifting the field from human-designed loops to algorithm-optimized conditioning.

25. D A reinforcement-learning algorithm inferring preferences from watch time, completions, and skips

The FYP runs on a reinforcement-learning algorithm that infers preferences from behavioral signals users aren't aware of giving — not social graphs or hand-tuned heuristics.

Lesson 2: The Brain Chemistry of Engagement

1. D When an outcome exceeds expectation

Dopamine fires strongly when an outcome exceeds expectations, reinforcing the preceding behavior; it is suppressed when the outcome falls below expectation. The signal is driven by surprise.

2. B Wanting and seeking

Berridge separated wanting from liking: dopamine drives the wanting/seeking system, while opioid circuits govern liking/enjoyment. That is why craving and satisfaction can come apart.

3. C The anticipation before the reward

Dopamine is an anticipation signal, not a reward signal. The hit comes from seeking, which is why a feed stays compulsive even when the content barely satisfies.

4. A It flattens toward nothing

Under Reward Prediction Error, meeting expectation produces a flat signal. A perfectly predictable reward trains dopamine out of existence; uncertainty is the fuel.

5. A It is the brain's pleasure and liking chemical

The pleasure/liking claim is the common misconception. Dopamine drives wanting and anticipation; liking runs on separate opioid circuits.

6. B After an unpredictable number of actions

On a variable-ratio schedule, rewards arrive after an unpredictable number of actions. That uncertainty, not the reward's quality, drives relentless repetition.

7. D B.F. Skinner

Skinner's 1950s rat experiments defined variable-ratio reinforcement. Berridge studied wanting vs. liking; Schultz described Reward Prediction Error.

8. C The slot machine

The slot machine is the archetypal variable-ratio payoff. Subscriptions, alarms, and punch cards are all fixed and predictable, so they lack the uncertainty that drives compulsion.

9. B Far more relentlessly

Rats on the variable-ratio schedule pressed far more relentlessly and persistently than those on any predictable schedule. The schedule, not the reward, drove the behavior.

10. C A reward that unlocks at a set hour each day

A reward on a set daily schedule is fixed and predictable, so it isn't variable-ratio. Notifications, loot boxes, and spin-to-win wheels all pay off on unpredictable odds — true variable-ratio schedules.

11. D Dopamine

Dopamine powers seeking and anticipation, the pull toward the next notification or variable reward. Oxytocin bonds, serotonin signals status, endorphins reward exertion.

12. A Oxytocin

Oxytocin drives social bonding and trust, the warmth from peer acknowledgment or a friend's message. Serotonin handles status, dopamine seeking, endorphins exertion.

13. C Serotonin

Serotonin drives status and belonging, which is what leaderboards and follower counts feed. Dopamine handles seeking, oxytocin bonding, endorphins exertion.

14. D Suppressing pain and rewarding exertion

Endorphins suppress pain and reward exertion, like the release from finishing a hard lesson or workout. The other drives map to serotonin, oxytocin, and dopamine.

15. B Serotonin drives social bonding and trust

Serotonin drives status and belonging, not bonding. Bonding and trust are oxytocin's role; the other three pairings are correct.

16. A Finishing a hard lesson or workout

Endorphins suppress pain and produce pleasure from exertion — finishing a hard challenge triggers genuine euphoria. Notifications hit dopamine, status hits serotonin, peer acknowledgment hits oxytocin.

17. D Oxytocin

Peer acknowledgment and cooperative recognition run on oxytocin, the bonding-and-trust chemical. Status signals would be serotonin; exertion would be endorphins.

18. A Follower counts are status signals, which run on serotonin

A follower count is a visible status signal, so it feeds serotonin, not endorphins. Endorphins reward physical exertion and effort, like finishing a hard challenge.

19. C Dopamine

An unpredictable notification is a variable reward, which drives the dopamine seeking system. Serotonin is status, oxytocin is bonding, endorphins are exertion.

20. B Oxytocin, then serotonin

In the four-lever model, social acknowledgment releases oxytocin (bonding) followed by serotonin (status), and the pair lands in the nucleus accumbens, the reward center dopamine also targets. The serotonin link is contested in humans. Endorphins reward exertion instead.

21. A The basal ganglia

Once scrolling is automatic and frictionless, control shifts from the prefrontal cortex to the basal ganglia — the brain's habit-execution system — and the DMN takes the wheel. Users call it 'zoning out'; the dopamine loop then runs without conscious permission.

22. D Mind-wandering and self-referential thought

The DMN is the network of mind-wandering, self-referential thought, and inward drift. When scrolling turns automatic, it takes over from deliberate attention.

23. C The prefrontal cortex

The prefrontal cortex holds executive control during deliberate use. As scrolling becomes habitual, control shifts to the basal ganglia and the DMN takes over.

24. B Cognitive load depletes the prefrontal cortex's inhibitory capacity

Attentional control is depletable. Prolonged exposure raises cognitive load, draining the prefrontal cortex's inhibition, so the stop signal weakens over time.

25. B It removes the natural pause points that let inhibition reassert itself

Infinite scroll strips out page turns and load screens, the natural pauses where inhibitory capacity could reassert. A depleted brain with no stopping cue keeps going.

Lesson 3: The Psychological Frameworks

1. B Trigger → Action → Variable Reward → Investment

Eyal's loop runs Trigger → Action → Variable Reward → Investment. The cue starts it, the action is the simple behavior, the reward is unpredictable, and investment feeds back into the next loop.

2. D The cue that starts the loop — external or internal

The Trigger is the cue that starts the loop; it can be external (a notification) or internal (an emotion like boredom). The other options describe Variable Reward, Action, and Investment.

3. C Action

Action is the simplest behavior a user performs expecting a reward. The lower the friction, the more reliably it happens.

4. A Variable Reward

Variable Reward is the unpredictable payoff. Unpredictable outcomes release more dopamine than predictable ones, which is why a slot machine beats a vending machine as a habit engine.

5. B Reinforcement

The four stages are Trigger, Action, Variable Reward, and Investment. 'Reinforcement' is not one of them.

6. A Endowment Effect

Investment works through the Endowment Effect: users overvalue what they already own — their accumulated profile, history, and social graph inside the app. Each piece of data loaded in raises switching costs and compounds retention over time.

7. C Unpredictable outcomes release more dopamine than predictable

Eyal's Hook Model relies on the finding that unpredictable outcomes release more dopamine than predictable ones — the reason a slot machine outperforms a vending machine as a habit engine.

8. D Contacts, preferences, and history

The Investment stage is built from what users load in — contacts, preferences, and history — which raises switching costs and feeds back into future triggers and rewards.

9. D It improves the next Trigger and Reward, deepening the loop

Each pass through Investment feeds back into the loop: the data a user adds improves future Triggers and Rewards, compounding retention over time.

10. B The Endowment Effect makes users overvalue what they already own

Investment works through the Endowment Effect: users overvalue their accumulated profile and social graph, so leaving feels like losing something valuable. That raises switching cost and compounds retention.

11. A Reduce friction — simplify the action and cut steps

Motivation is already high, so the blocker is ability. Simplify the action — cut taps and steps — to lower the ability threshold the prompt needs.

12. C They multiply — if any one is zero, the behavior won't happen

B = MAP is multiplicative: Motivation, Ability, AND a Prompt must all be present at once. If any factor is zero the product is zero and no behavior occurs — which is why it's × not +.

13. D Motivation

Teams over-invest in motivation — better copy, stronger appeals — when the real blocker is usually ability. A highly motivated user still won't act if the action has too many steps.

14. B A simple prompt or signal, like a notification sound

With motivation and ability both sufficient, a simple signal suffices — the notification alone drives the behavior. Sparks are for low motivation; simplifying is for low ability.

15. C Accelerate uninstalls

Prompts only help when motivation and ability are already in place. Firing more prompts into a low-ability experience just annoys users and accelerates uninstalls.

16. A About 2×

Kahneman and Tversky established that a loss feels roughly 2× as painful as an equivalent gain feels good — the asymmetry that makes breaking a streak so effective at driving retention.

17. A Kahneman and Tversky

Kahneman and Tversky's Prospect Theory established loss aversion and the ~2x asymmetry. Fogg (B=MAP), Csikszentmihalyi (flow), and Zeigarnik (open loops) are associated with other ideas.

18. C Value something more highly simply because you own it

The endowment effect is overvaluing what you own. Feeling losses about twice as strongly is loss aversion, the pull of unfinished tasks is the Zeigarnik effect, and staying for sunk investment is the sunk-cost fallacy.

19. D Loss aversion inflated by the endowment effect

The behavior is irrational unless the endowment effect inflates the perceived value of the streak about to be lost, and loss aversion makes that loss feel devastating. The hourglass is loss aversion as a feature.

20. B A loss and an equal gain feel about equally powerful

The false statement is that losses and gains feel equal — Prospect Theory shows losses feel about 2× as powerful, which is exactly why streaks drive retention.

21. B Ending a session just as the next chapter unlocks but won't let you start it

The Zeigarnik effect is the pull of unfinished tasks. Designers manufacture that itch — a chapter that unlocks but won't start, or progress stuck at 95% — then fire a push notification when you're idle to bring you back and close the loop.

22. D Mihaly Csikszentmihalyi

Csikszentmihalyi described the flow channel. Eyal built the Hook Model, Fogg the B=MAP model, and Zeigarnik documented the pull of unfinished tasks.

23. C Anxiety — the user feels overwhelmed and churns

Above the flow channel, excess difficulty produces anxiety; below it, insufficient challenge produces boredom. Both drive churn.

24. A Track performance in real time and modulate challenge to keep users in the flow channel

DDA tracks performance in real time and tunes challenge to keep users inside the flow channel — Duolingo tunes course structure to each user's learning pace rather than a fixed curriculum.

25. C Tasks left incomplete

The Zeigarnik effect is that incomplete tasks are remembered and pull us back more strongly than completed ones. The brain treats the unfinished task as an open file it can't close.

Lesson 4: Gamification Mechanics

1. C It's visible and legible but easy to habituate to

PBL operates on the surface — points, badges, and leaderboards are easy to see and easy to tire of. Durable engagement comes from deeper drives like narrative, identity, and social positioning.

2. A Points, Badges, Leaderboards

PBL is Points, Badges, and Leaderboards — the visible, legible reward elements that are easy to bolt on but also easy to habituate to.

3. B Streaks

PBL is Points, Badges, and Leaderboards. Streaks are a deeper loss-aversion mechanic, not part of the PBL surface layer.

4. D Strong early engagement followed by a plateau

Designers who stop at PBL tend to see strong early engagement then a plateau, because novelty accounts for most of the lift. Once the novelty of visible rewards fades, PBL alone can't sustain growth.

5. A Narrative, identity, and social positioning

PBL works as scaffolding, not the whole structure. The deeper work of retention operates at the level of narrative, identity, and social meaning — not bigger versions of the same surface rewards.

6. C Core Drives

7. B 8

Octalysis maps motivation onto eight Core Drives, from Epic Meaning & Calling to Loss & Avoidance.

8. D Epic Meaning & Calling

Epic Meaning & Calling is the pull of a mission, story, or community with stakes bigger than one person. Ownership is about accumulating things you feel are yours.

9. D Ownership & Possession

Ownership & Possession is the drive to accumulate and protect things you feel are yours — virtual currency, streaks, and customized profiles are its typical expressions.

10. B Engage several Core Drives at once so another picks up the slack

No single drive sustains engagement indefinitely — each has a ceiling. The craft is firing several drives simultaneously, so when one weakens another keeps the user tethered.

11. C Loss aversion

The streak is framed as something you can lose, not a prize you collect. Loss aversion means the pain of losing an existing streak outweighs an equivalent future gain — so a 90-day streak already at risk pulls harder than a promised badge.

12. A A purchasable or earnable item that protects a streak during an absence

The Streak Freeze is bought or earned and protects the streak during an absence. Users buy insurance for a number — itself a product of the streak's perceived value.

13. B The counter resets to zero

Miss one day and the counter resets to zero. That reset is the engine: the threat of losing an existing streak drives loss aversion.

14. D The accumulated days act as a growing sunk cost the user is reluctant to forfeit

The longer a streak runs, the larger the sunk cost and the harder it is to rationalize walking away. The escalating investment — not new rewards — is what raises the stakes over time.

15. C Both reactions bring the user back — anxiety is engagement without pleasure

The reactions feel opposed, but the retention outcome is identical: both groups came back. Anxiety is engagement without pleasure, so Duolingo profits either way.

16. A 7.5 million

Duolingo reported 7.5 million daily active users at its 2021 IPO, the baseline against which later growth is measured.

17. D 46.6 million

Duolingo's DAU reached 46.6 million by Q1 2025, up from 7.5 million at its 2021 IPO.

18. A 521%
Growing from 7.5 million to 46.6 million DAU is a 521% increase, the headline evidence the streak mechanic drives retention.

19. C 21%
The DAU/MAU ratio was 21% at the 2021 IPO; it later climbed to 36% by Q1 2025.

20. B A growing share of monthly users became daily habits
DAU/MAU rising from 21% to 36% means a growing share of monthly users turned into daily habits — the stickiness the streak mechanic is designed to produce.

21. D Rising DAU/MAU ratio showing daily-habit conversion
DAU/MAU climbing from 21% to 36% means a growing share of monthly users became daily habits, the retention signal linked to the streak.

22. C A growing share of monthly users became daily habits
The rising ratio means a growing share of monthly users became daily habits, the retention outcome credited to the streak mechanic.

23. A The pre-stamps create an illusion of being already underway, triggering the Goal Gradient Effect
Both cards require eight purchases, but the pre-stamped one creates an illusion of progress already underway — triggering the Goal Gradient Effect (people accelerate as they near a goal) before any real investment. Same logic powers starter bonuses and welcome XP.

24. B People accelerate their effort as they approach a goal
The Goal Gradient Effect is the empirical finding that people accelerate effort as they near a goal — proximity to a reward raises its perceived value.

25. C The Goal Gradient Effect
The Saga Map shows users exactly how close they are to the next milestone, exploiting the Goal Gradient Effect — completion rates spike near checkpoints.

26. A Fixed ratio — 10 XP per 10 cards
Fixed ratio delivers a reward after a set number of actions — 10 XP per 10 cards. Loot boxes are variable ratio; the daily login bonus is fixed interval.

27. D Variable ratio
Variable-ratio reinforcement — rewards after an unpredictable number of actions — produces the highest and most persistent response rates, which is why loot boxes and randomized drops are so widely used.

Lesson 5: Social Architecture & Network Effects

1. A The square of the number of users (n^2)
Metcalfe's Law models value as scaling with n^2 — the count of possible connections between users grows roughly with the square of the user count.

2. C A product becomes more valuable to each user as more people join
A network effect exists when a product becomes more valuable to each user as more people use it. The other options describe economies of scale or ad models, not network effects.

3. B More friends on a messaging app makes messaging more useful
A direct effect improves your experience because more people are on the same side of the product. The other three are indirect effects: you benefit from growth you don't personally connect to.

4. D More iPhone users attract more app developers, improving the platform

Indirect effects benefit you through parties you never meet — more iPhone users draw more developers. The 'same side' and 'more friends' options describe direct effects.

5. C Quadruples

Value scales with n^2, so doubling users (2n) yields $(2n)^2 = 4x$ the value — a quadrupling. This is a directional intuition, not precise accounting.

6. A It stacked six distinct network effects, like six concentric walls

NFX counted no fewer than six distinct network effects at Facebook — each an additional wall a competitor must breach.

7. D A persistent, identity-based map of real-world relationships

The social graph tied users to their actual names and contacts — a persistent map of real-world relationships. An interest-based map is TikTok's interest graph, not the social graph.

8. B NFX

The VC firm NFX coined 'layered defensibility' to describe Facebook stacking six distinct network effects, imagined as a castle with six concentric walls.

9. D Drawbridges layered on top of the graph, adding reasons to return

The graph itself was the moat; the features were merely drawbridges across it. Competitors could copy the features but not replicate the graph underneath.

10. A Embedding in third-party sites

NFX adds embedding, exemplified by Facebook Connect letting other sites use Facebook login, to Facebook's network effects, scale and brand. The other options are engagement mechanics from other kinds of apps, not layers in NFX's account of Facebook.

11. B About 4.6 cents a month

The paper's largest imputed value for one connection, a Facebook connection the user lives with, is about 4.6 cents a month: small individually, enormous in aggregate.

12. C $78–$101

Platform value ranged from about $78 (X) to $101 (Facebook) per user per month across the four platforms. $20–$34 is not a monthly dollar value in this study.

13. B 8.1–23.7%

The study found 8.1–23.7% of platform value was explained by local network effects, with Facebook showing the strongest. The remainder was value not tied to specific connections. 69% is the FOMO prevalence figure, not a value share.

14. D Socially-tied users are retained better than users of an equivalent solo-use tool

Social anchoring is the pattern in which socially-tied users are retained noticeably better than users of an equivalent solo-use tool — the behavioral payoff of the social graph moat.

15. C Facebook showed the weakest local network effects of the four platforms

The study found Facebook had the strongest local network effects of the four platforms (X the weakest), not the weakest. The other three statements match its findings.

16. A Instagram Stories

17. B Serotonin — status

Leaderboards work on status and serotonin. Oxytocin drives bonding (co-op quests, parasocial bonds), not competitive status ranking.

18. C An oxytocin-mediated attachment to a non-reciprocating entity

A parasocial bond is an oxytocin-mediated attachment to a non-human or non-reciprocating entity, manufactured through consistency and mild threat of loss.

19. D The social consequences of missed bonding

Cornell found FOMO isn't about missed content — it's anxiety over the social consequences of missed bonding. Adding more content won't resolve it.

20. A Avoiding demotion outweighs the pleasure of promotion

Loss aversion is the engine: the pain of dropping a tier outweighs the pleasure of climbing one, so players grind to avoid demotion from the rank they hold.

21. C Completion rate and shares

The interest graph ingests completion rate, shares, comments, follows, and re-watches — but weights completion and sharing most heavily, learning your interests from behavior rather than from who you follow. The video is judged, not the creator's history.

22. D What you're drawn to, learned from your behavior

The interest graph is a machine-curated map of what you're drawn to, learned from behavior — not who you know, which is the social graph.

23. B A zero-follower account can go viral in 24h if content clears thresholds

The video is judged, not the creator's history — a brand-new zero-follower account can earn viral distribution within 24 hours if content clears engagement thresholds.

24. A Longer sessions but weaker social bonding

Optimizing for raw engagement produces far longer sessions but weaker social bonding, since ties are to content categories, not people — sacrificing structural stickiness.

25. D The interest graph judges the video on its own merits

On the interest graph the video is judged, not the creator — so no followers are needed. Getting more accurate with use describes the interest graph, and mapping who you know describes the social graph.

Lesson 6: Engineering Viral Growth

1. D Product-market fit and low CAC

K>1 means each user recruits more than one new user — self-sustaining growth that signals product-market fit, low customer acquisition cost, and a strong user experience.

2. C Invitations sent and the conversion rate on those invitations

K = i x c: invitations sent multiplied by the conversion rate on those invitations. The other pairs mix in unrelated metrics like LTV, CAC, or churn.

3. B 1

K above 1 is the inflection point for self-sustaining, exponential growth. A K of 0.2 still helps but leaves the product dependent on paid or organic top-of-funnel.

4. A Five users collectively produce one additional user over their lifetime

K = 0.2 means it takes five existing users to generate one additional user. It is below the K>1 self-sustaining threshold, so it is a reciprocal, not a multiplier of five.

5. C Virality still helps, but the product depends on paid or organic top-of-funnel to survive

Below 1, virality contributes but cannot sustain growth alone, so paid or organic top-of-funnel is still required. Only K above 1 is self-replicating.

6. A The dollar amount spent to land one new user

CAC is the cost to acquire one new user, the denominator that viral dynamics attack. The other options describe LTV, conversion rate, and the K-factor.

7. B $41

Duolingo's CAC was estimated at roughly $41 at IPO and had fallen to about $33 by Q1 2025 as its base became more self-referencing.

8. D $33

CAC fell to roughly $33 by Q1 2025, down from about $41 at IPO. The drop reflects a larger, more engaged base doing more of the recruiting.

9. C A larger, more engaged user base did more of the recruiting itself

Duolingo's CAC fell not because the ad budget shrank, but because a bigger, more engaged base recruited more users organically, replacing paid installs.

10. A Organic growth has stalled and viral loops may be decaying

Watching CAC over time reveals whether viral loops compound or decay; a flat or rising CAC at scale signals stalled organic growth, the opposite of compounding virality.

11. D The viral and content loops lower blended CAC, letting the paid loop reach users who'd never arrive organically

The viral and content/ASO loops are compounding and nearly free at the margin, so they lower blended CAC — letting the paid loop profitably reach users who'd never arrive organically. The resulting scale then feeds more content and referrals, reinforcing the first two.

12. B The content/ASO loop

The content/ASO loop converts posts, reviews, and profiles into indexable material that pulls in cold-search installs. The viral loop is about direct recruiting; the paid loop buys installs.

13. A Ad spend buys installs whose in-app revenue funds more ad spend

The paid loop reinvests in-app revenue from bought installs into more ad spend. The other options describe the viral and content/ASO loops, which are nearly free at the margin.

14. D The paid acquisition loop

The viral and content/ASO loops are compounding and nearly free per incremental install; the paid loop costs ad dollars for every install and only works when LTV far exceeds CAC.

15. C Users recruiting other users through sharing, invitations, or social artifacts

The viral loop is users recruiting users, costing almost nothing per install. It works best when sharing is intrinsic to the core value loop, not a bolted-on Share button.

16. B The total value a user generates over their lifetime

LTV is the total value a user produces over their lifetime. The cost to acquire a user is CAC; the paid loop is viable only when LTV far exceeds CAC.

17. A LTV far exceeds CAC

Paid loops only work when the lifetime value of a bought user greatly exceeds the cost to acquire them. If CAC exceeds LTV, the loop accelerates losses.

18. C Accelerates losses rather than growth

With negative unit economics, spending more on ads buys installs that lose money faster, so the paid loop accelerates losses instead of growth.

19. B It buys installs whose revenue funds even more ad spend

The paid loop can scale fast because ad spend buys installs whose in-app revenue funds still more ad spend, but only once LTV far exceeds CAC. It doesn't merge with the viral loop or by itself lift K.

20. D LTV against CAC

Viability of the paid loop is the LTV-versus-CAC comparison: LTV must greatly exceed CAC. The other pairings mix unrelated growth metrics.

21. B They exploit reciprocity norms by rewarding both the referrer and the new user

When both sides receive value, the offer taps reciprocity norms — the referrer feels they're giving a genuine gift, not just farming a bonus. Uber's early referral program, which credited both the referrer and the invited friend with ride credit, is a well-known example.

22. D Reflects well on them, letting them perform a version of themselves

A shareable artifact makes the user look good; they promote themselves, and the app is merely the medium. It is not a paid or forced share.

23. C Spotify Wrapped

Spotify Wrapped is the archetypal identity-affirming yearly summary that spreads with no paid media. Uber's free ride is a referral, not a self-expressive artifact.

24. A It signals discipline to the user's social graph, drawing curious onlookers

The badge is a shareable artifact: it signals discipline to a user's social graph, and curious onlookers get pulled in. It relies on self-presentation, not cash or ads.

25. B Embedding the incentive in content value tied to the core loop, e.g. 'unlock this deck by inviting a partner'

Tying the reward to content value in the core loop attracts users who want the product, not the coupon, and avoids the bribe framing of a cash reward.

Lesson 7: Retention Architecture

1. D 7 friends in 10 days

Facebook's Aha Moment was '7 friends in 10 days' — reach that social density and the feed becomes meaningful; miss it and the app is an empty room. 'Follow 30 accounts' was Twitter's threshold, and Duolingo's was the first lesson's animated XP reward.

2. B The instant the app's core value becomes emotionally real

The Aha Moment is feeling the value, not finishing a tutorial. Completing a walkthrough is explicitly NOT the Aha Moment.

3. A Follow 30 accounts

Twitter's threshold was following 30 accounts — enough signal to fill a timeline worth returning to. '7 friends in 10 days' was Facebook's.

4. C Completing the first lesson and receiving the animated XP reward

Duolingo's is immediate and sensory: the first lesson plus the gamified XP dopamine hit. The account and friend thresholds belong to Twitter and Facebook.

5. B Finishing the onboarding walkthrough

Finishing a walkthrough is explicitly not the Aha Moment — feeling the value is. The other three are the canonical measurable thresholds.

6. C Analyze which early actions correlate with long-term retention in cohort data

Teams analyze which early actions correlate with long-term retention in cohort data, then re-engineer onboarding to deliver every new user to that action sequence.

7. D 80%

About 80% of users stop after day 3, which reframes onboarding as a survival problem — two or three sessions to prove value.

8. A Predicts a user still being active about 30 days later

When a behavior reached in session one predicts 30-day retention in cohort data, that behavior is the Aha Moment. Surveys and tutorials do not define it.

9. A A survival problem — prove value within two or three sessions

The day-3 stat reframes onboarding as a survival problem: the app has two or three sessions to prove value before most users are gone. It is not about price, tutorial length, or acquisition.

10. B Choosing the last screen of the onboarding tutorial

The Aha Moment is located empirically from cohort data, not by picking a tutorial screen — finishing a tutorial is not the Aha Moment.

11. C Send at the same fixed interval every day regardless of context

Effective push follows timing, personalization, and a curiosity/FOMO gap. Arbitrary fixed intervals are exactly what these rules replace.

12. D The primary channel for reactivating users who left the habit loop

Push is the main re-engagement channel for pulling lapsed users back. Investment is a separate Hook phase, not the push definition.

13. B At moments the user has historically opened the app

Notifications land better at the user's historical open times. A fixed broadcast interval regardless of context is exactly what NOT to do.

14. D It signals the app is paying attention to the user

Referencing the user's streak, last action, or goal signals attention, which significantly beats generic copy. It does not replace the timing rule.

15. A 'Your streak is at risk'

Withholding just enough ('Your streak is at risk') creates a curiosity gap and mild FOMO that motivates a tap. 'Open the app' resolves nothing.

16. C Data, content, social connections, and reputation

Investment is the fourth Hook stage where users deposit data, content, connections, and reputation, making the product more valuable next use.

17. D Investment

Accumulated connections and profile detail are deposits the user makes into the product -- exactly what the Hook Model describes as the Investment stage, which raises switching costs via the endowment effect.

18. C Streak count

Duolingo's streak count is accumulated investment: a 100-day streak is sunk cost that feels devastatingly real. Push notifications are a re-engagement channel; the hearts system and an upgrade prompt store nothing the user has built up.

19. A Each investment makes the product more valuable next use and raises switching costs

Stored investment makes the product more valuable with each use and raises switching costs, so leaving means losing what the user built.

20. B The endowment effect

The endowment effect makes users value what they have put in, raising switching costs. The curiosity gap belongs to push notifications, and the goal gradient effect to speeding up near a goal.

21. D 26%

Adjust's 2025 benchmark puts median Day 1 retention across all apps at 26%. 13% is its Day 7 figure and 7% its Day 30 figure.

22. C 13%

Adjust's 2025 benchmark puts median Day 7 retention at 13%, between the 26% Day 1 figure and the 7% Day 30 figure.

23. A 7%

Adjust's 2025 benchmark puts median Day 30 retention at 7%, the lowest of the three checkpoints (Day 1 26%, Day 7 13%).

24. B Day 1 26% > Day 7 13% > Day 30 7%

Retention decays over time: Adjust's 2025 medians are Day 1 26%, Day 7 13%, Day 30 7%. The other orderings scramble those values.

25. B It is far more capital-efficient than paid acquisition

Keeping customers costs far less than winning new ones (HBR, 2014: acquiring a new customer costs five to 25 times more than keeping one), so a small retention gain can lift profits a lot. That makes retention more capital-efficient than paid acquisition.

Lesson 8: Design Patterns & Ethics

1. D Below the Doherty Threshold the interaction feels immediate and responsive

The Doherty Threshold is the ~400ms ceiling below which feedback feels immediate; cross it and responsiveness — and engagement — drops off.

2. B Require an in-app purchase to complete

The four jobs are: completes in 2–5 min, gives feedback under the Doherty Threshold, ends with a variable reward, and sets up the next session. Requiring a purchase is not one of them.

3. C 400 ms

Doherty and Thadhani (IBM, 1982) found that responses under 400 ms keep users and systems from waiting on each other, so productivity soars.

4. A 2–5 minutes

A micro-session-compatible loop completes in 2–5 minutes, fitting between meetings or on a commute.

5. C Zeigarnik open loop

An open-loop hook leaves an unfinished task that users tend to want to resume (the Ovsiankina tendency, popularly credited to the Zeigarnik effect, whose memory advantage has proved hard to replicate). That pull is why the user returns to close the loop.

6. B The brain habituates to a predictable signal and starts ignoring it

A fixed clock-based signal is predictable, so the brain habituates and tunes it out over time. State-triggered notifications stay meaningful.

7. A Your 14-day streak is at risk

A personalized notification citing the user's own streak outperforms a generic reminder because it references their specific investment.

8. D Breaks their streak pattern or crosses a meaningful threshold

Contextually triggered notifications fire on behaviorally meaningful state changes — like breaking a streak pattern — not on the clock.

9. C Competitive loss aversion

Social triggers add competitive loss aversion on top of a personalized state signal, giving the user a rival-driven reason to return.

10. A Fixed daily clock alert → personalized streak alert → social 'a friend passed you' trigger

In this ranking, a fixed clock signal is the weakest (the brain habituates), a personalized state alert outperforms a generic reminder, and a social trigger layers competitive loss aversion on top of that, so it ranks strongest.

11. B Forcing real-time multiplayer on users who barely know the app destroys more sessions than it creates

The sequence follows where trust sits: asynchronous social proof first (no mutual timing needed), then cooperative features, then synchronous competition last — forcing real-time play on users who barely know the app destroys more sessions than it creates.

12. D Asynchronous social proof → cooperative features → synchronous competition

Async social proof needs no mutual timing so it comes first; cooperation once the user has a stake; synchronous competition last, since forcing real-time play too early destroys sessions.

13. B Revealing complexity gradually rather than dumping every feature at once

Progressive disclosure reveals complexity gradually; new users lack context to evaluate unseen features, so showing all at once creates overwhelm, not excitement.

14. C An empty screen signals that the app is worthless

Zero blank slate pre-populates a new user's experience with suggested friends or seeded content, because an empty screen communicates that nobody uses the app.

15. A A live real-time battle against a matched opponent

Async social proof (leaderboards, follower counts, activity feeds) needs no mutual timing. A live real-time battle is synchronous competition, which belongs last.

16. D An impossible-to-find cancellation flow

Impossible cancellation is a classic dark pattern that destroys trust. Freezes, session-end cues, and notification controls are humane alternatives.

17. C Help people do what they already want to do

Fogg's first maxim — help people do what they already want to do — holds that lasting behavior change requires motivation alignment, not pushing users toward goals they don't hold.

18. B Removing friction from a desired action (simplicity)

Fogg's maxim 'simplicity changes behavior' says removing friction from a desired action beats trying to increase motivation for a reluctant one.

19. D Streak freezes, gentle session-end cues, and notification-frequency controls

Fogg's maxims yield humane tools: streak freezes, gentle session-end cues, and user controls over notification frequency. The other trios are dark patterns or clock-based nags.

20. A Shaming copy, a dark pattern

Guilt-inducing decline labels are shaming copy — a dark pattern that works against the user's goals and erodes long-term trust.

21. D Things

Things are the artifacts a user accumulates; each one is a sunk cost that raises the switching cost of leaving.

22. B People, Places, Things, Events

PPTE organizes contextual design levers into People, Places, Things, and Events — each a distinct design question, not an afterthought.

23. C Who is in the user's social graph, and how does the app surface them?

People concerns the social graph — creating mutual accountability, competitive stakes, and belonging without any new content.

24. A Where the user is (physical and cognitive context) when they engage

Places asks where the user engages; a commute app behaves differently from a bedtime app, so design for the actual context of use, not a generic session.

25. D New Year's resolution-makers picking up language learning

Events are recurring cultural moments that open re-engagement windows; New Year's resolution-makers plausibly explain part of Duolingo's record Q1 2025 DAU additions.

Lesson 9: Case Studies in Stickiness

1. C Perfect Lesson

2. B It let them launch 148 new courses in under a year, instead of 12+ months per course

Generative AI collapsed course-building time from 12+ months each to 148 new courses in under a year — a step-change in content breadth, which feeds retention by giving users more to do.

3. A Loss aversion — the fear of dropping a tier outweighs the desire to climb

The demotion threat exploits loss aversion: users near the cutoff earn far more XP than those safely mid-tier because the dread of dropping outweighs the pull of advancing.

4. D Variable-ratio reinforcement

Unpredictable payouts are variable-ratio reinforcement, which produces the most durable behavior — you won't know if the next lesson yields double XP or nothing until you finish it.

5. A It compressed course-building from 12+ months each down to weeks

AI collapsed production from 12+ months per course down to weeks, enabling 148 new courses in under a year — the content engine now scales as fast as the engagement model.

6. D 36%

Duolingo's DAU/MAU ratio reached 36%, roughly double the 20% industry average. 55% is its day-over-day retention; 74 million was FarmVille's peak MAU.

7. B 20%

The industry-average DAU/MAU ratio is about 20%, so Duolingo's 36% is roughly double it. 55% is Duolingo's own day-over-day retention figure.

8. C 55%

Day-over-day retention of daily active users sits at 55%. 36% is the DAU/MAU ratio and 20% is the industry-average DAU/MAU.

9. C From $5 billion to $22 billion

Duolingo's market cap grew from $5 billion at IPO to $22 billion by Q1 2025.

10. A An 80% DAU/MAU ratio

Duolingo's DAU/MAU ratio is 36%, not 80%. The 55% retention and $22 billion Q1 2025 market cap are both real reported figures.

11. B Completion rate — watch-through to the final second

Completion rate is weighted above almost all other signals, pushing creators to hold attention to the last second. Following is largely irrelevant on the interest graph.

12. D The interest graph — what you consume

TikTok organizes content around the interest graph (what you consume), not the social graph. A follower-less new account gets a fully personalized feed within hours from behavioral signals alone.

13. D Connections with family and close friends

Research found users value family and close-friend connections at a qualitatively different level than content-only ones — the social graph Instagram's moat rests on, which TikTok's interest graph can't replicate.

14. C The social graph — years of accumulated relationships — cannot be ported

Instagram's moat is the social graph: users value family and close-friend connections at a qualitatively different level than content-only ones, and that graph can't be copied even when content quality is matched.

15. A Completion and sharing

Among completion, shares, comments, follows, and re-watches, completion and sharing rank highest — reflecting revealed preference rather than social identity.

16. B FOMO for the recipient and reduced social anxiety for the sender

Disappearing content creates FOMO — the recipient must open it now, not later — and reduces social anxiety, because imperfect posts cost nothing when no permanent record exists. That makes posting feel cheap, which makes it frequent.

17. D Primarily behavioral design, not a privacy feature

Ephemeral content is often described as privacy, but it was always primarily behavioral: disappearing posts create FOMO and lower the anxiety of sharing imperfect content, making posting cheap and frequent.

18. C They extended the obligation to multi-person chains, multiplying social pressure

Group Streaks require most members to Snap for the collective streak to survive, so non-participation costs the group's streak — the same loss-aversion loop with a larger blast radius.

19. A Loss aversion — protecting a number, not the content

The streak converts frequency into a loss-aversion engine — you're protecting a number, not quality content. The daily open is the real goal.

20. B FOMO and social obligation scale with the number of relationships implicated

FOMO and social obligation scale with the number of relationships implicated, so a group streak multiplies pressure by the group's size versus a two-person individual streak.

21. D 74 million

FarmVille (2009) peaked at 74 million monthly active users, the earliest mass demonstration that obligation loops could sustain engagement.

22. C Needing gifts from real Facebook friends to unlock crops and buildings

Players needed gifts from real Facebook friends to unlock crops and buildings, and those friends needed gifts back — progress was coupled to reciprocal participation.

23. B Reciprocal obligation loops can hold millions without the product being intrinsically rewarding

Most players called FarmVille a chore, yet social-obligation loops and loss aversion over planted crops kept them returning — proving reciprocal mechanics can hold users without intrinsic fun.

24. A 2009

FarmVille launched in 2009 and reached a peak of 74 million monthly active users, the prototype for social-obligation loops.

25. B Players returned mainly because the game was intrinsically fun

The case study says most players described FarmVille as a chore; retention came from social obligation and loss aversion, not intrinsic fun. The other three statements are all supported.

Lesson 10: Who's Who & What's What of Stickiness

1. A BJ Fogg

BJ Fogg established captology at Stanford and gave the field its formula, the Fogg Behavior Model (B=MAP). Nir Eyal later translated that academic research into the practitioner's Hook loop that product teams follow.

2. D B.F. Skinner

B.F. Skinner's lever-pressing rats on unpredictable schedules are the most cited work in the field. Fogg and Eyal came later; Berridge worked on dopamine, not reinforcement schedules.

3. B Nir Eyal

Nir Eyal turned the research into the practitioner's Hook loop. Fogg did the underlying academic work at Stanford; Skinner and Kahneman are earlier scientists, not product-loop authors.

4. C Creating the Hook Model loop

The Hook Model is Nir Eyal's loop, not Fogg's. Fogg coined captology, proved at Stanford that computers could change behavior, and gave the field its B=MAP formula.

5. D BJ Fogg

BJ Fogg gave the field its formula, the Fogg Behavior Model (B=MAP). Eyal built the Hook loop, Skinner studied reinforcement, and Schultz mapped reward prediction error.

6. B Kent Berridge

Kent Berridge separated wanting from liking, arguing dopamine drives pursuit, not pleasure. Schultz mapped reward-prediction error, and Kahneman established loss aversion.

7. A Wolfram Schultz

Wolfram Schultz mapped the reward-prediction-error signal. Berridge split wanting from liking, Kahneman worked on loss aversion, and Skinner studied reinforcement schedules.

8. C Daniel Kahneman

Daniel Kahneman, with Amos Tversky, established loss aversion — losses hurt about twice as much as gains. Berridge and Schultz are dopamine researchers; Skinner studied reinforcement.

9. D Daniel Kahneman

Kahneman (with Tversky) established loss aversion, the basis of streaks. Schultz and Berridge studied dopamine; Csikszentmihalyi named the flow state.

10. C Berridge — wanting vs. liking

Berridge split wanting from liking. Loss aversion is Kahneman's, reward-prediction error is Schultz's, and the flow state is Csikszentmihalyi's — so the other three are mismatched.

11. B Mihaly Csikszentmihalyi

Mihaly Csikszentmihalyi named the flow state. Chou built Octalysis, Raskin invented infinite scroll, and Lembke coined 'digital dopamine.'

12. A Yu-kai Chou

Yu-kai Chou mapped the eight Core Drives into the Octalysis Framework. Csikszentmihalyi named flow, Raskin built infinite scroll, and Fogg founded captology.

13. B Aza Raskin

Aza Raskin invented infinite scroll and later became one of its harshest critics. Lembke coined 'digital dopamine,' Chou built Octalysis, and Eyal wrote the Hook Model.

14. D Anna Lembke

Anna Lembke, a Stanford psychiatrist, coined that language. Csikszentmihalyi named flow, Berridge studied dopamine's wanting/liking split, and Raskin built infinite scroll.

15. C Anna Lembke — reward-prediction error

Reward-prediction error is Wolfram Schultz's work, not Lembke's — Lembke coined 'digital dopamine.' The other three pairings are correct.

16. A Trigger → Action → Variable Reward → Investment

The Hook Model cycles Trigger → Action → Variable Reward → Investment, with the investment stage loading the next trigger. Motivation × Ability × Prompt is a different framework — the Fogg Behavior Model (B=MAP).

17. D B = Motivation × Ability × Prompt

Fogg's model is B = MAP (Motivation × Ability × Prompt). 'Cue → Routine → Reward' is the habit loop, and invites × conversion is the viral coefficient.

18. B Variable-Ratio Reinforcement

Variable-ratio reinforcement — the slot-machine schedule — rewards after an unpredictable number of actions and resists extinction best. Fixed-ratio is predictable; the others are unrelated effects.

19. A Loss Aversion

Loss aversion, from behavioral economics, is the streak's engine — losses feel about twice as strong as gains. Zeigarnik is about unfinished tasks; goal gradient is acceleration near a reward.

20. C The Goal Gradient Effect

The Goal Gradient Effect is our acceleration toward a nearing reward. Loss aversion concerns losses vs. gains, Zeigarnik concerns unfinished tasks, and variable-ratio is a reward schedule.

21. C A progress bar left stuck at 95% complete

The Zeigarnik effect is our pull toward unfinished tasks, so a progress bar stuck at 95% keeps users coming back. The unpredictable reward is variable-ratio reinforcement, seeded friends are the zero blank slate, and the rank list is asynchronous social proof.

22. A Network Effects

Network effects (more users, more value) are modeled by Metcalfe's Law. The K-Factor measures virality, goal gradient is a motivation effect, and DMN is a brain state.

23. B The K-Factor

The K-Factor (viral coefficient) is i × c; above 1, growth goes exponential. Network effects and Metcalfe's Law describe value scaling, and Octalysis is a gamification framework.

24. D The Octalysis Framework

The Octalysis Framework maps eight Core Drives of motivation. The Hook Model is a four-stage loop, network effects concern user value, and DMN is a brain state.

25. D The Default Mode Network

The Default Mode Network is the zoning-out state infinite scroll induces. Goal gradient is reward acceleration, flow is deep absorption, and variable-ratio is a reward schedule.

Lesson 11: Essential Vocabulary & Quick Recall

1. B Wanting and seeking — it fires during the anticipation of a reward, not its delivery

Dopamine governs wanting and seeking and fires during anticipation, not fulfillment — which is why scrolling stays compulsive even when the content disappoints. Liking (pleasure at the reward) is a separate system.

2. A Reward Prediction Error (RPE)

RPE, from Wolfram Schultz, means dopamine responds to the gap between expectation and outcome, so the system runs on uncertainty. Variable-ratio is a reward schedule, not the neural signal itself.

3. D Variable-ratio reinforcement

Variable-ratio reinforcement delivers rewards after an unpredictable number of responses, producing the highest response rates and greatest resistance to extinction — the slot-machine logic of infinite scroll.

4. C Default Mode Network (DMN)

The Default Mode Network — linked to mind-wandering and self-referential thought — dominates when a habit needs little attention and prefrontal control goes offline; users experience it as zoning out.

5. A Goal gradient effect

The goal gradient effect is accelerating effort as a milestone nears; pre-stamps make the reward feel closer. Sunk cost is about past investment, not proximity to the goal.

6. D Trigger → Action → Variable Reward → Investment

The Hook Model cycles Trigger → Action → Variable Reward → Investment. Investment comes last because what the user puts in (data, content, reputation) loads the next trigger, making each pass through the loop harder to leave.

7. B Boredom or loneliness

Internal triggers are emotions like boredom or loneliness that the product becomes coupled to; notifications, badges, and emails are external triggers. The goal is to graduate users from external to internal triggers.

8. C Computers As Persuasive Technologies

Captology stands for Computers As Persuasive Technologies — how computers can be designed to change human thoughts and behaviors. BJ Fogg coined the term in 1996.

9. B Motivation, Ability, and a Prompt

B = MAP: Behavior = Motivation × Ability × Prompt, all three converging simultaneously. Trigger → Action → Reward belongs to the separate Hook Model.

10. A Eight

Octalysis identifies eight Core Drives, from Epic Meaning to Ownership to Social Influence; the most durable apps engage several at once.

11. C The square of its number of users (n^2)

Metcalfe's Law states a network's value scales with n^2 — the square of its user count — since each added user can potentially connect to every other. Real dynamics are more nuanced, as not every connection is equally valuable.

12. D The network effect

The network effect: value to each user rises with total users, directly or indirectly. A viral loop is a growth mechanism and a referral program is an explicit invite mechanic — related but distinct.

13. D An interest graph

An interest graph is a machine-curated map of what you're drawn to, not who you know. It freed distribution from your follower count, unlike the identity-based social graph.

14. A The social cost of non-participation

FOMO here is about the social penalty of not participating — why Instagram Stories' 24-hour expiry works. It's the bonding cost, not the content, that creates the pull.

15. C The K-Factor

The K-Factor (viral coefficient) is i × c; above 1, growth goes exponential. Network effects and Metcalfe's Law describe value scaling, and Octalysis is a gamification framework.

16. B Adding 7 friends in 10 days

Facebook found users who reached 7 friends in 10 days were far likelier to retain, so onboarding aimed everyone at that milestone. (Twitter's equivalent was following 30 accounts.) Teams locate these thresholds via cohort analysis.

17. D Send at the same fixed interval every day regardless of context

Effective push follows timing, personalization, and a curiosity/FOMO gap. Arbitrary fixed intervals are exactly what these rules replace.

18. C About 80%

Roughly 80% of users churn within three days of install, which is why the onboarding-to-Aha pipeline is the highest-leverage place to fight churn.

19. A Monthly active users

DAU/MAU is daily active users as a share of monthly active users. Industry average sits well below 20%; Duolingo reached 36%.

20. B CAC (Customer Acquisition Cost)

CAC is the cost to acquire one user; when users recruit each other (K>1), paid acquisition needs shrink and CAC falls. LTV is the value a user generates — a separate metric.

21. B They exploit reciprocity norms by rewarding both the referrer and the new user

When both sides receive value, the offer taps reciprocity norms — the referrer feels they're giving a genuine gift, not just farming a bonus. Uber's early referral program, which credited both the referrer and the invited friend with ride credit, is a well-known example.

22. D Trigger → Action → Variable Reward → Investment

The Hook Model loops through Trigger, Action, Variable Reward, and Investment. Motivation × Ability × Prompt is Fogg's separate B=MAP equation.

23. A Analyze which early actions correlate with long-term retention in cohort data

Teams analyze which early actions correlate with long-term retention in cohort data, then re-engineer onboarding to deliver every new user to that action sequence.

24. C Oxytocin

Parasocial bonds are oxytocin-mediated attachments to non-reciprocating entities like a mascot. Dopamine drives wanting; serotonin tracks status; oxytocin handles bonding and trust.

25. C It's visible and legible but easy to habituate to

PBL operates on the surface — points, badges, and leaderboards are easy to see and easy to tire of. Durable engagement comes from deeper drives like narrative, identity, and social positioning.

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The book

- *Hooked: How to Build Habit-Forming Products* by Nir Eyal, Ryan Hoover — flashfeedlearningapp.com/packs/sticky-apps

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