RESEARCH SERIES · DECISION DESIGN

Designed Dependency:

How the Visual and Interaction Architecture of Digital Products Engineers Habitual Use, and What Designers Are Responsible For

Artec Research · September 2024

Keywords: persuasive design, dark patterns, variable reward, infinite scroll, behavioural dependency, attention engineering, design ethics

Abstract

The average person checks their phone approximately 96 times per day. They did not choose this behaviour consciously. It was designed into them. This paper examines the specific visual and interaction design mechanisms through which digital platforms engineer habitual and compulsive use, drawing on research in behavioural psychology, neuroscience, and persuasive technology. It analyses the role of variable reward schedules, infinite scroll, notification architecture, social validation loops, and the deliberate removal of natural stopping cues in creating what researchers have termed designed dependency: a state of habitual platform engagement that persists even when users report a desire to disengage. The paper argues that understanding these mechanisms is not merely a concern for ethicists. It is essential knowledge for any designer whose work touches human attention, because the same tools that create dependency in harmful contexts are the tools that create genuine engagement in constructive ones. The difference between the two is not the mechanism but the intent behind its application.

1. Introduction: The Attention Economy and the Designer's Role

When Aza Raskin popularised infinite scroll as a web interface pattern around 2006, it addressed a genuine usability problem: the friction of pagination interrupted the flow of content consumption and created unnecessary user effort. The solution was elegant, intuitive, and rapidly adopted across virtually every major content platform on the internet. Raskin later publicly expressed regret over the pattern's consequences, estimating that infinite scroll wastes the equivalent of roughly 200,000 human lifetimes of attention per day, and has described how optimising something purely for ease of use does not mean it is best for the user or for humanity (Raskin, 2019).

This anecdote captures the central tension of designed dependency: the mechanisms that make products most engaging are the same mechanisms that make them most difficult to leave. They are not separable. Infinite scroll does not become addiction-enabling only when deployed maliciously. It becomes addiction-enabling the moment it removes a natural stopping point from a content consumption experience, regardless of the designer's intent. Intent and outcome diverge, and in the attention economy, the outcome consistently favours the platform over the user.

This paper examines the specific design mechanisms that drive this outcome, explains the neuroscience and psychology behind why they work, and argues that designers who understand these mechanisms have a professional responsibility to deploy them with precision and ethical awareness rather than defaulting to maximum engagement as the primary success metric.

> "*The tools that create dependency and the tools that create genuine engagement are identical. The difference is entirely in who benefits from the loop.*"

---

2. The Neurological Foundation: Dopamine and the Reward Loop

2.1 Variable Reward Schedules

The most foundational concept in understanding designed dependency is the variable reward schedule, a reinforcement pattern first documented by B.F. Skinner (1938) in which rewards are

delivered unpredictably rather than at fixed intervals. Skinner's research demonstrated that variable ratio reinforcement schedules, where rewards occur after a random number of responses, produce the highest rates of responding and the greatest resistance to extinction of any reinforcement pattern. The same principle that makes slot machines the most profitable devices in casino history is embedded in the architecture of every major social media platform.

When a user pulls to refresh a social media feed, they are performing the digital equivalent of pulling a slot machine lever. Sometimes the result is unrewarding content. Sometimes it is moderately interesting. Occasionally it is a piece of content that generates strong positive affect, a viral video, a message from a close friend, an image that provokes genuine emotion. The unpredictability of the reward is precisely what generates the compulsive checking behaviour. Predictable rewards are processed, satisfied, and extinguished. Variable rewards generate perpetual anticipation.

Neurologically, the mechanism involves dopamine not as a pleasure signal but as an anticipation signal. Schultz, Dayan, and Montague (1997) demonstrated in foundational research that dopamine neurons fire most strongly not at reward delivery but at the cue that predicts reward, and that they fire even more strongly when the reward is uncertain than when it is guaranteed. The notification badge, the pull-to-refresh gesture, the loading indicator: each of these is a reward-predicting cue that activates the dopamine system before the user has received any content at all.

2.2 The Zeigarnik Effect and Incompleteness Design

Bluma Zeigarnik (1927) demonstrated that people remember uncompleted tasks significantly better than completed ones, and experience a persistent cognitive tension around unresolved loops. Digital platforms exploit this effect through what researchers now call incompleteness design: the deliberate creation of visual and interaction states that communicate an unresolved loop requiring the user's attention.

The notification badge is the purest application of Zeigarnik's finding. A number on a red circle communicates an uncompleted task with a specificity that makes ignoring it psychologically uncomfortable. The unread count does not merely inform: it creates a felt obligation. The visual design of the badge, its high-contrast red color maximising salience, its numerical specificity making the incompleteness concrete rather than vague, is optimised to maximise the discomfort of non-engagement.

Infinite scroll operates on the same principle at the content level. A paginated feed has an end: it resolves. An infinite feed never resolves. The Zeigarnik tension of the unreviewed feed is perpetually maintained. There is always more. The loop is never closed. The felt incompleteness drives continued engagement not because the content is necessarily rewarding but because the unresolved state is uncomfortable.

Figure 1: Designed Dependency Mechanisms and Their Psychological Foundations

Design Mechanism	Psychological Foundation	Behavioural Outcome	Platform Examples
Variable reward feed	Variable ratio reinforcement	Compulsive checking, pull-to-refresh	Instagram, X, TikTok
Notification badges	Zeigarnik effect	Felt obligation to resolve	All major platforms
Infinite scroll	Incompleteness design	No natural stopping point	Facebook, YouTube, LinkedIn
Like / reaction counts	Social validation loop	Repeated return for affirmation	Instagram, Facebook
Autoplay	Passive continuation bias	Viewing beyond intent	YouTube, Netflix, Spotify
Streaks	Loss aversion + investment effect	Engagement to avoid loss	Snapchat, Duolingo

Figure 1: Core designed dependency mechanisms, their psychological foundations, behavioural outcomes, and platform examples.

3. Visual Design as a Dependency Tool

3.1 Color and Notification Architecture

The choice of red for notification badges is not arbitrary. Elliot and colleagues (2007) documented that red activates the threat-detection system of the amygdala, generating an automatic orienting response. The eye is drawn to red faster than to any other color in the standard visible spectrum, and the orienting response it activates is associated with urgency and required action. Applying this color to a notification count leverages an evolutionary vigilance mechanism in service of platform engagement metrics.

The strategic use of high-salience colors in notification and alert design extends beyond the badge. Platforms routinely use red, orange, and bright blue for interactive elements that require user response, while using muted, desaturated colors for content and interface elements that carry no engagement value to the platform. The visual hierarchy of a typical social media interface is a color-coded map of where the platform wants the user's attention to go, with engagement-generating elements consistently elevated in visual salience.

3.2 The Removal of Stopping Cues

One of the most consequential and least discussed design decisions in platform architecture is the deliberate removal of natural stopping cues. Levin and Levin (2002) established that human behaviour in any sequential task is strongly influenced by the presence or absence of natural episode boundaries: moments where the task reaches a satisfying state of completion that allows for disengagement without cognitive cost.

Traditional media was structured around these cues. A newspaper had a last page. A television programme had an end. A book had a chapter. Each of these created a natural decision point at which the user could assess whether to continue or stop. Digital platforms have systematically engineered these cues out of their interfaces. Infinite scroll eliminates the page boundary. Autoplay eliminates the inter-episode gap. Algorithmic feeds eliminate the temporal anchor of chronological order that would otherwise signal when the user had seen everything new. Each removal is a design decision that reduces the user's capacity to disengage.

Research by Sharpe and Spooner (2025) found that users who reported wanting to reduce their platform usage identified the absence of stopping cues as the primary design factor preventing them from doing so. They were not addicted to the content. They were architecturally trapped by an interface that provided no natural exit.

3.3 Social Validation Loops

The quantification of social approval, the visible like count, the follower number, the share metric, is perhaps the most psychologically sophisticated dependency mechanism in platform design. Receiving social validation activates the same neural reward pathways as other rewarding stimuli, with the additional dimension that the reward is unpredictable in timing and variable in magnitude: precisely the conditions that generate the strongest conditioning effects.

Critically, the design decision to make these metrics visible in real time, and to deliver notifications for each individual unit of social approval, converts a social signal into a continuous behavioral

conditioning system. The user returns to check their metrics not because they need the information but because the variable reward structure of social approval notifications has conditioned the return behavior. The design of the notification, its timing, its specificity, its visual priority, is as much a part of this system as the social interaction it reports.

Figure 2: Estimated Screen Time Reduction if Dependency Mechanisms Were Removed

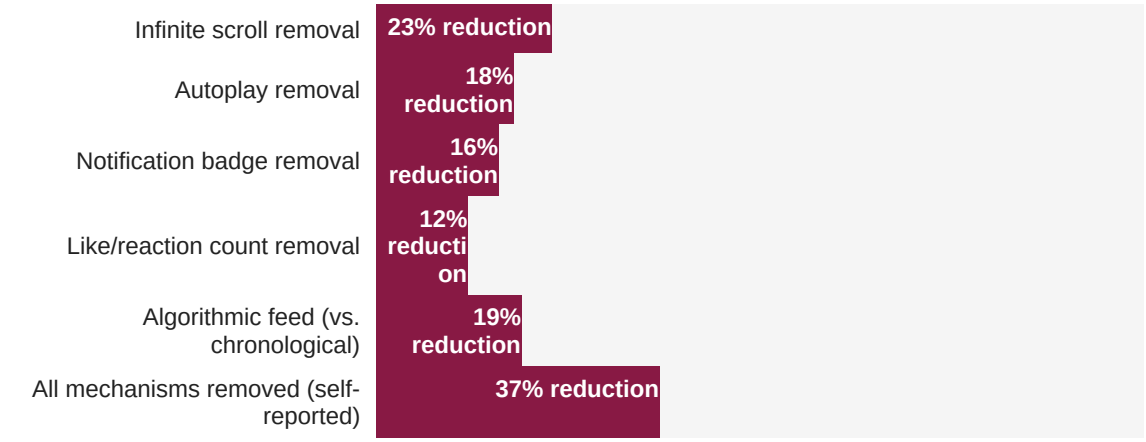

Figure 2: Estimated screen time reductions associated with individual dependency mechanisms. The aggregate self-reported figure (37%, with a participant range of 10% to 65%) is drawn from Weizenbaum Institute research (2023); the per-mechanism breakdown is illustrative, apportioning that aggregate across the mechanisms most cited by participants.

4. The Fogg Behavior Model and Platform Engineering

BJ Fogg's Behavior Model (2009), developed at Stanford University's Behavior Design Lab, provides the most widely adopted framework for understanding how design systems engineer behavior change. Fogg posits that a behavior occurs when three elements converge simultaneously: sufficient motivation, sufficient ability, and a trigger. Platform design optimises all three variables in parallel.

Motivation is maintained through variable reward schedules, social validation loops, and content algorithms that continuously surface material calibrated to the specific emotional triggers of each individual user. Ability is maximised through interface simplification: every friction point that might

impede engagement is removed, and every action the platform wants the user to take is made as effortless as possible. The trigger is omnipresent in the form of push notifications, badge counts, and the platform icon itself, which through classical conditioning becomes a reliable cue for the motivational state associated with platform use.

The combined effect of motivation optimisation, ability maximisation, and trigger omnipresence is a behavioral conditioning system of considerable power. Fogg himself has noted that the same model that describes ethical persuasive design also describes the architecture of manipulation, and that the difference lies entirely in whether the designed behavior serves the user's genuine long-term interests or merely the platform's engagement metrics.

Figure 3: Fogg Behavior Model Applied to Platform Dependency Design

Fogg Variable	Ethical Application	Dependency Application	Platform Implementation
Motivation	Content genuinely relevant to user goals	Variable rewards, social validation loops	Algorithmic feed, notification design
Ability	Reduce friction for meaningful actions	Remove all disengagement friction	Infinite scroll, autoplay, one-tap share
Trigger	Timely, contextually relevant prompts	Omnipresent, urgency-coded alerts	Push notifications, badge counts, streaks

Figure 3: The Fogg Behavior Model applied comparatively to ethical persuasive design and platform dependency architecture.

5. The Ethics of Designed Dependency

5.1 The Designer's Responsibility

Gray and colleagues (2018) introduced the concept of dark patterns to describe user interface design choices that benefit the platform at the expense of the user, including designs that make cancellation difficult, obscure privacy settings, or manufacture artificial urgency. Dependency-generating design mechanisms occupy a more complex ethical territory than classic dark patterns because they do not deceive in the conventional sense. The feed does not lie. The notification

badge accurately reports unread content. The autoplay genuinely plays the next video. The manipulation is not in the information but in the architecture.

This architectural manipulation is harder to identify and harder to legislate because no single design decision constitutes the harm. Infinite scroll is a usability feature. Variable reward is a content relevance mechanism. Notification design is a communication tool. Each, in isolation, is defensible. The harm emerges from their combination in a system optimised for engagement at the expense of user autonomy. The designer who implements each individual feature may never be confronted with the aggregate outcome of their work.

5.2 Counterdesign: Building Engagement Without Dependency

The existence of dependency-generating design mechanisms does not mean that engagement and user wellbeing are irreconcilable objectives. A growing body of design practice, sometimes called humane design or counterdesign, seeks to create products that generate genuine engagement without manufacturing compulsive use.

The core principle of counterdesign is restoring the user's capacity for autonomous decision-making about their own engagement. This means reintroducing natural stopping cues, such as progress indicators that show how much content remains and episode boundaries that create genuine decision points. It means designing notification systems that batch and schedule alerts rather than delivering them in real time. It means making disengagement as effortless as engagement, rather than engineering asymmetry between the two.

Critically, counterdesign does not necessarily sacrifice meaningful engagement. Data gathered by the Center for Humane Technology in partnership with the screen-time tracking app Moment, drawing on a pool of approximately 200,000 iPhone users, found that for the same applications, the amount of usage time people later regretted was on average more than twice the amount of usage time they reported feeling good about. For Facebook, users reported being happy with around 22 minutes per day but unhappy with roughly 59 minutes. This gap between satisfying use and regretted use suggests that a substantial portion of the engagement generated by dependency mechanisms is not experienced by users as valuable. Designing toward the satisfying portion rather than maximising raw time on platform aligns the product with what users actually want from it. Dependency and satisfaction are not the same thing, and optimising for one at the expense of the other is a strategic as well as an ethical mistake.

Figure 4: Dependency Design vs. Counterdesign: Metric Comparison

Metric	Dependency Design	Counterdesign	Difference
Daily session length	Higher	Lower	Dependency design wins
Sessions per day	Higher	Lower	Dependency design wins
User satisfaction score	Lower	Higher	Counterdesign wins
User retention (1 year)	Lower	Higher	Counterdesign wins
Reported sense of control	Low	High	Counterdesign wins
Regulatory risk	High and rising	Low	Counterdesign wins

Figure 4: Comparative metrics between dependency-optimised and counterdesign approaches. Raw session length favours dependency design; user satisfaction, retention, and regulatory standing favour counterdesign.

6. Implications for Design Practice

The mechanisms described in this paper are not the exclusive domain of social media platforms. Any product that uses notifications, feed-based content delivery, social interaction metrics, or sequential content consumption is operating within the architecture of designed dependency to some degree. E-commerce platforms use the same variable reward structures in product recommendation feeds. News sites use infinite scroll. Fitness applications use streaks and social validation loops. Professional networks quantify connection counts and engagement metrics.

For designers working in any of these contexts, the practical implication is that mechanical familiarity with these tools is not sufficient. Understanding why they work at the level of neurological and behavioral mechanism creates the foundation for responsible use. A designer who knows that notification badges work by activating the amygdala's threat-detection system through high-salience red coloring is in a position to ask whether that level of urgency is appropriate for the information being communicated. A designer who understands that infinite scroll works by eliminating the Zeigarnik resolution of task completion is in a position to evaluate whether that elimination serves the user's genuine interests.

The question for every designer who touches attention is not whether to use these mechanisms, but whether the behavior they engineer benefits the person experiencing it. When the answer is yes, designed dependency is designed engagement: a product that successfully matches human

psychology to human need. When the answer is no, it is simply extraction: human attention harvested for platform value at the user's cognitive and psychological expense. The mechanisms are the same. The ethics depend entirely on what the loop is designed to deliver.

---

7. Conclusion

Designed dependency is not an accident of digital product development. It is the predictable outcome of optimising for engagement metrics without accounting for the full psychological cost of the mechanisms used to generate them. The variable reward schedule, the Zeigarnik notification, the infinite feed, the social validation loop: each is a precisely engineered application of behavioral science to human attention, and each produces measurable, documented effects on user behavior that extend far beyond the intentions of any individual designer.

Understanding these mechanisms does not require condemning them. It requires understanding them clearly enough to deploy them responsibly. The same tools that manufacture compulsive checking of a social feed can, in a different product context, create the kind of deep, satisfying engagement that makes a learning platform effective or a creative tool genuinely useful. The difference is in the alignment between the behavior being designed and the interests of the person experiencing it.

For Artec, and for any design practice that takes the psychology of human behavior seriously, this is the central question of the digital era: not how to capture attention, but what to do with it once you have it. The science of designed dependency is also, in its mirror image, the science of designed meaning. The mechanisms are yours to use. The responsibility is yours to carry.

References

Center for Humane Technology. (2018). App ratings: Time well spent. Analysis conducted in partnership with Moment, based on screen-time data from approximately 200,000 iPhone users. https://www.humanetech.com/insights/app-ratings

Elliot, A. J., Maier, M. A., Moller, A. C., Friedman, R., & Meinhardt, J. (2007). Color and psychological functioning: The effect of red on performance attainment. Journal of Experimental Psychology: General, 136(1), 154–168.

Fogg, B. J. (2009). A behavior model for persuasive design. Proceedings of the 4th International Conference on Persuasive Technology, ACM. https://doi.org/10.1145/1541948.1542005

Gray, C. M., Kou, Y., Battles, B., Hoggatt, J., & Toombs, A. L. (2018). The dark (patterns) side of UX design. Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, ACM. https://doi.org/10.1145/3173574.3174108

Levin, D. T., & Levin, M. (2002). Task-induced cognitive load eliminates change blindness. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46(23), 2042–2046.

Raskin, A. (2019). Public statements on the consequences of infinite scroll, including the estimate that the pattern wastes approximately 200,000 human lifetimes of attention per day. As reported across multiple outlets and in the Netflix documentary The Social Dilemma (2020).

Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. Science, 275(5306), 1593–1599.

Sharpe, B. T., & Spooner, R. A. (2025). Dopamine-scrolling: A modern public health challenge requiring urgent attention. Perspectives in Public Health, 145(2), 89–95. https://doi.org/10.1177/17579139251331914

Skinner, B. F. (1938). The behavior of organisms: An experimental analysis. Appleton-Century-Crofts.

Weizenbaum Institute for the Networked Society. (2023). Dark patterns and addictive designs: User perception and behavioral impact. Weizenbaum Journal of the Digital Society, 3(2).

Zeigarnik, B. (1927). Das Behalten erledigter und unerledigter Handlungen [On finished and unfinished tasks]. Psychologische Forschung, 9, 1–85.

Research Series · Design, Branding & Behavioural Science

A Devante Butler Company