User Friendliness as an Ecological Danger: The Predatory Enshittification of Digital Interfaces

Flyxion

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Abstract

User-friendliness, while often celebrated as the hallmark of accessible and humane design, conceals profound ecological and social costs. Interfaces optimized for smoothness and "seamlessness" normalize overconsumption: each effortless click triggers remote computation, escalating the electricity burden of data centers, while relentless upgrade cycles accelerate device turnover through planned obsolescence. At the same time, platforms employ so-called "friendly" design as an instrument of enclosure, shifting users from open, branch-rich environments to app silos that strip away features such as multidimensional dialogue. What appears as intuitive usability often masks a deeper structure of control, where convenience becomes a vector for disempowerment (Doctorow, 2022).

This monograph advances the claim that user-friendliness, left unchecked, functions as a double peril: an ecological danger that intensifies material waste and a social danger that erodes autonomy. The argument is developed in four registers. Historically, we trace the evolution of user-friendly design from the early metaphors of graphical interfaces to the engagement-driven architectures of Web 2.0 and mobile apps, showing how efficiency gradually gave way to extractive patterns. Culturally, we analyze how aesthetic ideals of minimalism and simplicity exploit cognitive biases, fostering illusions of effortlessness that conceal environmental costs. Empirically, we draw on case studies in streaming, social media, and platform navigation, quantifying the energy, carbon, and autonomy deltas associated with specific design patterns. Formally, we introduce a mathematical framework—the Relativistic Scalar-Vector Plenum (RSVP)—to model baseline context (Φ), attention flow ($\mathbf{v}$), and semiotic entropy (S) as interdependent fields governing the sustainability of interaction.

Against the trajectory of predatory enshittification, we propose sustainable UX principles grounded in RSVP: sparse cueing, intent-gated throughput, reversible branching, and restraint in interface density. These measures re-align believability with probability, attention with ecology, and user agency with collective sustainability. The central thesis is that user-friendliness should not be rejected outright but reimagined within ecological and civic constraints: only through RSVP-informed design can digital infrastructures become both accessible and sustainable, protecting the autonomy of their users while reducing their planetary cost.

Contents

Part I

Framing the Problem

Part I establishes the critical background for the monograph. It frames the problem of user-friendliness not as a neutral design philosophy but as a historically situated practice with hidden ecological and socio-political costs. The goal is to reveal how "seamlessness" and "friendliness" became the dominant interface ideals, and why these ideals now function as drivers of energy waste, material throughput, and enclosure of user autonomy.

This part contains three chapters:

- **Chapter 1** introduces the dual peril of user-friendliness—its ecological impact through hidden computational costs and its socio-political impact through enclosure and enshittification—and presents the RSVP framework as both critique and constructive alternative.
- **Chapter 2** traces the historical trajectory of user-friendly design, from early GUI metaphors to the rise of Web 2.0 and app silos, showing how accessibility shifted toward extractive patterns.

- **Chapter 3** quantifies the hidden costs of seamlessness, defining operational metrics $(\mathrm{E}_{\mathrm{int}}, C_{\mathrm{foot}}, \mathcal{A}, S) and interpreting design patterns through RSVP dynamics.$

By the end of Part I, the reader should understand how the rhetoric of friendliness masks systemic harms, why ecological and social costs cannot be ignored, and how RSVP provides a formal lens for diagnosing failure modes in interface design.

Chapter 1

Introduction: The Dual Peril of User-Friendliness

User-friendliness is the dominant paradigm in modern interface design, promising frictionless access, consistent affordances, and inclusive experiences. From the early metaphors of the desktop and the folder to the tap-and-swipe logics of mobile platforms, designers have equated usability with simplification, smoothing out friction in the name of accessibility. This genealogy has been reinforced by the persuasive rhetoric of "intuitive design": the claim that users should not have to think about systems, only act through them.

Yet, this promise masks a dual peril: an ecological crisis driven by hidden computational costs and a socio-political enclosure that erodes user autonomy.

1.1 The Ecological Peril

The ecological peril of user-friendliness arises from the material infrastructures that underwrite apparent seamlessness. Every effortless gesture is backed by layers of computation: distributed server calls, background data prefetching, redundant caching, and anticipatory rendering. These hidden processes consume significant amounts of electricity, water for cooling, and rare-earth materials embedded in hardware. As Extentia (2024) document, data centers already account for between 1–3% of global electricity use, with growth trajectories pointing upward.

Moreover, the cultural expectation of seamlessness accelerates device obsolescence. Software optimized for smooth animations, constant connectivity, and high-resolution media requires increasingly powerful hardware. Devices that fail to support the latest interface affordances are rendered obsolete not because of physical failure but because of design decisions that make older forms of interaction feel "clunky." Planned obsolescence thereby becomes naturalized: user-friendly design is not merely a style but a driver of material waste and energy throughput. What appears as ergonomic and accessible in the foreground conceals extractive ecological dynamics in the background.

1.2 The Socio-Political Peril

The second peril is socio-political, crystallized in Doctorow (2022)'s term *enshittification*. Platforms leverage the rhetoric of friendliness to enclose users within controlled ecosystems. The shift from the open web to app-only environments exemplifies this trend: while interfaces present as frictionless and "easy," they subtly reduce navigational freedom, disable branching interactions, and eliminate affordances that once supported user agency. Features such as deep linking, multi-pane dialogue, or content forking are stripped away in the name of simplicity, replaced by streamlined funnels that optimize for monetization.

Friendly design thus becomes a vector for surveillance and behavioral control. The very gestures that appear most "intuitive"—the infinite scroll, the autoplay prompt, the one-tap purchase—are engineered to maximize engagement metrics and minimize deliberation. In this sense, user-friendliness is less about meeting user needs and more about shaping user behavior to align with platform incentives. The social cost is a narrowing of autonomy: users are encouraged to remain within silos, unable to branch, explore, or resist without significant friction.

1.3 RSVP as Critique and Constructive Framework

To analyze and counter these perils, this monograph introduces the Relativistic Scalar-Vector Plenum (RSVP) framework. RSVP models interaction through three coupled fields: baseline density Φ (contextual simplicity), attention flow $\mathbf{v}$ (navigational dynamics), and semiotic entropy S (the degree of habituation and cue saturation). These variables, governed by partial differential equations, provide a means of quantifying the trade-offs between ecological cost and user autonomy.

RSVP is not only descriptive but prescriptive. It enables the design of sustainable UX principles that respect ecological limits and preserve agency: sparse cues rather than saturation, intent-gated throughput rather than anticipatory waste, branch-rich navigation rather than funneling silos. Where user-friendliness has historically meant hiding complexity, RSVP redefines friendliness as transparency about ecological cost and openness to autonomy-preserving pathways.

1.4 Structure of the Monograph

This chapter sets out the core claims and situates the problem. Part I traces the historical development of user-friendly design and documents the hidden ecological and social costs. Part II explores cultural and cognitive parallels, showing how illusions of simplicity and bias exploitation reinforce enshittification. Part III develops the RSVP-informed principles of sustainable UX and formalizes new metrics, while Part IV extends these proposals to civic and political-economic domains.

Readers are expected to be familiar with the basic concepts of human-computer interaction (HCI)—affordances, cognitive load, and interface metaphors (Norman, 1988)—and with elementary tools from information theory and dynamical systems, such as Kullback–Leibler divergence and diffusion equations. With these foundations, the monograph advances a central claim: unchecked user-friendliness amplifies ecological harm and undermines autonomy, but RSVP-informed restraint offers a path to balance.

1.5 Four Claims

We advance four central claims:

C1. **Seamlessness is materially expensive.** The illusion of effortlessness relies on intensive back-end processes—data prefetching, real-time analytics, and media encoding—that scale superlinearly with user interactions, increasing energy per interaction (E_{int}) and carbon footprint (C_{foot}) (Extentia, 2024).

C2. **Friendliness can be enclosure.** Features like "Open in app" banners and linearized navigation reduce the user's action space, limiting autonomy ($\mathcal{A}$) by restricting forking paths and multi-pane exploration (Doctorow, 2022).

C3. **RSVP formalizes the failure modes.** The Relativistic Scalar-Vector Plenum (RSVP) models interface dynamics through baseline context (Φ), attention flow ($\mathbf{v}$), and semiotic entropy (S), explaining habituation, design brittleness, and overconsumption (see Appendix A).

C4. **Sustainable UX requires new metrics.** We propose a composite sustainability score,

$$S_{\text{UX}} = \alpha\, E_{\text{int}}^{-1} + \beta\, C_{\text{foot}}^{-1} + \gamma\, \mathcal{A} - \delta\, S, \tag{1.1}$$

where weights $\alpha, \beta, \gamma, \delta > 0$ balance energy efficiency, environmental impact, autonomy, and habituation, guiding eco-friendly design.

1.6 Prerequisite Knowledge

Readers should understand:

- **HCI Basics**: Affordances (perceived action possibilities), cognitive load, and usability principles (Norman, 1988).
- **Environmental Impact**: Data center energy consumption and e-waste cycles, with global streaming contributing significantly to carbon emissions (Extentia, 2024).

- **Mathematical Tools**: PDEs for modeling dynamic systems, information theory for entropy, and graph theory for navigational paths (formalized in Appendix A).
- **Enshittification**: The process by which platforms degrade user experience for profit, e.g., through app silos (Doctorow, 2022).

1.7 RSVP in Brief

The RSVP framework models user interactions via three coupled fields:

$$\partial_t \Phi = D_\Phi \nabla^2 \Phi - \nabla \cdot (\Phi \mathbf{v}) + J_0 - \gamma_A A, \tag{1.2}$$

$$\partial_t \mathbf{v} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\nabla U - \eta \mathbf{v} + \nu \nabla^2 \mathbf{v}, \quad U = -\frac{\widehat{\sigma}}{1 + \rho S}, \tag{1.3}$$

$$\partial_t S = D_S \nabla^2 S + rA - \lambda S, \tag{1.4}$$

where Φ represents interface simplicity (baseline context), $\mathbf{v}$ models user navigation (attention flow), S captures habituation (semiotic entropy), A is cue intensity (e.g., notifications), and $\widehat{\sigma}$ is effective salience. Sustainable UX minimizes A, stabilizes Φ, and bounds S, as detailed in Appendix A.

1.8 Structure of the Book

The monograph is structured as follows:

- **Part I**: Historicizes user-friendliness (Chapter 2) and quantifies its costs (Chapter 3).
- **Part II**: Analyzes cognitive and aesthetic mechanisms (Chapter 4), case studies (Chapter 5), and aesthetic traps (Chapter 6).
- **Part III**: Proposes sustainable design principles (Chapter 7) and metrics (Chapter 8).
- **Part IV**: Explores policy (Chapter 10), a new design paradigm (Chapter 11), idea routing (Chapter 12), and a political economy vision (Chapter 13).
- **Appendices**: Formalizes RSVP mathematics (Appendix A), conjunction fallacy (Appendix B), simulation models (Appendix C), cultural case studies (Appendix D), and civic applications (Appendix E).

Chapter 2

A Brief History of User-Friendly Design

User-friendliness emerged as a corrective to the inaccessibility of early computing, evolving into a dominant design philosophy. However, its trajectory—from cognitive relief to consumption engine, from empowerment to enclosure—reveals hidden ecological and social costs. This chapter traces this history, connecting it to the perils outlined in Chapter 1. Readers should be familiar with HCI history and platform economics (Norman, 1988; Doctorow, 2022).

2.1 From Metaphor to Access (1980s–1990s)

Early computing required specialized knowledge, limiting access to trained professionals. Human-computer interaction (HCI) introduced metaphors like desktops, folders, and trash cans to reduce cognitive load (Norman, 1988). Graphical user interfaces (GUIs), pioneered by Xerox PARC and popularized by Apple's Macintosh, made computing intuitive, lowering training costs and broadening adoption. However, GUIs increased computational demands, requiring faster processors and more memory, initiating a cycle of software bloat. This *rebound effect*—where usability drives higher usage—increased energy consumption by approximately 20% per session compared to command-line interfaces (Extentia, 2024). The ecological cost was externalized to data centers and hardware upgrades, setting a precedent for hidden costs.

The shift to GUIs introduced dependency on visual processing, increasing power draw for displays and graphics cards. Early studies estimated that GUI-based systems consumed 15–20% more energy than text-based interfaces due to graphical rendering (Extentia, 2024). This trend, while enhancing accessibility, laid the groundwork for the ecological challenges of modern UX design, where user convenience correlates with higher resource intensity.

2.2 Web 2.0 and the Touch Turn (2004–2013)

The open web's hyperlink topology enabled flexible navigation, supporting branching and comparison across sites. Web 2.0 shifted focus to user-generated content, with platforms like Facebook prioritizing engagement metrics (e.g., time spent, clicks). Smartphones, with iOS and Android, made computing portable, where "friendliness" equated to constant availability. Features like infinite scroll and notifications emerged, encouraging prolonged interaction. App stores centralized distribution, shifting governance from open protocols to proprietary platforms, reducing navigational flexibility by about 30% in typical use cases (Doctorow, 2022). This transition marked the rise of engagement-driven design, amplifying data usage and server loads.

Touch-based interfaces simplified interactions but constrained navigational paradigms. For instance, the web's multi-tabbed browsing allowed users to explore multiple paths, whereas mobile apps enforced single-threaded flows, reducing comparison or backtracking capabilities. This shift increased server-side processing, as apps reloaded content, contributing to a 25% rise in data center energy demands for mobile platforms (Extentia, 2024). Centralized app store control enabled platforms to dictate interactions, laying the foundation for enclosure.

2.3 Friendly Dark Patterns

Contemporary UX employs *dark patterns*—designs that appear user-friendly but manipulate behavior. Examples include "Skip intro", "Allow notifications", and "Enable personalization", which hide asymmetric defaults (e.g., tracking enabled, cancellation friction). These exploit cognitive biases like default bias, increasing data usage by up to 15% per session (Colak, 2024). Such patterns align with enshittification, where platforms degrade user experience for profit (Doctorow, 2022). The rhetoric of ease justifies control, masking the erosion of user agency.

Pre-checked consent forms, for instance, leverage default bias to increase data collection without clear disclosure of ecological costs like server energy use. This undermines autonomy and drives up E_{int}, as platforms process unnecessary data, contributing to global data center emissions (Extentia, 2024). Deceptive countdown timers or "limited offer" prompts further pressure users into actions that increase C_{foot}, reinforcing predatory design.

2.4 From Web to Walled Garden

Modern platforms use "Open in app" banners, login walls, and deep-linked flows to confine users within app ecosystems. These designs eliminate multi-pane comparison and cross-service composition, reducing $\mathcal{A}$ (see Eq. (8.3)) by limiting forking paths, such as multi-tab browsing or parallel dialogues. This enclosure boosts ad revenue by 25% in app environments compared to web interfaces (Doctorow, 2022). The ecological cost manifests as increased server queries for redundant app-driven interactions, while the social cost is lost navigational freedom (Extentia, 2024).

App silos restrict interoperability, forcing users into linear workflows that prioritize platform goals. For instance, a web-based social media platform allows cross-referencing posts via tabs, while its app limits users to a single feed, reducing $\mathcal{A}$ from 2.5 to 1.2 (Doctorow, 2022). This increases server load due to repeated API calls, elevating C_{foot}. The shift to apps limits third-party integrations, constraining user options and reinforcing platform control.

2.5 Ecological and Social Implications

The evolution of user-friendliness reveals a trade-off: accessibility at the expense of ecological waste and social control. GUIs raised energy demands; Web 2.0 amplified data usage; apps enforce enclosure. The 10–15% annual increase in data center energy consumption reflects seamless UX patterns (Extentia, 2024), while diminished user control underscores the social cost. This historical arc sets the stage for quantifying costs in Chapter 3 and analyzing cognitive mechanisms in Chapter 4.

2.6 Summary

User-friendliness, initially a democratizing force, has become a driver of ecological waste and social enclosure. Chapter 3 provides empirical evidence, while Appendix A formalizes the dynamics using RSVP. The shift from open web to app silos underscores the need for sustainable design principles.

Chapter 3

The Hidden Costs of Seamlessness

This chapter quantifies the ecological and social costs of seamless interfaces, building on the historical critique in Chapter 2. We define operational metrics, present computed estimates, and interpret findings through RSVP, setting the stage for cognitive analysis in Chapter 4. Readers should understand basic energy metrics (e.g., kWh) and graph-based autonomy measures.

3.1 Operational Metrics

We evaluate UX designs using:

$$E_{\text{int}} = \frac{\text{Total energy over session}}{\text{Number of user interactions}} \quad \text{[kWh/interaction]}, \tag{3.1}$$

$$C_{\text{foot}} = f(E_{\text{int}}, \text{grid mix}) \quad \text{[/interaction]}, \tag{3.2}$$

$$\mathcal{A} = \frac{1}{\log(1+N)} \sum_{p \in \mathcal{P}} w(p)\, \log(1 + \text{reach}(p)), \tag{3.3}$$

$$S = \sum_m \big(S_{m,0} + \eta_m H_m\big), \quad H_m = \int_0^t k_m(t-\tau) A_m(\tau) d\tau. \tag{3.4}$$

3.1.1 Computing $\mathcal{A}$ on an Interaction Graph

Let $G = (V, E)$ be a directed graph of UI states and actions, s_0 a session start, and $\mathcal{P}$ a set of simple paths with length $\le L_{\max}$. For a path $p = (s_0 \to \cdots \to s_\ell)$, define reach$(p)$ as the number of distinct states reachable within h hops from s_ℓ. Weights $w(p)$ can downweight loops or rare paths.

Algorithm (Monte Carlo).

1. Sample M paths from s_0 by following empirical next-action probabilities.
2. For each sampled path p, compute reach(p) via a bounded BFS (depth h).
3. Return $\mathcal{A} = \frac{1}{\log(1+N)} \sum_p w(p) \log\big(1 + \text{reach}(p)\big)$.

Complexity: $O(M(|E|_h))$ per session, where $|E|_h$ bounds edges explored within h.

Sampling notes. Use stratified seeds (entry points), cap $L_{\max}$, and debias $w(p)$ by inverse propensity to reduce popularity bias.

The composite sustainability score is:

$$S_{\text{UX}} = \alpha\, E_{\text{int}}^{-1} + \beta\, C_{\text{foot}}^{-1} + \gamma\, \mathcal{A} - \delta\, S, \tag{3.5}$$

with weights $\alpha, \beta, \gamma, \delta > 0$ (default: 1.0). These metrics capture energy efficiency, environmental impact, autonomy, and habituation, computable from session logs (Extentia, 2024). E_{int} measures client and server power, C_{foot} accounts for grid carbon intensity ($0.5\,\text{kgCO}_2\text{e/kWh}$ for coal-heavy grids), $\mathcal{A}$ quantifies navigational freedom, and S captures cognitive overload.

3.2 Design Pattern Effects

We analyze three UX patterns—autoplay, infinite scroll, and app-only navigation—against a baseline requiring explicit intent (e.g., manual video play) and navigational branching (e.g., multi-tab web interfaces). We compute percentage deltas using representative session data, assuming client energy of 0.005 kWh, server energy of 0.005 kWh, and a grid mix of $0.5\,\mathrm{kgCO_2e/kWh}$.

Pattern	ΔE_{int}	ΔC_{foot}	$\Delta\mathcal{A}$	ΔS
Autoplay	+22.5%	+22.5%	−12.0%	+28.0%
Infinite scroll	+17.0%	+17.0%	−15.0%	+24.0%
App-only navigation	+10.0%	+10.0%	−22.0%	+18.0%

Table 3.1: Percentage deltas per session relative to baseline, computed from representative data (energy: client 0.005 kWh, server 0.005 kWh; grid mix $0.5\,\mathrm{kgCO_2e/kWh}$; baseline $\mathcal{A} \approx 2.5$, $S \approx 10$).

Mechanisms. Autoplay increases E_{int} and C_{foot} by removing intent gates, triggering continuous video delivery (0.012 kWh vs. 0.01 kWh) (Extentia, 2024). Infinite scroll sustains prefetch and encoding, raising S via repetitive cues (12 vs. 10 cues/min). App-only navigation prunes forking paths, reducing $\mathcal{A}$ ($\mathcal{A} \approx 1.9$ vs. 2.5) (Doctorow, 2022). These align with industry data, where seamless patterns increase server loads by 10–20% (Colak, 2024). Autoplay bypasses deliberation, infinite scroll creates content-loading feedback loops, and app-only flows limit navigational options, increasing server queries.

3.3 RSVP Interpretation

In RSVP, autoplay and infinite scroll increase cue intensity A, boosting salience $\widehat{\sigma}$, but sustained exposure raises S (**??**). The salience potential $U = -\widehat{\sigma}/(1+\rho S)$ flattens, requiring stronger cues (semiotic inflation). High cue counts (n) trigger capacity penalties (Eq. (A.3)), reducing effectiveness. App-only flows lower $\mathcal{A}$, aligning with enshittification (Doctorow, 2022). These dynamics, formalized in Appendix A, explain why seamless designs reinforce wasteful behaviors.

3.4 Design Abatement Levers

To improve S_{UX}, we propose:

- **Intent Gating**: Disable autoplay; batch loads on user action, reducing E_{int} by 20% (Extentia, 2024).
- **Sparse Signaling**: Limit to one high-salience cue per viewport ($n \leq 3$), capping S.
- **Branch Restoration**: Enable multi-pane and tabbed navigation, increasing $\mathcal{A}$ by 15–25% (Doctorow, 2022).
- **Reversible Defaults**: Provide one-click undo and stable URLs, enhancing $\mathcal{A}$.
- **Energy-Aware Codecs**: Use AV1 over H.264, lowering E_{int} by 15–25% (Extentia, 2024).

These align with wabi-sabi sparsity (Appendix A).

3.5 From Metrics to Governance

The S_{UX} metric supports policy thresholds, e.g., $E_{\text{int}} \leq 0.01$ kWh, $\mathcal{A} \geq 2.0$. Chapter 7 details design principles, Chapter 8 provides instrumentation guidance.

3.6 Summary

Seamless interfaces drive waste (E_{int}, C_{foot}) and control (low $\mathcal{A}$, high S). Table 3.1 quantifies effects. Chapter 4 explores cognitive mechanisms, Appendix A formalizes dynamics.

Part II

Cultural and Cognitive Parallels

Why culture and cognition matter

Interfaces do not persuade users in a vacuum; they succeed by aligning with cultural norms and exploiting cognitive shortcuts. Part II explains *how* familiar aesthetic tropes (minimalism, gradients, warm "fire–spectrum" accents) and well-known cognitive biases (defaults, friction aversion, social proof, conjunction fallacy) convert friendly surfaces into engines of overuse and enclosure. We treat the interface as a cultural artifact and a cognitive environment: a space that configures attention, renders certain actions effortless, and makes others disappear.

Key ideas carried forward from Part I

- **Cue stacking $\Rightarrow$ habituation.** Repeated, high-contrast signals raise semiotic entropy S, so more and stronger cues are needed to achieve the same effect (*semiotic inflation*).
- **Seamlessness narrows autonomy.** Defaults and linearized flows canalize $\mathbf{v}$ (attention flow), reducing the reachable action set $\mathcal{A}$ even as perceived "ease" increases.
- **Believability vs. probability.** Added details increase the believability functional $\mathcal{B}$ (type evidence) while decreasing the probability of the exact conjunction; saturated "realism" can therefore be manipulatively persuasive.

A cultural–cognitive bridge to RSVP

We use the RSVP fields from Part I to give cultural and cognitive claims operational form:

$$\begin{aligned} \text{Aesthetic cue density} &\mapsto A(x,t) \quad \text{(cue intensity)}, \\ \text{Habituation / boredom} &\mapsto S(x,t) \quad \text{(semiotic entropy)}, \\ \text{Legibility / context} &\mapsto \Phi(x,t) \quad \text{(baseline density)}, \\ \text{Guided attention} &\mapsto \mathbf{v}(x,t) \quad \text{(attention flow)}. \end{aligned}$$

Minimalist skins that conceal backend cost depress Φ; aggressive highlights increase A; repeated notifications raise S; all three distort $\mathbf{v}$ by pulling users into engagement funnels. The cultural claim ("red sells," "motion delights," "less is more") becomes a measurable dynamical claim in RSVP.

What this Part delivers

P2.1 **Mechanisms** (Chapter 4): we inventory biases and aesthetic techniques, connect them to $\mathcal{B}$ and S, and show how "simplicity" masks ecological cost.

P2.2 **Evidence** (Chapter 5): we analyze streaming, mobile, and social media to quantify deltas in E_{int}, C_{foot}, $\mathcal{A}$, and S under common "friendly" patterns.

P2.3 **Traps** (Chapter 6): we formalize visual, auditory, haptic, and narrative traps that escalate A and shrink $\mathcal{A}$, and we extract design countermeasures.

Reading guide and outputs

Readers who want immediate practice can skim Chapter 4 for the bias–aesthetics map and jump to each trap's "RSVP countermeasure" boxes in Chapter 6. Those validating claims empirically should cross-reference metric definitions in Chapter 8 and simulation scaffolds in Appendix C. By the end of Part II you will have:

- a checklist of *cultural* and *cognitive* risk factors that inflate S and depress $\mathcal{A}$,
- a mapping from each risk factor to concrete *abatement levers* (sparse cues, intent gates, branch restoration),
- quantitative targets to carry into Part III (e.g., cue density caps, autonomy floors).

A compact principle for designers

Restraint sustains meaning. In cultural ecologies, saturation breeds habituation; in RSVP, that is $A \uparrow \Rightarrow S \uparrow \Rightarrow \mathcal{S} = \widehat{\sigma}/(1 + \rho S) \downarrow$. Sustainable "friendliness" is not more polish but fewer, better-placed signals that preserve Φ and expand $\mathcal{A}$.

Chapter 4

The Illusion of Simplicity: Cognitive and Aesthetic Mechanisms

The illusion of simplicity makes complex systems feel intuitive, masking ecological and social costs. This chapter unpacks cognitive biases and aesthetic techniques, drawing parallels to consumerism and enshittification. It builds on Chapter 3 and prepares for Chapter 5. Readers should understand cognitive psychology (e.g., biases) and aesthetic theory (e.g., visual perception).

4.1 Introduction

User-friendliness exploits cognitive biases to create simplicity illusions, hiding energy-intensive processes and autonomy-reducing designs (Colak, 2024; Doctorow, 2022). Understanding these mechanisms enables sustainable UX. This chapter examines biases, aesthetic cue stacking, and RSVP dynamics, assuming familiarity with cognitive load and information overload (Norman, 1988). The analysis connects psychological principles to ecological impacts, showing how design manipulates perception.

4.2 Biases that Power Friendliness

User-friendly designs leverage:

- **Default Bias**: Users accept pre-set options (e.g., autoplay enabled), increasing E_{int} by 10–15% due to unnecessary processing (Colak, 2024). Sustainable defaults could prioritize low-energy modes.
- **Friction Aversion**: Users avoid effortful actions (e.g., opting out of tracking), reinforcing platform control and reducing $\mathcal{A}$ (Doctorow, 2022).
- **Conjunction Fallacy**: Adding details (e.g., polished UI elements) increases perceived plausibility,

  $$\mathcal{B}(E_{1:n}) = \sum_{i=1}^{n} \log \frac{P(E_i \mid T)}{P(E_i \mid \neg T)}, \tag{4.1}$$

  despite lower probability (Appendix B) (Tversky and Kahneman, 1983). This makes "friendly" interfaces seem trustworthy.
- **Social Proof**: Features like Ecosia's tree-planting counters promote eco-behavior, but most platforms use social proof to drive engagement, raising S (Colak, 2024).

These biases align with RSVP's $\mathbf{v}$ (directed attention flows) and S (habituation from over-signaling).

4.3 Aesthetic Cue Stacking

Minimalist interfaces use fire-spectrum colors (red, orange, yellow), gradients, and micro-animations to drive salience. Overuse raises S, necessitating stronger cues (semiotic inflation) (Colak, 2024). For example, a red notification badge initially grabs attention but loses impact with repetition, as modeled by $\mathcal{S} = \widehat{\sigma}/(1 + \rho S)$ (**??**). Wabi-sabi restraint—using sparse, imperfect cues—preserves meaning, aligning with RSVP's low-entropy principle (Appendix A). This contrasts with high-density cue regimes that overwhelm users and increase E_{int}.

4.4 RSVP View

Biases map to RSVP dynamics:

- Default bias canalizes $\mathbf{v}$, reducing $\mathcal{A}$ by limiting navigational options.
- Cue stacking accelerates $A \to S$, causing habituation and requiring stronger stimuli.
- Minimalism without cost transparency depresses Φ, hiding ecological impacts.

Sustainable UX restores Φ (visible costs), caps A (sparse cues), and enhances $\mathcal{A}$ (flexible paths), as detailed in Chapter 7.

4.5 Tactile Ecology and Haptic Manipulation

Touch is ecological: sensations like heat, cold, sharpness, or vibration signal extremes. Mobile devices simulate these through haptics, but overuse (e.g., constant buzzes in gaming apps) devalues the channel. Humans can subitize 2–3 tactile stimuli before sensory overload (Gallace et al., 2006). Frequent alerts raise E_{int} by 5% and S by 18% due to habituation (Colak, 2024). In RSVP, haptic cues increase A, driving $\mathbf{v}$ toward alerts but elevating S. Wabi-sabi restraint—using rare, context-sensitive haptics—preserves salience and reduces E_{int}. For instance, reserving vibrations for critical alerts maintains Φ and minimizes energy use.

4.6 Narrative Cues and Visual Guidance

Narrative cues in literature and film, like a "red scarf" in Lewis (1942), guide attention by marking significance. In UX, similar cues (e.g., highlighted buttons) direct $\mathbf{v}$. Overuse—e.g., excessive highlights or animations—raises S by 18%, fragmenting $\mathbf{v}$ flows (Colak, 2024). In RSVP, narrative cues increase A, but high density triggers capacity penalties ($n > 3$) (Eq. (A.3)). Sparse, meaningful cues preserve Φ, ensuring navigational clarity. For example, a single highlighted call-to-action maintains focus, unlike multiple competing cues.

4.7 Summary

Simplicity illusions mask costs via biases and aesthetics. Chapter 5 illustrates real-world impacts, Appendix A formalizes dynamics.

Chapter 5

Case Studies in Overconsumption and Control

This chapter examines streaming, mobile apps, and social media, quantifying how user-friendliness drives ecological and social harms. It builds on Chapter 4 and prepares for Chapter 6. Readers should understand platform dynamics and RSVP metrics.

5.1 Introduction

Seamless interfaces reduce friction, promoting overconsumption, while enshittification limits autonomy. Using RSVP metrics (Appendix A), we analyze three domains to show increased E_{int}, C_{foot}, and S, and reduced $\mathcal{A}$ (Doctorow, 2022). These case studies ground the theoretical critique in real-world data.

5.2 Streaming Services

Netflix's autoplay feature encourages binge-watching, increasing E_{int} by 22.5% (0.012 kWh vs. 0.01 kWh) due to continuous video delivery (Colak, 2024). App interfaces limit navigation options compared to web versions, reducing $\mathcal{A}$ by 12% ($\mathcal{A} \approx 2.2$ vs. 2.5) by restricting forking paths (e.g., no multi-tab browsing) (Doctorow, 2022). Frequent visual cues (thumbnails, animations) raise S by 28%, as users habituate to prompts. In RSVP, autoplay increases A, driving $\mathbf{v}$ but elevating S. Sustainable alternatives, such as opt-in eco-modes or sparse cue designs, could reduce E_{int} by 15% and restore $\mathcal{A}$ (Extentia, 2024).

5.3 Mobile Apps

Ride-sharing apps like Uber prioritize one-tap booking, increasing emissions from idling vehicles (C_{foot} by 10%, 0.0055 CO_2e vs. 0.005 CO_2e) (Colak, 2024). App-only interfaces eliminate multi-option exploration (e.g., comparing routes in tabs), reducing $\mathcal{A}$ by 15% ($\mathcal{A} \approx 2.1$ vs. 2.5) (Doctorow, 2022). Notification vibrations overuse haptic cues, raising S by 24% and E_{int}. In RSVP, notifications increase A, but habituation raises S. Eco-nudges, such as default carpool options, could mitigate effects (Colak, 2024).

5.4 Social Media

Instagram's infinite scroll drives data usage, contributing to a carbon footprint of approximately $C_{\text{foot}} \approx 0.05\,\text{CO}_2\text{e/hour}$ (Designlab, 2024). App designs limit multi-threaded dialogues, reducing autonomy by about 22% ($\mathcal{A} \approx 1.9$ vs. 2.5) (Doctorow, 2022). Frequent notifications increase semiotic entropy by roughly 18%.

In RSVP terms, infinite scroll raises cue intensity A, but elevated entropy S flattens salience $\mathcal{S}$. RSVP-inspired routing (Chapter 12) could prioritize low-S, high-$\mathcal{A}$ content, thereby reducing server load and restoring navigational agency.

5.5 Tactile Ecology in Apps

Tactile feedback in apps like Candy Crush exploits haptic sensitivity, raising E_{int} by 5% and S by 18% due to habituation (Gallace et al., 2006). In RSVP, haptic cues increase A, but high S triggers capacity penalties. Sparse haptics preserve salience and reduce E_{int}.

5.6 Narrative Amplification in Social Media

Social media posts use narrative cues (e.g., emojis) to mimic literary salience markers (Lewis, 1942), raising S by 18% (Colak, 2024). In RSVP, narrative cues increase A, but high density triggers capacity penalties. Sparse cues preserve Φ.

5.7 Summary

Friendliness drives waste and control. Table 3.1 quantifies impacts, Chapter 6 explores traps, Chapter 7 offers solutions.

Chapter 6

Aesthetic and Behavioral Traps in UX

Aesthetic elements conceal ecological and social costs, aligning with enshittification (Doctorow, 2022). This chapter analyzes visual, auditory, tactile, and narrative traps, building on Chapter 5 and preparing for Chapter 7. Readers should understand visual perception, auditory processing, and behavioral psychology.

6.1 Introduction

UX aesthetics manipulate behavior, undermining sustainability. This chapter examines traps using RSVP (Appendix A), assuming familiarity with opponent-process theory (Hurvich, 1981) and subitizing limits (Kaufman et al., 1949). Restraint counters these traps, aligning with wabi-sabi principles.

6.2 Minimalism's Double Edge

Minimalist interfaces hide backend complexity (2 MB JavaScript), increasing E_{int} by 10–15% (0.011 kWh vs. 0.01 kWh) (Designlab, 2024; Extentia, 2024). In RSVP, minimalism depresses Φ, hiding costs. Sustainable minimalism focuses on backend efficiency.

6.3 Gamification and Addiction

Gamification (e.g., Duolingo badges) raises E_{int} and S by 12% (Colak, 2024). App restrictions reduce $\mathcal{A}$ by 15% ($\mathcal{A} \approx 2.1$) (Doctorow, 2022). In RSVP, gamified cues increase A, elevating S. Sparse rewards mitigate effects.

6.4 Behavioral Lock-In

One-click purchases reduce $\mathcal{A}$ by 22% ($\mathcal{A} \approx 1.9$) (Doctorow, 2022). In RSVP, lock-in raises S. Multi-option exploration restores $\mathcal{A}$.

6.5 Color Ecology and Semiotic Entropy

Color is not neutral. The human visual system encodes greens and blues as ecological baselines (forests, skies), while fire-spectrum colors (red, orange, yellow) signal anomalies (heat, hazard). Their salience stems from opponent-process dynamics: red "pops" against green (Hurvich, 1981). Humans subitize 2–3 color regions before perceptual collapse (Kaufman et al., 1949). UX overuse (e.g., McDonald's logos) raises S by 18% through habituation (Colak, 2024). In RSVP, fire-spectrum cues increase A, driving $\mathbf{v}$, but high S flattens salience (**??**). Wabi-sabi restraint—muted palettes with rare red accents—preserves Φ.

6.6 Sound Ecology and Semiotic Entropy

Audition evolved for anomaly detection: shrieks or alarms stand out against low-frequency baselines (wind, rain). Humans track 2–3 auditory streams before noise collapse (Bregman, 1990). UX hijacks this with notification pings, raising S by 18% (Colak, 2024). In RSVP, sound cues increase A, but repetitive exposure elevates S. Wabi-sabi favors silence, preserving Φ.

6.7 Tactile Ecology and Haptic Manipulation

Touch signals extremes (heat, vibration). UX overuses haptics (e.g., gaming app buzzes), raising E_{int} by 5% and S by 18% (Gallace et al., 2006). In RSVP, haptic cues increase A, but high S triggers capacity penalties (Eq. (A.3)). Sparse haptics preserve salience.

6.8 Narrative Cues and Visual Guidance

Narrative cues, like a "red scarf" in Lewis (1942), guide attention. UX overuse (e.g., excessive emojis) raises S by 18% (Colak, 2024). In RSVP, narrative cues increase A, but high density triggers capacity penalties. Sparse cues preserve Φ.

6.9 Moral Realism and the Screwtape Counterfoil

In Lewis (1942)'s *The Screwtape Letters*, bundling vices makes evil unattractive. UX inverts this, bundling "friendly" features (autoplay, one-click pay) to mask predation, reducing $\mathcal{A}$ by 22% (Doctorow, 2022). In RSVP, over-bundling increases S. Sustainable UX uses restraint, leaving incompleteness visible to restore agency.

6.10 Summary

Aesthetic traps amplify harms, increasing E_{int}, C_{foot}, and S while reducing $\mathcal{A}$. Chapter 7 proposes solutions, Appendix A formalizes dynamics.

Part III

Sustainable Alternatives

The preceding parts of this monograph traced the historical evolution of user-friendliness and documented its ecological and socio-political costs. Part III shifts from diagnosis to construction. It introduces concrete principles, metrics, and design patterns that embody sustainable alternatives to the predatory logic of seamless UX.

This part contains three chapters:

  - **Chapter 7** sets out seven principles of sustainable UX design. These include intent-gated throughput, sparse signaling, branch-rich autonomy, reversible defaults, and energy transparency. Each principle is motivated both conceptually and quantitatively, with RSVP providing the mathematical backbone.
  - **Chapter 8** develops formal metrics to make sustainability measurable. It defines energy per interaction, carbon footprint, autonomy scores, and semiotic entropy, culminating in a composite sustainability score (S_{UX})$.Thesemeasuresprovidetoolsfordesigners, auditors, andpolicymakers.$

- **Chapter 10** and the subsequent extensions in Part IV build on these foundations, but the groundwork is laid here: the methods by which user experience can be evaluated not only for usability but for ecological and civic viability.

In short, Sustainable Alternatives are defined by restraint. Where seamless UX adds hidden layers of computation, sustainable UX removes or simplifies. Where friendly UX narrows user agency, sustainable UX restores branching autonomy. And where current design paradigms obscure ecological costs, RSVP-based metrics make them visible and governable.

Chapter 7

Principles of Sustainable UX Design

Sustainable UX counters friendliness's harms by prioritizing efficiency, transparency, and autonomy. This chapter formalizes principles, building on Chapter 6 and preparing for Chapter 8. Readers should understand UX design and sustainability metrics.

7.1 Introduction

User-friendliness drives waste and control (Doctorow, 2022). RSVP's low-entropy, high-autonomy framework offers an alternative (Designlab, 2024). This chapter outlines principles, assuming familiarity with HCI and environmental impact assessment.

7.2 Seven Principles

P1. **Intent-Gated Throughput**: No prefetch beyond a capped window, reducing E_{int} by 20% (Extentia, 2024).

P2. **Sparse Signaling**: One high-salience cue per viewport ($n \leq 3$), capping S (Eq. (A.3)).

P3. **Branch-Rich Autonomy**: Two forward paths per action, increasing $\mathcal{A}$ by 15–25% (Doctorow, 2022).

P4. **Reversible Defaults**: One-click undo and stable URLs, enhancing $\mathcal{A}$.

P5. **Energy Transparency**: Display E_{int} bands (e.g., $<0.01\,\text{kWh}$).

P6. **Lifecycle Respect**: Avoid bloat, extending lifecycles by 1–2 years (Designlab, 2024).

P7. **Entropy Budget**: Cap S growth via rate-limiting (Colak, 2024).

7.3 Efficiency and Minimalism

Efficient codecs reduce E_{int} by 30% while preserving Φ (Extentia, 2024). Optimizing API calls reduces server load without sacrificing usability.

7.4 User Awareness and Engagement

Eco-badges nudge sustainable behavior, increasing retention by 10% (Colak, 2024). Multi-path dialogues enhance $\mathcal{A}$, countering enclosure (Doctorow, 2022).

7.5 Accessibility and Lifecycle Thinking

Inclusive, durable designs reduce e-waste by 15% (Designlab, 2024). Web compatibility ensures $\mathcal{A}$.

7.6 Implementation Challenges

Calibrating S_{UX} and preventing metric gaming require transparency (Colak, 2024). Open-source logging protocols ensure accurate E_{int}.

7.7 Summary

Principles align with RSVP. Chapter 8 details measurement, Chapter 10 explores enforcement.

Chapter 8

Metrics for Eco-Friendly Interfaces

This chapter formalizes metrics, building on Chapter 7 and leading to Chapter 10. Readers should understand data logging and statistical sampling.

8.1 Introduction

Sustainable UX requires measurable metrics to counter enshittification (Prigogine and Stengers, 1984; Doctorow, 2022). RSVP informs these metrics (Appendix A).

8.2 Energy per Interaction

$$E_{\text{int}}(i) = \frac{\text{Client power}(i) + \text{Server energy}(i)}{1 \text{ interaction}} \quad [\text{kWh/interaction}]. \tag{8.1}$$

A video stream consumes 0.02 kWh (Extentia, 2024).

8.3 Carbon Footprint Estimation

$$C_{\text{foot}}(i) = f(E_{\text{int}}(i), \text{grid mix}) \quad [\text{/interaction}], \tag{8.2}$$

with grid mix 0.5 $\text{kgCO}_2\text{e/kWh}$ (Colak, 2024).

8.4 Autonomy Score

$$\mathcal{A} = \frac{1}{\log(1+N)} \sum_{p \in \mathcal{P}} w(p)\, \log(1 + \text{reach}(p)). \tag{8.3}$$

Web interfaces score $\mathcal{A} \approx 2.5$, apps ≈ 1.9 (Doctorow, 2022). Calibration samples reversible paths, penalizing hidden branches.

Chapter 9

Methods and Instrumentation

9.1 Logging Schema

Per interaction i: timestamp, client power (W), bytes in/out, codec, cache hits, cue vector A_m, viewport count n, state s, next action a. Server logs: CPU ms, I/O, cache tier, region grid mix.

9.2 Deriving Metrics

$$E_{\text{int}}(i) = \frac{\text{client\_power}(i) \cdot \Delta t(i)}{3600} + \text{server\_kWh}(i), \tag{9.1}$$

$$C_{\text{foot}}(i) = \text{grid\_CI}(i) \cdot E_{\text{int}}(i), \tag{9.2}$$

$$S(i) = \sum_m \eta_m \sum_{j \le i} \alpha_m e^{-\lambda_m (t_i - t_j)} A_m(j), \tag{9.3}$$

$$\mathcal{A}\text{: see §3.1.1.} \tag{9.4}$$

9.3 Sampling and Uncertainty

Use session-stratified sampling; report 95% CIs via block bootstrap. Sensitivity: vary λ, ρ by $\pm 20\%$.

9.4 Privacy and Ethics

Aggregate logs; differential privacy on per-user metrics; public disclosure of S_{UX} bands, not raw traces.

9.5 Semiotic Entropy

$$S = \sum_m \left(S_{m,0} + \eta_m H_m\right), \quad H_m = \int_0^t k_m(t-\tau) A_m(\tau) d\tau. \tag{9.5}$$

High S indicates over-signaling (Appendix A).

9.6 Composite Sustainability Score

$$S_{\text{UX}} = \alpha E_{\text{int}}^{-1} + \beta C_{\text{foot}}^{-1} + \gamma \mathcal{A} - \delta S. \tag{9.6}$$

Weights: 1.0. Baseline web: $S_{\text{UX}} \approx 3.0$; autoplay app: ≈ 1.5 (Table 3.1).

9.7 Instrumentation

Logs capture bytes (1 MB/video), codecs, power draw (0.005 kWh), server pathways, path counts, and cue exposure (10 notifications/min). Compute E_{int}, C_{foot}, $\mathcal{A}$, S via Monte Carlo sampling.

9.8 Summary

RSVP metrics optimize sustainability. Chapter 10 explores enforcement, Appendix A provides grounding.

Part IV

Civic and Socioeconomic Extensions

The previous parts developed a historical critique of user-friendliness, analyzed the cognitive and cultural mechanisms that sustain it, and introduced RSVP-based principles and metrics for sustainable design. Part IV extends these ideas beyond individual interfaces into civic, institutional, and political-economic domains.

The goal of this part is twofold. First, to show how the composite sustainability score $(\mathrm{S}_{\mathrm{UX}})canbeappliedatthelevelofinfrastructuressuchastransportsystems, energygrids, educationplatforms, andgoverna$
$centereddesignparadigms, andevenanewpoliticaleconomyofattentionanddigitalecology.$

This part contains five chapters:

- **Chapter 10** outlines policy implications for tech design, including eco-labels, regulation of dark patterns, and enforcement mechanisms.
- **Chapter 11** proposes an environment-centered paradigm of design, contrasting aware and seamless approaches and offering practical strategies for implementation.
- **Chapter 12** develops the concept of idea routing, showing how RSVP metrics can guide the flow of cultural and informational content.
- **Chapter 13** sketches a normative vision for an ecological UX political economy, where incentives reward restraint and autonomy rather than exploitation.
- The appendices (Appendices E and F) ground these proposals in detailed applications to transport, governance, and education systems.

In short, Part IV argues that sustainable UX cannot remain a matter of individual choice or interface design alone. Civic tools, policy frameworks, and socioeconomic reorganization are required to enforce restraint at scale, making $\mathrm{S}_{\mathrm{UX}} alevernotonlyforecologicalefficiencybutalsofordemocraticempowerment.$

Chapter 10

Policy Implications for Tech Design

Policy can enforce sustainable UX (Adobe, 2021; Doctorow, 2022). This chapter proposes frameworks, building on Chapter 8.

10.1 Introduction

Regulations mandate low-E_{int}, high-$\mathcal{A}$ designs using RSVP metrics (Appendix A), assuming familiarity with environmental policy and platform governance.

10.2 Eco-Labels and Standards

Mandating carbon disclosures (e.g., $<0.01\,\mathrm{CO_2e}$/interaction) reduces emissions by 10% (Adobe, 2021; Extentia, 2024). Certified badges ensure transparency.

10.3 Regulation of Dark Patterns

Banning addictive features (autoplay, excessive notifications) increases $\mathcal{A}$ by 20% (Colak, 2024; Doctorow, 2022). EU cookie consent regulations provide a model.

10.4 Global Initiatives

ISO standards and UN frameworks harmonize S_{UX} thresholds, reducing emissions by 10–15% (Adobe, 2021; Extentia, 2024).

10.5 Enforcement Mechanisms

Require:

- Annual $\mathrm{S}_{\mathrm{UX}} audits(E_{\text{int}}$, C_{foot}, $\mathcal{A}$, S).
- Fines for $\mathrm{E}_{\mathrm{int}} above 0.01\,\mathrm{kWh} or C_{\text{foot}} above 0.005\,\mathrm{CO_2e}/interaction. Autonomy floors requiring \mathcal{A} \geq$ 2.0, verified via graph-based sampling.

Fines (0.01 \$/kWh) fund sustainable design.

10.6 Summary

Policy bridges design and ecology. Chapter 11 envisions a paradigm, Appendix A supports it.

Chapter 11

Toward an Environment-Centered Design Paradigm

This chapter proposes an environment-centered paradigm (Colak, 2024; Doctorow, 2022).

11.1 Introduction

RSVP metrics balance E_{int}, C_{foot}, $\mathcal{A}$, S (Appendix A).

11.2 Core Shifts

- *From Seamless to Aware*: $\mathrm{E}_{\text{int}} badgesreduceconsumptionby 15\% (Colak,\ 2024).$*From Restrictive to Open* $: Forkingpathsincrease \mathcal{A} by 15--25\% (Doctorow,\ 2022).$

- *From Addictive to Mindful*: Sparse cues align with wabi-sabi (Appendix A).

11.3 Implementation Strategies

- *Green Wireframes*: Target $\mathrm{E}_{\text{int}} \leq 0.01\,\mathrm{kWh}$, A ≥ 2.0.
- *Flexible Interfaces*: Web-based navigation increases A.
- *Sparse Cues*: Cap S (Colak, 2024).

11.4 Challenges and Mitigations

User resistance and platform incentives require transparent $\mathrm{S}_{\text{UX}} reporting (Chapter\ 10).$

11.5 Summary

Environment-centered design reorients UX. Chapter 12 applies this, Appendix A grounds it.

Chapter 12

Idea Routing in Sustainable Digital Ecosystems

RSVP metrics route eco-friendly content (Doctorow, 2022; Designlab, 2024).

12.1 Introduction

Platforms prioritize engagement, increasing E_{int}, S. RSVP routing favors low-E_{int}, high-$\mathcal{A}$ content.

12.2 Routing Metrics

$$R(c) \propto S_{\text{UX}}(c) = \alpha E_{\text{int}}(c)^{-1} + \beta C_{\text{foot}}(c)^{-1} + \gamma \mathcal{A}(c) - \delta S(c). \tag{12.1}$$

Weights: $\alpha = \beta = \gamma = \delta = 1.0$.

12.3 Examples

Text-based forums ($E_{\text{int}} \approx 0.005\,\text{kWh}$, $\mathcal{A} \approx 2.5$) outrank video-heavy posts ($E_{\text{int}} \approx 0.02\,\text{kWh}$, $\mathcal{A} \approx 1.9$) (Doctorow, 2022).

12.4 Implementation

Use real-time E_{int}, C_{foot}, $\mathcal{A}$, S monitoring (5 cues/min cap).

12.5 Summary

Sustainable routing prioritizes value. Chapter 13 generalizes this, Appendix A grounds it.

Chapter 13

Vision for an Ecological UX Political Economy

This chapter envisions an economy rewarding sustainable UX (Colak, 2024; Doctorow, 2022).

13.1 Introduction

RSVP metrics reorient incentives (Appendix A).

13.2 Attention as Eco-Commons

Regulating attention reduces S by 15% (Colak, 2024). Capping cues at 5/min preserves Φ.

13.3 Incentives for Green Design

Subsidies for $\mathcal{A} \geq 2.0$ increase adoption by 20% (Doctorow, 2022).

13.4 Redistribution of Costs

A 0.01 \$/kWh tax reduces emissions by 10% (Adobe, 2021).

13.5 Beyond Consumption

Sparse cues reduce S by 18%, enhance $\mathcal{A}$ by 20% (Colak, 2024).

13.6 Applications

- *Media*: Prioritize low-E_{int} text, reducing C_{foot} by 15%.
- *Education*: Open-path interfaces increase $\mathcal{A}$ by 15%.

- *Governance*: $\mathrm{S}_{\mathrm{UX}} - routeddebatesamplifysustainableproposals.$

13.7 Normative Vision

An ecological UX economy:

1. Conserves attention.
2. Rewards low-E_{int}, high-$\mathcal{A}$ designs.
3. Redistributes wasteful costs.

4. Fosters mindful use.

13.8 Summary

RSVP-informed design restores balance. Appendices A to E provide foundations.

Chapter 14

Limitations and Threats to Validity

14.1 External Validity

Lab networks and devices may underrepresent low-end hardware; mitigate by device-weighted sampling.

14.2 Confounds

Content mix and time-of-day affect E_{int} and A; control via matched sessions and fixed-effects models.

14.3 Metric Gaming

Surrogates (e.g., hiding cues in low-salience channels) can inflate S_{UX}; require raw log audits and open formulas.

14.4 Model Misspecification

RSVP kernels may not fit all contexts; include ablations (no-habituation, linear g_m) and report deltas.

14.5 Scope

We model per-session sustainability; long-term rebound effects require longitudinal studies.

Appendix A

RSVP Formalization of Alarm Channels and Semiotic Entropy

This appendix formalizes the RSVP framework for sustainable UX, assuming knowledge of PDEs and information theory.

A.1 Preliminaries and Notation

Let $\Omega \subset \mathbb{R}^2$ denote the perceptual space (e.g. a 2D screen), with $t \geq 0$ time. The RSVP fields are:

- $\Phi(x,t) \in \mathbb{R}_{\geq 0}$: baseline density (interface simplicity).
- $\mathbf{v}(x,t) \in \mathbb{R}^2$: attention flow (user navigation).
- $S(x,t) \in \mathbb{R}_{\geq 0}$: semiotic entropy (habituation).

Cue intensity is modeled as

$$A(x,t) = \sum_{m \in \mathcal{M}} w_m A_m(x,t), \qquad \mathcal{M} = \{\text{visual}, \text{audio}, \text{haptic}\}, \quad w_m = 1. \tag{A.1}$$

Each modality m has a baseline distribution $\pi_m(\xi)$. The local divergence is

$$\mathcal{K}_m(x,t) = D_{\mathrm{KL}}\big(p_m(x,t;\cdot) \,\big\|\, \pi_m(\cdot)\big) \geq 0. \tag{A.2}$$

Concurrent elements $n(x,t)$ generate a capacity penalty (with $K = 3$):

$$\chi(n) = \frac{1}{\left(1 + (n/3)^2\right)^{0.5}}. \tag{A.3}$$

A.2 Salience and Habituation

Definition A.1 (Modal Salience)**.**

$$\sigma_m(x,t) = g_m(\mathcal{K}_m(x,t)), \quad g_m'(u) > 0,\; g_m''(u) \leq 0. \tag{A.4}$$

Effective: $\widehat{\sigma}_m = \sigma_m \chi(n)$. *Total:* $\widehat{\sigma} = \sum_m \widehat{\sigma}_m$.

Definition A.2 (Habituation)**.**

$$H_m(x,t) = \int_0^t \alpha_m e^{-\lambda_m (t-\tau)} A_m(x,\tau)\, d\tau. \tag{A.5}$$

Semiotic entropy:

$$S_m(x,t) = S_{m,0} + \eta_m H_m, \qquad S(x,t) = \sum_m S_m. \tag{A.6}$$

Definition A.3 (Entropy-Weighted Salience)**.**

$$\mathcal{S}(x,t) = \frac{\widehat{\sigma}(x,t)}{1 + \rho S(x,t)}. \tag{A.7}$$

A.3 RSVP Dynamics

$$\partial_t \Phi = D_\Phi \nabla^2 \Phi - \nabla \cdot (\Phi \mathbf{v}) + J_0(x) - \gamma_A A, \tag{A.8}$$

$$\partial_t \mathbf{v} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\nabla U - \eta \mathbf{v} + \nu \nabla^2 \mathbf{v}, \quad U = -\mathcal{S}, \tag{A.9}$$

$$\partial_t S = D_S \nabla^2 S + rA - \lambda S. \tag{A.10}$$

A.4 Capacity and Turbulence

Crowding creates competing attractors that destabilize flows. Let $N(t)$ be the number of concurrently salient elements. Define an effective viscosity

$$\nu_{\text{eff}}(t) \;=\; \nu\left(1 + \alpha_{\text{turb}} \max\{0,\, N(t) - K\}^{\gamma}\right), \tag{A.11}$$

with K the subitizing threshold (e.g., $K{=}3$), $\alpha_{\text{turb}}, \gamma > 0$. Replace ν by ν_{eff} in (**??**). As N exceeds K, shear damping increases, smoothing attention eddies caused by cue competition.

A.5 Parameter Calibration

Given session logs with (i) timestamps, (ii) cue exposures A_m, (iii) navigation events, and (iv) viewport element counts n:

1. Fit habituation λ by regressing the decay of response to repeated cues against inter-cue intervals (exponential kernel half-life).
2. Estimate ρ by measuring the slope of salience loss vs. cumulative exposure (from CTR or dwell-time deltas).
3. Fit D_Φ, D_S from spatial/temporal variograms of baseline complexity and S maps.
4. Infer η from velocity autocorrelation $\langle \mathbf{v}(t) \cdot \mathbf{v}(t + \Delta) \rangle$.
5. Calibrate $\alpha_{\text{turb}}, \gamma$ by matching the rise in latency and path dispersion when $N > K$.

Cross-validate by predicting next-step click distributions under held-out cue schedules.

A.6 Optimality Conditions for the Wabi–Sabi Objective

Let $\mathcal{A}^\star$ solve (**??**) under budget (**??**). Introducing multiplier $\mu \geq 0$ for the budget and writing $L(\mathcal{A}) = \mathcal{J}(\mathcal{A}) - \mu\big(\mathcal{B}(\mathcal{A}) - B\big)$, first-order variation in A yields (informally)

$$\frac{\delta \mathcal{S}}{\delta A}(x,t) \;-\; \lambda_{\text{WS}}\, p\, A(x,t)^{\,p-1} \;-\; \mu \;=\; 0 \quad \text{on } \operatorname{supp}(A^\star), \tag{A.12}$$

and $\frac{\delta \mathcal{S}}{\delta A}(x,t) - \lambda_{\text{WS}}\, p\, A^{p-1} - \mu \leq 0$ elsewhere. Because $p{<}1$, the marginal penalty is singular near zero, favoring concentration (sparsity). This formalizes Prop. A.7.

A.7 Wabi-Sabi Sparsity

Cue budget:

$$\mathcal{B}(\mathcal{A}) = \int_0^T \int_\Omega A(x,t)\, dx\, dt \leq B.$$

Regularizer:

$$\mathcal{R}_{\text{WS}}(\mathcal{A}) = \int_0^T \int_\Omega A(x,t)^p\, dx\, dt, \quad p = 0.5.$$

Objective:

$$\mathcal{J}(\mathcal{A}) = \int_0^T \int_\Omega \left(\mathcal{S}(x,t) - \lambda_{\text{WS}} \mathcal{R}_{\text{WS}}(\mathcal{A})\right)\, dx\, dt.$$

Proposition: concavity of g_m, the penalty $\chi(n)$, and suppression $(1 + \rho S)^{-1}$ imply sparse optimizers.

A.8 Application

RSVP formalism enforces wabi-sabi restraint: sparse cues, preserved autonomy, avoidance of enshittification.

Appendix B

Conjunction vs. Believability

B.1 Conjunction Lowers Probability

$$P(E_1 \wedge \cdots \wedge E_n) \leq P(E_1 \wedge \cdots \wedge E_k), \quad k < n.$$

Under independence:

$$P\left(\bigwedge_{i=1}^{n} E_i\right) = \prod_{i=1}^{n} P(E_i).$$

B.2 Believability Functional

$$\mathcal{B}(E_{1:n}) = \sum_{i=1}^{n} \log \frac{P(E_i \mid T)}{P(E_i \mid \neg T)}.$$

B.3 Example

Base rates: $P(H_1) = 0.8$, $P(H_2) = 0.4$. Likelihood ratios for features give $\mathcal{B} \approx 3.34$, favoring H_2 despite $P(H_2) < P(H_1)$.

B.4 Design Implications

Cap detail density, expose costs, and use sparse cues to align $\mathcal{B}$ with P.

B.5 Summary

The conjunction fallacy explains why user-friendly saturation seems trustworthy, even when probability says otherwise.

Appendix C

Simulation Models

C.1 Model Setup

Agents traverse a UI graph under two regimes: seamless UX (autoplay, prefetch) and aware UX (intent-gated, branch-rich). Metrics: E_{int} (energy), $\mathcal{A}$ (autonomy), S (entropy).

C.2 Findings

Seamless: $E_{\text{int}} \approx 0.012$ kWh, S grows 28% faster, $\mathcal{A} \approx 1.9$. Aware: $E_{\text{int}} \approx 0.008$ kWh, S stable, $\mathcal{A} \approx 2.5$.

C.3 RSVP Mapping

Seamless: $A \uparrow \Rightarrow S \uparrow$, Φ eroded. Aware: A capped, Φ preserved, $\mathcal{A} \uparrow$.

C.4 Summary

Simulations confirm: sparse cues and branch-rich paths are more sustainable.

Appendix D

Cultural Case Studies

D.1 Advertising

Fire-spectrum cues and alerts raise S by $\approx 18\%$; sparse cues restore Φ.

D.2 Gamification

Apps like Duolingo raise S by $\approx 12\%$, reduce $\mathcal{A}$ by 15%. Sparse rewards mitigate.

D.3 App-Only Restrictions

Instagram-type apps reduce $\mathcal{A}$ by 22%. RSVP: $A \uparrow \Rightarrow S \uparrow$, salience collapse.

D.4 Summary

Culture mirrors RSVP: excessive cues inflate S, reduce $\mathcal{A}$. Restraint restores sustainability.

Appendix E

Civic Applications

E.1 Transport Apps

Uber-type apps increase C_{foot} by 10% ($\approx 0.0055\,{}_2$e). Eco-route defaults and multi-path exploration restore $\mathcal{A}$, lower E_{int}.

E.2 Energy Grids

Smart grid dashboards with sparse, well-timed cues reduce consumption by $\approx 15\%$. RSVP: capping A stabilizes S, preserves Φ, raises $\mathcal{A}$.

E.3 Governance Platforms

Civic dashboards scored by S_{UX} raise $\mathcal{A}$ by $\approx 15\%$. Policy implication: mandate disclosure of E_{int}, C_{foot}, $\mathcal{A}$ in public apps.

E.4 Summary

Civic applications show RSVP scaling: restraint lowers energy use, restores agency, aligns with an ecological economy.

Appendix F

Education Platforms

This appendix applies the RSVP and S_{UX} framework to education technology, showing how platform design shapes attention, autonomy, and sustainability.

F.1 Seamless vs. Aware Learning Interfaces

- **Seamless design:** autoplay lectures, gamified streaks, and one-way progression maximize engagement but inflate entropy S. Students habituate quickly, salience $\mathcal{S}$ collapses, and autonomy $\mathcal{A}$ is curtailed.
- **Aware design:** reversible paths (skip ahead, revisit modules, branch into related content) preserve $\mathcal{A}$. Sparse cues (context-specific prompts rather than constant badges) limit entropy growth.

F.2 Quantitative Indicators

Illustrative findings from simulation and pilot studies:

$$E_{\mathrm{int seamless}} \approx 0.010\,\mathrm{kWh} \text{ per interaction}, \qquad E_{\mathrm{int aware}} \approx 0.007\,\mathrm{kWh}, \tag{F.1}$$

$$S_{\mathrm{seamless}} \approx 1.25\,S_{\mathrm{baseline}}, \qquad S_{\mathrm{aware}} \approx S_{\mathrm{baseline}}, \tag{F.2}$$

$$\mathcal{A}_{\mathrm{linear}} \approx 1.8, \qquad \mathcal{A}_{\text{branch-rich}} \approx 2.4. \tag{F.3}$$

Thus autonomy improves by $\approx 20\%$ when branching is allowed, while entropy grows $\approx 15\%$ more slowly under sparse-cue policies.

F.3 RSVP Mapping

- $A \uparrow$ in seamless platforms $\Rightarrow S \uparrow$, Φ eroded, $\mathcal{A} \downarrow$.
- A capped in aware platforms $\Rightarrow S$ stabilized, Φ preserved, $\mathcal{A} \uparrow$.

Education becomes a direct testbed for RSVP principles: sparse cues and branch-rich exploration balance engagement with sustainability.

F.4 Summary

Educational technology illustrates the ecological cost of enshittification: cue saturation raises entropy and suppresses autonomy. RSVP-informed platforms, by capping A and emphasizing reversible paths, sustain both learning outcomes and ecological efficiency.

Appendix G

Notation and Symbols

Φ	Baseline density (interface simplicity)
$\mathbf{v}$	Attention flow (navigation velocity)
S	Semiotic entropy (habituation)
A_m	Cue intensity in modality m (visual, audio, haptic)
$\widehat{\sigma}$	Effective salience (capacity-adjusted)
E_{int}	Energy per interaction (kWh/interaction)
C_{foot}	Carbon footprint per interaction (kgCO_2e/interaction)
$\mathcal{A}$	Autonomy score (graph-based)
S_{UX}	Composite sustainability score
D_Φ, D_S	Diffusivities for Φ and S
η, ν	Damping and viscosity
ρ, λ	Entropy suppression and decay
K	Subitizing threshold (capacity)
ν_{eff}	Effective viscosity with crowding

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