The Dark Patterns Knowledge Stack: Exploring New Ways to Negotiate Context, Law, and Design

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Abstract

Research on dark patterns has grown rapidly, but challenges remain in situating these practices within broader socio-technical, legal, and design contexts. In this essay, I introduce the concept of the "dark patterns knowledge stack" as a new way of synthesizing evidence about manipulative, coercive, and deceptive design practices. Inspired by Alexander's notion of pattern language, I demonstrate how the knowledge stack aligns multiple layers of analysis and evidence—from interfaces and user characteristics to the socio-technical landscape and user intentions—revealing how manipulative practices interrelate across scales, are perpetuated through key business metrics, and evolve over time. Use of the knowledge stack is demonstrated through two case studies, followed by provocations for scholars, regulators, and practitioners to work together to more effectively identify harms, negotiate accountability, and chart pathways for more just and transparent digital systems.

CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**; **Empirical studies in HCI**; • **Applied computing** → **Law**.

Keywords

dark patterns, deceptive design, surveillance capitalism, law, regulation

1 Introduction

Our everyday lives are increasingly mediated by interactions with digital systems—including both "big tech" players and small and medium sized app and website developers. These digital systems have been an object of study by HCI researchers, and over the past 15 years, practitioners and scholars alike have noted the degree to which these systems incorporate manipulative, coercive, or deceptive practices that result in out-sized benefits to shareholders that subvert or impair user autonomy or agency. These practices, commonly known as "dark patterns,"[1] are ubiquitous and increasingly recognized as not mere "tricks" as Brignull first described when he coined the term in 2010 [14] but rather systemic strategies that are deeply and carefully embedded into digital systems [29].

HCI scholars have been leaders in the study of dark patterns and their impact on society [7, 30, 43], with major accomplishments including a definitional foundation for dark patterns work [47], a harmonized ontology of legal and academic guidance [32], and a methodology to map how dark patterns are experienced over time [26, 29]. Scholars have described the presence of dark patterns in numerous contexts and portions of our digital landscape, including e-commerce [46], social media [48, 49], and smart homes [40], among many others. Systematic reviews of dark patterns scholarship have shown the broad reach and diversity of this literature, including utilization of a range of methodologies, attention to differing types of systems or contexts, and leveraging of existing theoretical or conceptual frameworks [16, 30]. While many studies of dark patterns have focused on the US, UK, and EU [60], emerging literature shows the power and diversity of dark patterns in other contexts, such as in China [67], Brazil [55], India [45], and Japan [36, 61].

Over the past few years, the focus of dark patterns scholarship has included a diversification of genres where dark patterns are in play (e.g., social media [48, 49], mixed reality [41], haptics [64]) alongside a heightened awareness of the legal implications of these practices [27, 31, 42]. And in the process, scholars have begun to recognize the importance of describing dark patterns at different scales—from user interface [28] to code [59, 63] to system level [29, 42]. In addition, there has been increasing attention to the legal issues and regulatory sanctions that dark patterns scholars can support, including both tensions in design and legal requirements [11, 13, 31] and pending sanctions that specifically invoke dark patterns and their harms (e.g., [3, 39, 54]; see also a database of legal sanctions[2]). Yet our field still lacks a conceptual framework that connects interface-level manipulation to the broader business

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[1]Scholars currently use a range of terms that fit within the broad conceptual umbrella of "dark patterns," including manipulative user interfaces [62], disloyal patterns [34], or deceptive design. Dark patterns remains the mostly broadly used term, appearing in legal statute and public discourse, but we acknowledge that some scholars feel the term is "exclusionary and harmful" [5].
[2]https://www.deceptive.design/cases

models and socio-technical forces that produce and re-produce them.

In this short essay, I build upon this robust foundation of work that describes dark patterns and their impacts with a focus on the socio-technical contexts in which dark patterns exist, function, evolve, and thrive. To do so, I first motivate the need for a new framework in Section 2 to describe the threats of dark patterns, aligning the language and perspectives of multiple stakeholders. Then, in Section 3 I return to the "pattern language" roots of dark patterns using the original language of Christopher Alexander [12] and relate this language and hierarchy to the present dark patterns discourse—visually and structurally conveyed through the "dark patterns knowledge stack." This stack brings together disparate yet related elements that relate to the broad socio-technical landscape in which digital systems exist, the goals and intentions that users and shareholders bring to this landscape, the ways in which the user interface mediates these goals and intentions, and the limitations, characteristics, and knowledge the user brings with them to their interactions with digital systems. Finally, after describing the elements of the knowledge stack conceptually, I illustrate its utility through two contemporary case studies in Section 4: 1) Google's systemic location tracking (an example of surveillance capitalism); and 2) social media companies' use of attention capture techniques that harm vulnerable users (an example of the attention economy).

2 Why a New Analytic Approach for Dark Patterns Is Needed

While taxonomies and ontologies of dark patterns (e.g., [32, 47]) have provided increasingly robust vocabularies for describing manipulative and deceptive interface strategies, these tools largely focus on categorizing discrete, interface-level phenomena. Similarly, HCI has a long history of modeling user-system interaction (e.g., Norman's Action Cycle; the Model Human Processor), which dark patterns scholars have contributed to by considering users' interpretation of manipulation (e.g., [25, 47]). What remains underdeveloped is an ecological account that connects these user perceptions and interface manifestations to the broader socio-technical forces that enable and sustain them. This work responds to direct calls for contextualization of dark patterns and their impacts across technological, human, and societal scales by both dark patterns researchers and policymakers [42, 51, 59]. The knowledge stack addresses this need by offering a multi-layered analytic lens that reveals how dark patterns emerge not in isolation, but through the interplay of platform business models, user goals, interface architectures, and human limitations. This layered framing supports scholars, regulators, and designers in synthesizing diverse forms of evidence across these scales—something existing taxonomies or cognitive models were not designed to do.

The knowledge stack is designed as a translational device or analytic bridge for multiple stakeholder groups. For HCI scholars, it provides a structured analytic vocabulary to trace how manipulative practices accumulate across levels of a system. For regulators and legal practitioners, the stack aligns interface evidence with system-level intentions and harms—an alignment increasingly demanded in regulatory enforcement actions (e.g., [13, 33]). For designers, the

stack functions as a diagnostic tool for identifying how organizational priorities shape interface decisions that may unintentionally (or intentionally) constrain user autonomy.

3 Leveraging Alexander's Pattern Language to Inform an Ecological View of Dark Patterns

Christopher Alexander was a leader in the early design methods movement and is credited with coining the term "pattern language" [12]. This term spawned a conceptual way of describing knowledge construction that now dominates many fields, including computer science (software design patterns, originally proposed by the "gang of four" in a foundational 1994 software engineering textbook; [22]), visual design (UI design patterns and design systems, with early origins in Apple's Human Interface Guidelines in 1987; [37]), and even the study of dark patterns, which themselves are a type of pattern language [14, 32]. While the ideas behind pattern language are not without their criticisms [18, 19], I build upon this vocabulary to leverage HCI scholars' historic interest in the concept [53]—including brief mentions in relation to dark patterns [15]—using it to interrogate and call for extension of current dark patterns scholarship.

Patterns are one example of what HCI scholars have referred to as "intermediate-level knowledge" [44]—knowledge which exists in the expansive yet liminal space between particular precedent artifacts and general theory. Patterns as a form of intermediate-level knowledge are made legible through their presence in particular designed artifacts (e.g., the pattern of "breadcrumb" is understandable as a navigational aid by recognizing it as an abstraction of many manifestations of breadcrumbs on actual websites), yet can relate to high-level theoretical encapsulations of user behavior. Similarly, dark patterns represent abstractions of common instances of deception, manipulation, or coercion in digital systems that gain coherence through high level theorizations of deception or manipulation.

Alexander's hierarchy, which originated in architecture and urban planning, is organized into patterns corresponding to different scales of a built system [12]: "*town*" patterns describe how the built environment is experienced by a community as a combination of personal dwellings and collective spaces; "*building*" patterns describe arrangements of individual spaces and social functions; and "*construction*" patterns describe material realities as these spaces are built. My adaptation maps these layers to digital systems by analogizing platforms to towns, user goals and platform affordances to buildings, interfaces to constructed spaces, and user characteristics to the lived experience of inhabiting those spaces. This mapping allows scholars, designers, and regulators to articulate how manipulative design practices emerge from, and reinforce, these interconnected layers.

I draw upon and expand Alexander's original pattern language to leverage its core insight which has been lost in much of dark patterns scholarship: complex systems are built through nested, interdependent patterns operating across multiple scales. This ecological orientation—which for Alexander related to the ecology of urban planning, architecture, and construction—is uniquely suited to describing dark patterns, which similarly arise from the interaction of local interface decisions and global business imperatives.

(Adapting language from Alexander et al., 1977)

Figure 1: An alignment of Alexander's hierarchy of pattern language to digital systems

To begin, I will disassemble elements of digital systems so that these elements can be linked to relevant concepts in Alexander's pattern language. As shown in Figure 1, the following four elements span the breadth of digital systems from their manifestation as part of the socio-technical landscape to the individual characteristics we bring as humans to these digital systems.

- **The Socio-Technical Landscape:** What is the high level organizing concept that a platform seeks to support? This concept may be very obvious and accessible to an end user (e.g., Amazon is an e-commerce company, and the organizing concept is the sale of products and services) but could also be quite opaque (e.g., Google is an advertising company, but their search or productivity-related services are more visible in everyday user interactions).
- **The Goal or Intention:** With what goal does a user approach a digital system? What do they hope to accomplish, what experience are they seeking to have, or what kinds of social norms or behaviors are they seeking to support, suppress, or reproduce?
- **The Interface:** What elements of the user interface guide, direct, and reveal the user experience over time? This includes not only the discrete UI elements (e.g., buttons, disclaimers, functions) but also their arrangement into a logically-ordered task flow through which a user can seek to reach a specific goal or intention.
- **The User's Limitations and Knowledge:** What knowledge does the user have that can inform their action or perception of the digital world they experience? What social or perceptual limitations does the user have by virtue of them being a human, or someone with a specific set of accessibility limitations?

Within each of these knowledge stack levels, we can find inspiration in the hierarchies present in Alexander's original pattern language, which I describe in the following sub-sections.

3.1 Alexander's "Town" and the Socio-Technical Landscape

On towns, Alexander notes:

> *We begin with that part of the language which defines a town or community. These patterns can never be "designed" or "built" in one fell swoop—but patient piecemeal growth, designed in such a way that every individual act is always helping to create or generate these larger global patterns, will, slowly and surely, over the years, make a community that has these global patterns in it.* (p. xix)

Just as towns have components such as neighborhood boundaries, means of public transport, life cycles, and other limits (e.g., the height of buildings), so do the socio-technical landscapes in which digital platforms exist. While for towns, these components not only describe physical elements (e.g., a shopping street or ring roads) but also how people are designed to interact (e.g., children in the city, old people everywhere, dancing in the street). For platforms, these components can similarly be separated into distinct, yet interrelated social and technical components. For instance, technical elements of platforms might include mechanisms for tracking, means of reading or interacting with content, or approaches for managing one's platform identity. Social components build upon these technical affordances to maximize certain forms of interaction—whether they include buying products, sharing information to a community, engaging in social comparison, or generally being engaged or entertained on a platform. These elements merge as part of the

socio-technical landscape, revealing both platform-level affordances and related socio-technical gaps [10].

3.2 Alexander's "Building" and Goals or Intentions

On buildings, Alexander notes:

> We now start that part of the language which gives shape to groups of buildings, and individual buildings, on the land, in three dimensions. These are the patterns which can be "designed" or "built"—the patterns which define the individual buildings and the spaces between buildings; where we are dealing for the first time with patterns that are under the control of individuals or small groups of individuals, who are able to build the patterns all at once. (p. xxv)

Buildings have a number of technical and social components, similar to the design of towns or communities—and this interaction is reflected in the design of digital platforms. While in Alexander's rendering, buildings have physical components (e.g., number of stories, a sheltering roof), they also invite certain forms of interaction (e.g., flow between rooms, hierarchy, staircase as a stage) and inform specific types of social relations (e.g., communal eating, the children's realm). Digital platforms are also designed with specific social and technical affordances that relate to goals or intentions a user might bring to the platform—whether it be characteristic socio-technical features like a news feed, or social norming behaviors around where and how to self-disclose information about oneself. These affordances relate to the platform-level experiences that are prioritized (e.g., engagement, commerce, connection, entertainment) but with additional specificity that relates to more specific user goals they wish to achieve on the platform.

3.3 Alexander's "Construction" and the User Interface

Alexander continues with a description of the construction of these spaces as follows:

> At this stage, you have a complete design for an individual building. If you have followed the patterns given, you have a scheme of spaces, either marked on the ground, with stakes, or on a piece of paper, accurate to the nearest foot or so. You know the height of rooms, the rough size and position of windows and doors, and you know roughly how the roofs of the building, and the gardens are laid out. [//] The next, and last part of the language, tells how to make a buildable building directly from this rough scheme of spaces, and tells you how to build it, in detail. (pp. xxxi-xxxii)

Construction involves the actual realization of what has been designed, including the situated realities that often complicate things as plans guide what is actually built—and often involve redesign on site. While Alexander describes these practical construction realities as they impact the material properties of a building, such as room height or the relationship of the building to the land, digital platforms similarly require a mapping from the wireframes or technical descriptions of how the platform functions to the actual user interface that allows for direct or indirect manipulation by a user. Perhaps extending the analogy of construction further, digital platforms could be viewed as continuously "under construction." Unlike a building, whose physical existence is somewhat stable, digital systems are continuously being updated, refreshed with new information that changes their shape and form, and evaluated using A/B testing or other mechanisms that allow for testing of new functionality. And since the platforms on the socio-technical landscape level reveal both platform-level affordances and gaps, here too, that realization of what can be accomplished easily and what *should* be able to be accomplished easily enters the user experience.

3.4 The User Confronting the Built Environment

Finally, although not part of Alexander's original pattern language, we must consider the user who is meant to engage in the thing that is designed and constructed. Based on knowledge gained through decades of research in HCI, we can outline the knowledge that a user brings to their interaction with a digital system (e.g., [23]) as well as the differences in ability [66] and social and perceptual limitations that we as humans experience [47, 56].

4 The Knowledge Stack: Tying Together Multiple Forms of Evidence into a Coherent Whole

In this section, I activate the knowledge stack to reveal how the different layers and areas of focus can aid in producing a unified account of both the presence of dark patterns and the overall business model that is enabled and sustained through deceptive, manipulative, and coercive practices. In the first case study, I describe Google's tracking practices which have been under legal scrutiny [65] and have resulted in almost USD $500 million in settlements from 40 US states, a USD $1.375 billion settlement from the State of Texas [9], as well as judicial action in other countries (e.g., Australia [1]).[3] This case links the ultimate goals of surveillance with a lack of user knowledge or ability to control data capture in adequate ways. In the second case, I illustrate the engagement maximizing strategies of social media platforms such as Instagram and TikTok which are currently being questioned by regulators and lawmakers in the US [8, 52] and EU [6], as well as being impacted by active legal cases [4].[4] This case study draws together the attention capture strategies used by social media companies to sell ads and the vulnerability of teen users who are particularly susceptible to harms that stem from their use of these platforms.

Reading the Knowledge Stack. There is no single "correct" way to read the knowledge stack. Its analytic value lies in connecting relationships across layers rather than treating any one level as primary. Reading the stack from top to bottom can help explain how low-level interface decisions—such as defaults, friction, or obfuscation—support higher-level business and monetization strategies; for example, by obstructing users from exiting a service to maximize

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[3]I provided expert analysis and testimony on the *State of Arizona v. Google LLC* and *State of Texas v. Google LLC cases.*
[4]I have provided expert analysis and testimony in current litigation against multiple social media companies, including *Social Media Adolescent Addiction/Personal Injury Products Liability Litigation, MDL No. 3047.*

attention or data extraction. Reading from bottom to top can instead foreground who is most likely to be harmed, under what conditions, and why design choices that appear to be simply "bad design" may in fact be systematically enabling and perpetuating broader exploitative market logics. A third, horizontal reading is particularly important: examining the tension between user and shareholder perspectives at the socio-technical landscape and goal/intention layers. This tension is foundational to the concept of dark patterns [28] and reveals how different stakeholder viewpoints illuminate distinct forms of complexity, constraint, and assumption that shape manipulative design practices across the system.

4.1 Case One: Google's version of "surveillance capitalism"

In 2022, Google reached an $85 million settlement with the State of Arizona after investigators found that the company continued to collect geolocation data even when users believed they had opted out of tracking [2]. Subsequent cases brought by more than forty US states revealed a broader pattern: Google's Android operating system and related services used a variety of overlapping settings that created the illusion of control over location tracking, even while the platform enabled persistent data collection. Android settings such as *Location History* and *Web & App Activity* were structured in ways that misled users, with defaults set to "on" and key disclosures buried within menus and secondary information screens. Cases relating to Google's capture of user data continues, with another case being argued in US Federal court in August 2025, in which Google claims they used appropriate "progressive disclosure" techniques which the plaintiffs countered, describing these practices as "shady data collection" [65]. In this knowledge stack case, I leverage my expert reports for the *State of Arizona v. Google, LLC* case I worked on [24] which illustrates how any user might unwittingly give up their location data [5]. I use the various elements of the stack to illustrate how dark patterns compound harms and ultimately support Google's goals of surveillance capitalism.

As shown in Figure 2, at the highest level, these practices highlight Google's business model which relies heavily on advertising revenue enriched by granular location data. While an end user might engage with Google services in a way that simply makes them think they are accessing the internet, in the background, Google leverages these interactions in service of their goals to serve ads—and at the highest level, use location data to enable their broad provision of location-based services (LBS) [38]. This immediate tension between user and shareholder perceptions of the socio-technical landscape is further complicated at the goal/intention layer, where a user frames their interaction through the lens of using their smartphone. However, Google's ultimate goal or intention at this same level is to serve ads—which makes up over 80% of their total revenue[6]. This tension between user and shareholder is realized by considering the business model of Google; the platform meets their ultimate goal of maximizing engagement by serving

ads—particularly those enriched with location data, which increases revenues the more location data is captured and used to serve back to smartphone users in the form of ads. The interface supports these broader goals, realized through harmful defaults alongside obstructive and forced action practices across the Android ecosystem. For instance, the *Web & App Activity* (which actually collects location data, despite its name) is opted to on by default, requiring a user to navigate multiple levels of the account signup process to first recognize it is enabled by default, and then more clicks to recognize it collects location data. Similarly, once the account is set up, the *Location History* setting is opt in by default, but is located in a location-focused settings panel that specifically excludes Web and App Activity (which the user must locate elsewhere in the sprawling settings screens). Finally, and perhaps most problematically, even if a user is successful in locating and turning off all of these settings, Google still uses its proprietary IPGeo technology to enrich the user's IP address with other information that allows Google to track a highly granular location for each user—thereby subverting their goals of privacy. Across all of these experiences, the characteristics of *all* users are systematically preyed upon, leading to potential or actual harms. These harms extend beyond advertising itself, including the potential for profiling and discrimination, exposure of sensitive routines (e.g., visits to clinics or places of worship), and security risks if granular location histories are leaked, subpoenaed, or shared with third parties. Perceptual manipulation is realized through a complicated and misleading visual choice architecture, alongside bad defaults and reduced discoverability for privacy-preserving functionality. Social manipulation is strengthened through legitimization of mass surveillance normalizing the idea of sharing granular location, directly supporting "Google's desire to obtain the 'next billion location users.' [original legal source removed]" [24]. Importantly, these manipulative practices unfold temporally [29], collectively reinforcing Google's ability to track location regardless of their choices.

We can then abstract these findings from the first knowledge stack, revealing the dark patterns that support each of these layers of interaction and engagement. In Figure 3, the same general layers are shown, revealing the implications of the tensions between user and shareholder in the previous figure. At the highest level, the socio-technical landscape is driven by the "surveillance capitalism" [68], which is enabled through a constellation of high-level dark patterns that shape, hide, or force different kinds of interaction that are littered across the Google ecosystem. As a temporal analysis of the platform reveals, issues begin with bad defaults, obstruction, and interface interference from the account signup screen, which reduces legibility of what settings impact location tracking and how. This ambiguity continues with false choice architecture across the settings pages, making it difficult to understand which settings are specific to device and which are account-level settings that span multiple devices. Finally, the interface elements themselves are shown to misrepresent a user's control over their experience, since Google tracks their location anyway—just through other more surreptitious means. Google's goals of supporting a business model driven by values of surveillance capitalism are strengthened through restrictive, deceptive, and information hiding characteristics [47].

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[5]Since this essay relies upon prior legal analysis from 2022, some aspects of the interface may have since been changed. However, the core impacts on collection of personal data still appear to be accurate, based on current litigation such as the Rodriguez v. Google LLC case, which settled resulted in a $425 million against Google in early September 2025.

[6]https://www.statista.com/statistics/266249/advertising-revenue-of-google/

Figure 2: A detailed "knowledge stack" illustration of the tensions implicit in Google's approach to location tracking.

Figure 3: An abstracted "knowledge stack" illustrating the broad themes of Google's location tracking ecosystem.

4.2 Case Two: Social media giants' realization of the "attention economy"

Social media companies (e.g., Instagram, TikTok) have been built on the notion of user engagement, often realized through goals such as connecting with friends and family, staying in communication, and building and performing one's identity. However, these platforms also have the potential to produce many harms [52], including addiction and compulsive use, social comparison, and access to harmful content or predation. While all users are vulnerable to some extent, Rossi et al. [56] has shown that some types of users are more vulnerable than others. In this knowledge stack case, I show how teen users engage with social media platforms, using the various elements of the stack to illustrate how dark patterns compound harms and ultimately support the shareholder goals of attention capture. Of course, many of these harms might apply equally to non-teen users, but the focus here is on the unique vulnerabilities of teens as a group [21, 56, 58].

As shown in Figure 4, at the highest level, users experience the platform as "social media" while the shareholder perspective focuses on increasing engagement through attention capture. Clearly,
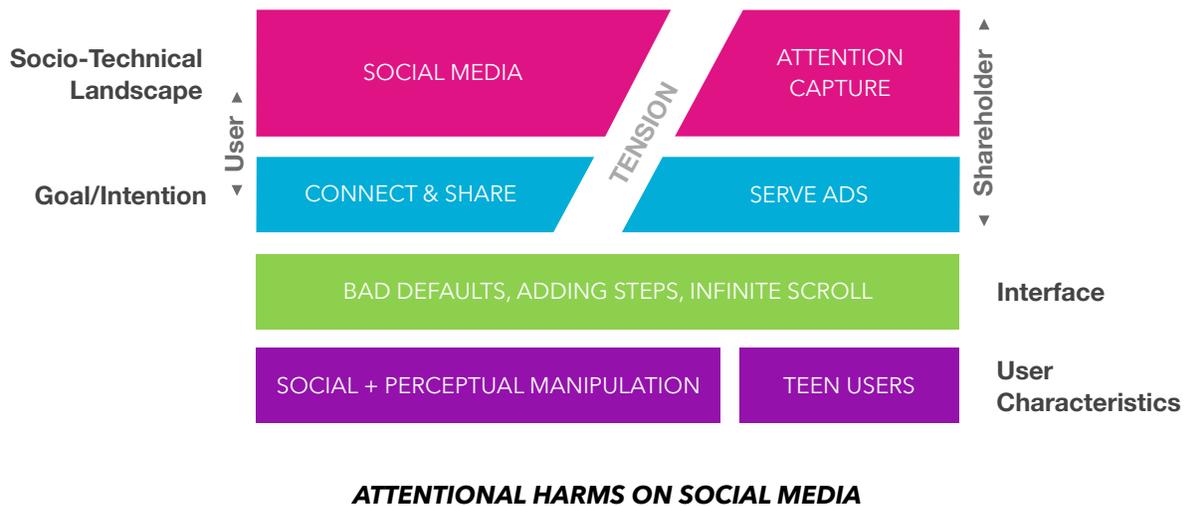
ATTENTIONAL HARMS ON SOCIAL MEDIA

Figure 4: A detailed "knowledge stack" illustration of the tensions implicit in social media platforms' approach to user engagement and addiction.

ATTENTIONAL HARMS ON SOCIAL MEDIA, ABSTRACTED

Figure 5: An abstracted "knowledge stack" illustrating the broad themes of social media platforms' attention capture infrastructure.

the goal of maximizing engagement has been successful, since a 2023 Gallup poll showed that US teens spend 4.8 hours per day on social media platforms [57]. However, users frame this use as "social media" rather than the capture of their attention and consider their patterns of use through the goals or intentions of connecting with others and sharing information. However, the tension between user and shareholder is realized by considering the business model of social media platforms; the platform meets their ultimate goal of

maximizing engagement by serving ads, which result in positive monetary impact the more time users spend on the platform. The interface supports these broader goals, realized through harmful defaults across the social media ecosystem. For instance, age-checking relies only on the honesty of the user signing up, even though studies have shown that many users lie about their age in order to get on these platforms (Nagata et al. [50] showed that over 60% of under 13 users had one or more social media accounts). Whistleblowers

like Frances Haugen [35], previously a product manager at Meta, have also revealed the lack of attention to key safety issues that impact teens and other users. These harms to teens are serious and wide-ranging, including contributions to suicidal ideation, eating disorders, and unhealthy body comparison. Once users are on the platform, controls to manage their use (e.g., reducing use, allowing a parent or guardian to have oversight) are often opted off by default or easy to dismiss. And even if a teen user has negative experiences on these platforms, it is difficult for them to leave the platform; both TikTok and Instagram have instituted a 30 day "cooling off" period before their account can be deleted. One of the core elements of interaction design—the "infinite scroll" pattern—also serves as a key element to encourage addictive and compulsive use, providing an endless stream of content. Across all of these experiences, the user characteristics of teens are systematically preyed upon. Perceptual manipulation is realized through the slot machine-like variability of the infinite scroll mechanism, while social manipulation is strengthened through social comparison and construction of false or problematic ideals a teen might want to measure up to.

We can then abstract these findings from the first knowledge stack, revealing the dark patterns that support each of these layers of interaction and engagement. In Figure 5, the same general layers of the knowledge stack are in play but reveal new information about the relationships between user and platform engagement. At the highest level, the socio-technical landscape is driven by the "attention economy" [17], which is then supported by a range of high-level dark patterns that influence, direct, or force different kinds of interaction. Examples include forced action in the account deletion procedure, obstruction from accessing key safety features, and social engineering in encouraging compulsive use through recapture notifications, among others. All of these high-level dark patterns are then realized in the interface through too many low-level dark patterns to list (see a fuller account of the specific patterns by Mildner et al. [49]). Ultimately, the broad goals of supporting a business model driven by values of the attention economy[7] are strengthened through restrictive, covert, deceptive, and information hiding characteristics [47].

5 Discussion and Provocations for Future Scholarship and Action

These two case studies illustrate the value of the *dark patterns knowledge stack* as a lens for understanding how dark patterns practices operate across multiple levels of digital systems. Whereas traditional analyses of dark patterns frequently isolate specific manipulative elements, the stack reveals how these elements are interdependent outcomes of broader platform logics—encompassing monetization models, infrastructural choices, and cognitive vulnerabilities. This multi-level synthesis is essential for explaining not only where dark patterns appear, but why they remain so resistant to correction despite regulatory scrutiny. In conjunction with emerging methodologies, such as *temporal analysis of dark patterns* [29], the stack enables scholars, regulators, legal experts,

and practitioners to document and problematize the tensions between user goals and shareholder imperatives, trace manipulative practices across temporal and system scales, and situate individual harms within a broader socio-technical landscape.

In the case of **Google's location tracking**, the stack made clear how bad default settings, hidden disclosures, and misleading framings systematically undermined user autonomy. What appeared to users as benign smartphone setup choices were in fact entry points into a surveillance regime central to Google's business model. Here, harms arose not only from immediate privacy violations but also from the normalization of surveillance capitalism as a condition of everyday digital life. In the case of **social media platforms and teen users**, the stack revealed how attention capture strategies exploited both perceptual limitations (through mechanisms like infinite scroll) and social vulnerabilities (through comparison and identity performance). These practices created cumulative psychological and developmental harms, even as they aligned neatly with shareholder goals of maximizing engagement and advertising revenue. Whereas Google's case exemplifies infrastructural surveillance harms, social media illustrates experiential and psychological harms; but both rely on layering dark patterns across the stack.

Together, these cases demonstrate that dark patterns cannot be fully understood when confined to the visible user interface alone. Instead, they are woven into the very fabric of platform business models and socio-technical infrastructures. Alexander's original pattern types from the 1970s are instructive in considering this issue of scale, and the levels I have identified and visualized within the knowledge stack show promise in enabling multiple stakeholders to recognize and describe how manipulative, deceptive, and coercive practices are experienced and intertwined at different scales of impact.

5.1 Provocations for Scholars, Regulators, and Designers

- **For scholars:** Future research should continue to integrate ecological and temporal perspectives on dark patterns. The stack offers one pathway for connecting individual design decisions with systemic outcomes, but there is still much to learn about how patterns are experienced by specific populations. Future work could investigate links between platform-level affordances and individual UI elements, indicating cases where key functionality is missing entirely, is available but present primarily in a performative way that has no lasting impact on the broader socio-technical landscape, or is privacy and agency preserving in its presentation and ultimate impact. If scholars focus only on the presence of discrete, UI-based dark patterns but miss the goals that a user enters with, they may miss the whole picture. Similarly, if scholars only view a system at the socio-techical landscape level, they may miss the specific UI or user characteristic enablers that make the business model so effective or difficult to resist. The stack approach leverages both descriptive accounts and ties them together to make tangible connections.
- **For regulators:** Enforcement actions must recognize that evidence of manipulation exists at multiple scales. While UI-level dark patterns may provide obvious entry points

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for analysis, the larger harms often emerge from the cumulative effects of defaults, data practices, and systemic obfuscation. By embracing a holistic perspective around dark patterns that accounts for elements in the UI, the platform affordances and priorities, and the nature of how the user experience unfolds over time may provide a more compelling account for not only *what* deceptive or manipulative practices are present in the interface (which, indeed, often lead to what Doctorow [20] has described as the "enshittification" of the web), but also *why* business motivations have led to the careful nurturing and protection of these harmful practices. Regulation must therefore address both elements of the interface that shape user choice in obvious visual ways as well as the system-level structures that incentivize and explain their persistence.

- **For designers and practitioners:** The stack can serve as a diagnostic tool to reflect critically on the values embedded in design work. Rather than treating the presence of deceptive and manipulative design patterns only as a matter of individual professional ethics or business ethics that the company takes on, the stack encourages collective attention to how organizational imperatives, business models, interface choices, and assumptions about users interact to enable harm.

5.2 Toward More Just and Transparent Digital Systems

In this short essay, I have built upon Alexander's pattern language vocabulary to illustrate the wide range of forces and choices that impact users' experiences of dark patterns and their latent or actual harms. The resulting dark patterns knowledge stack provides both an analytic vocabulary and a provocation, aligning with the multiple levels of Gray et al. [32]'s ontology and revealing new links between UI decisions and ultimate impacts from a business model perspective. The stack provides a timely reminder that harms emerge when shareholder priorities are reified into digital systems without a counter-balance that accounts for user autonomy and choice; when regulatory frameworks lag behind systemic manipulation and address only the visible elements of the user interface without attending to the system level; and when users are left with limited means of resistance due to a lack of digital literacy, or simply the dearth of reasonable alternatives.

By building up through the stack by considering user vulnerabilities and drilling down from socio-technical imperatives, multiple stakeholder groups can use this analytic approach to more fully describe the ecosystem and infrastructure of deception and manipulation—and, critically, chart pathways toward more just, transparent, and accountable digital systems.

Acknowledgments

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