Crank, Shake, and Tilt: Transforming Social Media Interfaces with Embodied Constraints

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Research Project

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Abstract

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Professor Eric Paulos, Chair

Using social media is engaging, enthralling, and stimulating but simultaneously routine and habitual. In this thesis, I explore a series of critical designs that transform digital social media experiences into physically interactive experiences, to provoke users to interrogate their motivations for using social media. I present four social media intervention systems with embodied constraints requiring continuous physical participation: the *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. In a study with twelve social media users, I identify that exclusively accessing social media through these critical designs caused temporary or persistent decreases in social media usage for all participants. Through analysis of daily diary studies, qualitative interviews, and social media usage metrics, I uncovered how users changed their behaviors and values around social media as a result of the interventions. Users devoted their time to different social media content and activities, demonstrated novel collaborative ways to operate social media, and increased their awareness about the role of social media in their lives. Based on the intervention designs that produced these outcomes, I present seven design factors to consider for future social media interventions. I further propose design speculations about sensory, spatial, and distorted interactions for future critical exploration of social media interfaces beyond digital surfaces.

To my parents and sister
for always inspiring me to work toward my dreams.

Contents

Acknowledgments

Land Acknowledgement[1]

I respectfully recognize that I conducted research and wrote this thesis while based in the territory of the ancestral lands of Tamyen-speaking Ohlone peoples, as a student UC Berkeley, which since 1868 occupies and is located in the territory of Huichin, the ancestral and unceded lands of Chochenyo-speaking Ohlone peoples, specifically the Confederated Villages of Lisjan. I recognize that all historical technological infrastructures and current development, in which I partake, depend on this land. I seek to learn about and support the pursuit of sovereignty and ongoing stewardship of this land and place by Ohlone peoples. Additionally, I share this land acknowledgement not as a performative end but as a prompt to non-indigenous readers of this thesis to learn about and engage in support of indigenous groups in our localities, as we benefit from the rich offerings of their land every day.

Academic Support, Guidance, and Collaboration

I sincerely thank my advisor, Professor Eric Paulos, for his valuable guidance, feedback, and sponsorship throughout the research presented in this thesis. I am grateful to my second reader, Professor Niloufar Salehi, for overseeing my research project from its inception in her graduate research course to its publication in this thesis. I thank my collaborator and co-author Lynn Yeom for working with me on the user studies for this project. I also thank and my collaborator Katherine Song who acts as a co-author on portions of this thesis about the *Crank Box* design and my collaborator Jackson Chui who worked on iOS app development for the *Tilter* prototype. I am also grateful to my fellow graduate students in the Hybrid Ecologies Lab, the design experts and resources at the CITRIS Invention Lab and Jacobs Institute for Design Innovation, and members of the greater human-computer interaction network at UC Berkeley for their community, inclusion, and friendship.

Family

Lastly, and with my deepest gratitude, I thank my parents and sister for their unwavering, lifelong support and care throughout my academic journey, especially as I completed grad school and produced this thesis during the COVID-19 pandemic.

[1] Portions of my land acknowledgement use language from the Berkeley Center for New Media's land acknowledgement, which was shaped in collaboration with Professor Marcelo Garzo Montalvo and the Sogorea Te' Land Trust.

Chapter 1

Introduction

Though the human body possesses a wealth of sensory organs and interactive capabilities, most digital interfaces rely only on input from users' "digits," or fingers. The static torpidity of scrolling through a flat, digital screen is at odds with the rich, meaningful potential of dynamic online interactions. On one hand, being online can enable individuals to enter networked spaces, histories, subcultures, and contexts, all through the portal of their digital screens. Online social media platforms, shown in Figure 1, are an exemplar genre of digital interfaces that captivate users, provide them with information, and are imbued with social meaning that users must extract. On the other hand, users' distinct motivations for being online – and the value that they get from being online – are often lost in translation across their lifeless, habitual interactions with digital interfaces.

I identify an opportunity to transform digital screen-based interfaces into physically interactive interfaces in a way that provokes users to interrogate their online behaviors, specifically on social media. Drawing from prior work in *embodied interaction*, *tangible interfaces*, *critical design*, *persuasive technology*, and *slow technology*, I hypothesize that using physically interactive interfaces may promote reflective social media use. In particular, I aim to shift social media experiences from low-friction digital screens to a high-friction physically interactive mediums designed to slow [45], limit [105], and exert [88] users. This critical design approach is oppositional to traditional human-computer interaction (HCI) research approaches that center around tools and techniques for smooth, seamless, and functional user interactions with technology [53, 93]. Instead of optimizing for long-term usability of a designed technology, my approach places emphasis on building temporary technological interventions that evoke critical reflection lasting beyond the intervention period.

Existing approaches to regulating online use treat using social media as a predominantly unproductive way to spend time. For example, digital detoxes and apps for digital well-being [130, 78, 118, 96, 48, 99] often aim to reduce or prevent users' social media access. Such approaches discount the productive impacts that being online and using social media can achieve. As a result, existing approaches to regulating social media usage preclude users from identifying the social media content, patterns, and interactions that constitute valuable uses of time for them. In contrast, the focus of my work is on how individuals identify the

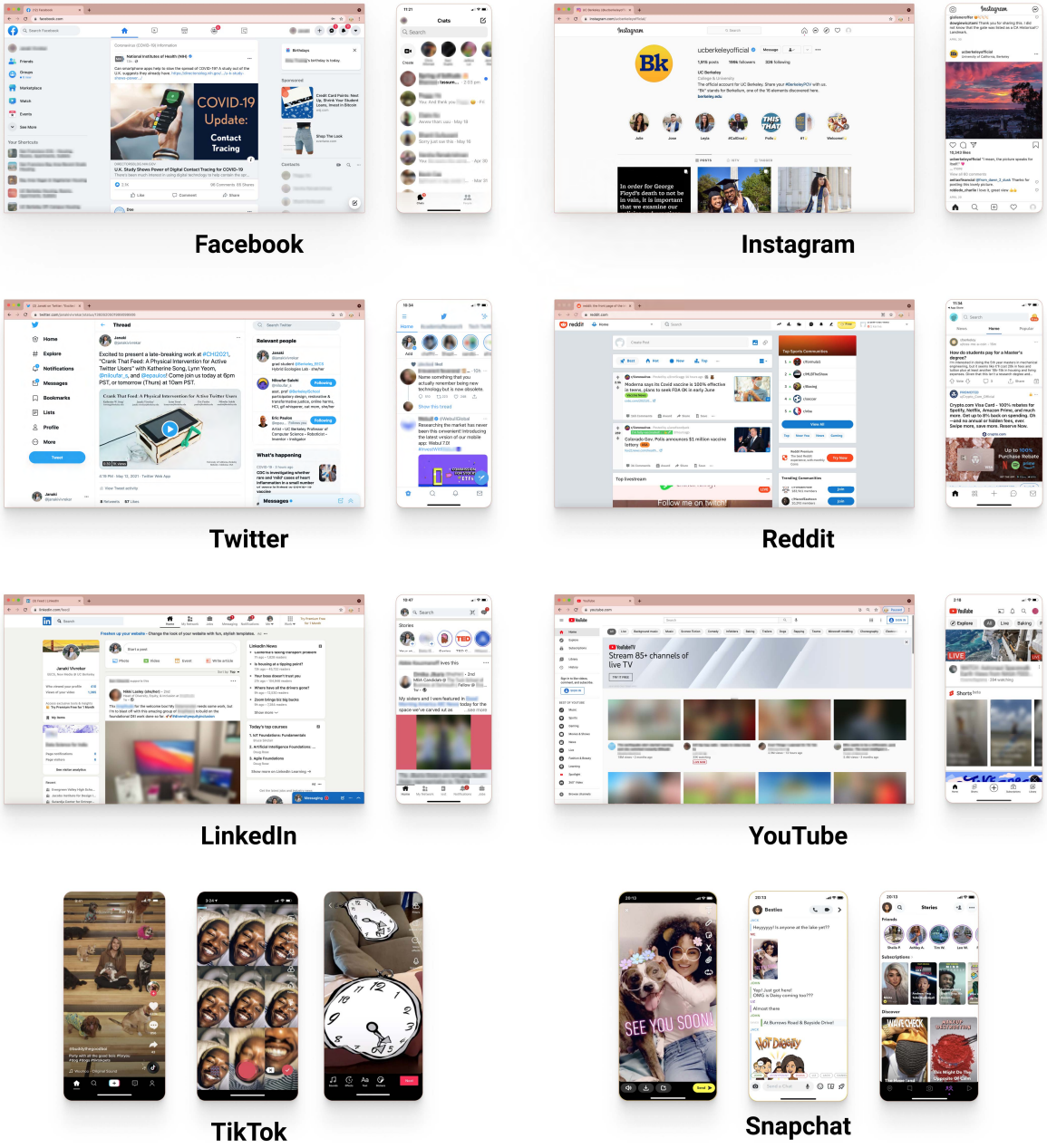


Figure 1: Popular social media platforms include Facebook, Instagram, Twitter, Reddit, LinkedIn, YouTube, TikTok, and Snapchat. The desktop web and mobile interfaces for these social media allow users to explore content from friends, read news headlines, message others, create content, share posts, and more. Loaded with functionality, these interfaces aim to make user interactions as frictionless as possible.

Screenshots of interfaces were captured manually or adapted from the Apple App Store app listings in May 2021.

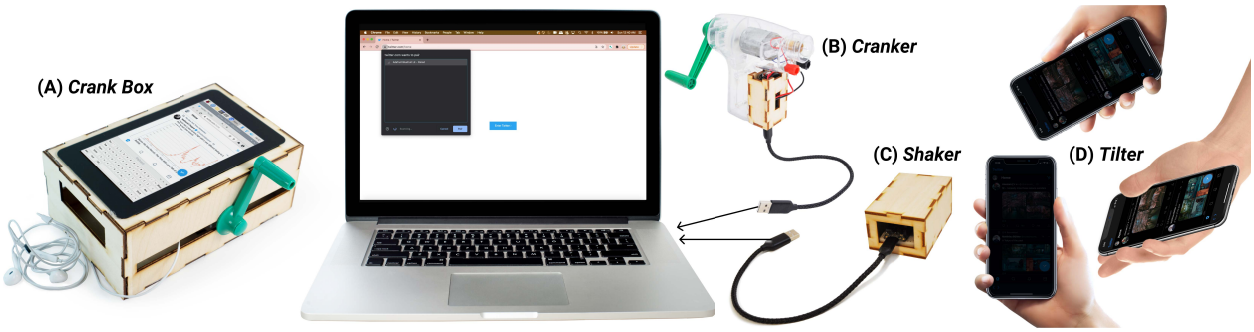


Figure 2: I present four social media intervention systems: the *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. These systems require users to provide continuous physical action – such as cranking, shaking, or tilting a device – to control the onscreen visibility of social media content.

value of social media experiences in their own life, and how they regulate and align their behaviors with that value.

I propose four critical designs of social media interventions, shown in Figure 2: the *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. These interventions require constant physical action from users in order to access social media. The *Crank Box* is a handheld box with a screen interface and hand crank attachment that the user must continuously turn to reveal onscreen content. The *Cranker* is hand crank device that interfaces with a desktop browser extension to modulate the visibility of a social media browser window based on whether the user is continuously cranking the hand crank device. Similarly, the *Shaker* is a handheld device that the user must continuously and rapidly shake in order to reveal onscreen content. The *Tilter* is a mobile application that requires users to tilt and hold their phones at specific angles that they must repeatedly discover through trial and error. For each of these designs, if a user halts providing the active and continuous physical effort required by the intervention system, then the social media screen appears dim and illegible until the user resumes providing physical effort.

I conducted a user study with twelve participants who each interacted with one of the four prototypes over a week-long intervention. For each participant, the intervention mediated access to a single social media platform out of those shown in Figure 1. I collected data from daily diary studies, semi-structured pre-intervention and post-intervention interviews, and social media usage metrics from before, during, and after the intervention for each participant. I analyzed the data by transcribing and inductively coding the interviews and diary study responses.

The added friction and intentional physical limitations in the intervention systems caused all participants' usage of social media to drop during the intervention week. In the post-intervention week, some users maintained low social media use and others experienced rebounds and spikes in their social media use, with newfound understandings of their relation-

ship with social media. Through a thematic analysis method, I identify and report themes in three categories related to how the intervention systems affected users values and behaviors toward social media. Firstly, users transformed their patterns of social media use during and after the intervention, including changes to the time of day, duration, and typical content of their social media sessions. Secondly, using the intervention resulted in novel social dynamics around content-sharing and gave rise to new modes of collaborative social media operation. Lastly, users developed higher levels of awareness and insights about their relationships with social media.

The *Crank Box*, *Cranker*, *Shaker*, and *Tilter* systems leverage design qualities, like physicality and continuous friction, that distinguish them from other existing social media interventions. I categorize these unique design qualities into 7 design factors, which I define and generalize as a set of design considerations for building social media interventions. Design factors emerging from my work include the amounts of physical and digital apparata, the friction in activation, the continuity of friction, and the overrideability of the intervention. Based on these design considerations, I identify novel opportunities for inserting design qualities – such as *embodied constraints*, or physically limiting controls – into the space of social media interventions.

I further propose design speculations about sensory, social, spatial, and distorted interactions that may inspire future critical designs of social media interfaces. For example, I envision a variety of breath-powered, heat-powered, and ingestive interactions as well as crowd-powered, scavenged, foggy, and fragile interfaces. Lastly, I comment on how insights from this thesis may be extrapolated to domains outside of social media, in the broader realm of online spaces and digital interfaces.

Chapter 2

Related Work

2.1 Embodiment and Tangible Interaction

2.1.1 Technical Mediation of Artifacts

In a single human-computer interaction, there are various forces of influence at play in determining the possibilities and outcomes of the interaction. In the frame of Latour's actor-network theory, the interaction of any two actants, human or non-human, assembles a new composite agent with its own program of action, or trajectory toward goals [70, 69]. Materialists may argue that the affordances of technology determine how individuals behave. Moralists and humanists may argue that human will is the locus of interactions. However, Latour argues that human agents and non-living objects mutually influence each other in a view that entangles *physis* (the natural living object space) and *techne* (the manufactured technical object space) as one and the same [68].

My work seeks to intervene in users' habitual routines of social media access with a manufactured *interruption* — a disruption, "displacement," or "breach in the straight path" of an agent to its goal, in the words of Latour [70]. I discuss user interactions with social media in a Latourian sense, where any action is a property of an association or network of individual actants (the user, the screen interface, the digital social media platform, the social media content), which are black-boxed actant networks in themselves. To pose an *interruption*, I introduce another genre of actants into the actor-network of a social media experience: constraints that require physical interaction from the user as a prerequisite to interacting with other aspects of the social media experience, like scrolling through the feed, consuming, or creating content.

2.1.2 Embodiment

Drawing from studies in psychology and sociology alongside philosophy, Klemmer et al. point out that embodiment is critical to how humans experience, think, and learn [61]. Dourish's approach of *embodied interaction* proposes a way to recognize how physical interactions with

computational systems produce social meaning [32]. Dourish discusses embodiment as the central basis of tangible computing, which recognizes actions as embedded in the world, and of social computing, which recognizes actions as embedded in systems of meaning [32].

Klemmer et al. argue that incorporating physical bodies into a digital interactive system has potential to promote *epistemic actions* [61], which users perform not to accomplish a task but to uncover information that was previously hidden within contexts [60]. Kirsh & Maglio discuss *epistemic actions* as ones that "make mental computation easier, faster, or more reliable" in the context of Tetris, where they found that players leveraged an object rotation function to visualize outcomes and simplify cognitive decision-making processes [60]. Social media environments bear certain similarities to game contexts, such as the gamification of micro-interactions on social media websites and the use of "methods similar to the gambling industry to keep users on their sites" [115, 20]. When interacting with social media, users often make split-second decisions about notifications to click on, advertisements to notice, and posts to read. I identify an opportunity to design systems that urge users to take deliberate actions that allow them to better understand the state of their interaction with social media, their underlying motivations, and the resulting value that they derive from it. In my work, I translate users' digital social media interaction into a physically embodied medium, which has potential to bring more user awareness to each interaction since the experience engages their body [61]. I hypothesize that the physicality of my proposed social media systems will heighten user awareness about their own decision-making and reveal their motivations for actions on social media platforms.

In a theoretical frame, we can also understand *epistemic actions* [60] as a performance of Heidegger's concept of *unconcealment* (*Unverborgenheit*, in German) – how technology and use of technology produce a "revealing," or uncovering of truth (*alētheia* in Heidegger's vocabulary) about our worldly context [46]. Dourish discusses understanding context not as a representational problem concerned with encoding static existing information but rather as an interactional problem, where context arises from an embodied activity [31]. We can additionally understand context generation via Latour, as a produced space of shifting delegates arising from action composed across an association of actants [70]. Following these approaches to revealing underlying truths about context, I propose that physically interactive technologies for social media usage can enable users to discover details about the context of their social media use – particularly their own hidden values, urges, and perceptions toward their social media practices.

2.1.3 Tangible Interaction

Tangible user interfaces (TUIs), a field launched by Ishii & Ullmer's proposal of "tangible bits" in 1997, presents an approach to bridging the physical and digital realms by "giving physical form to digital information" [53]. The field of TUIs envisions digital user interfaces embedded in physical objects beyond the mouse, keyboard, and touchscreen [116]. This original "data-centered" [51] approach to tangible interfaces is concerned with imbuing the physical world with "computationally mediated digital information" [49]. Hornecker

identifies other broad spaces of tangible studies, including the "perceptual-motor-centered" approach of *tangible interaction*, concerned with the sensory interactivity of physical objects [51]. Rather than augmenting existing physical objects or settings with digital bits of data, I take a *tangible interaction* approach to building new systems that introduce physicality to existing digital experiences.

Figure 3: (left to right) *Squeeze* mobile phone that requires users to squeeze to power it [106]; *Treadle* laptop table that requires users to pedal to power their laptop [106]; a pair of sneakers with piezoelectric power-generating insoles and a self-powered transmitter [100]

Designing self-powered devices is a subspace of TUIs that deliberately introduces "added discomfort" into interaction with devices to harness alternative human-generated energy sources [54]. In 2006, Paradiso explored the space of "wearable energy scavenging" – how the human body can be used as an environment to source energy, which can be captured via implantable biosensors or electromechanical elements, to power devices [100]. Examples of discussed human body energy sources include body heat, blood pressure, arm motion, and force from feet when walking [100]. Pierce & Paulos also explore the space of *interactive microgeneration* – the "direct or indirect human interaction with electricity generation technologies" in the design of tools like the *Squeeze* phone and the *Treadle* laptop table [106], shown in Figure 3. In 2011, Badshah et al. designed a self-powered device shown in Figure 3 called the *Interactive Generator* (*InGen*) that takes manual rotary input from the user as the sole power source used to generate haptic or force feedback [9].

I bring prior work on self-powered devices into the space of digital social media experiences with my proposed designs of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* social media interventions. These novel systems are modeled after an *active harvesting* of human power, where "the user of the electronic product has to do a specific work in order to power the product that otherwise the user would not have done" [80, 106]. The "specific work" [80] that users must do to access social media via my presented systems includes motions of cranking, shaking, and tilting. These motions additionally introduce "added discomforts" [54] to the social media experience. I differentiate my work from traditional energy harvesting research because my systems control the visibility of onscreen social media content based on measuring the presence of physical user actions rather than explicitly harvesting the mechanical energy produced by the users. However, the end user experiences produced by the *Crank*

Box, *Cranker*, and *Shaker* mimic the interaction of a user powering a device by providing physical input.

2.1.4 Embodied Facilitation and Embodied Constraints

Hornecker describes the theme of *embodied facilitation* as a feature of *tangible interaction* systems, which are simultaneously embedded with the user in physical space and embedded with software that determines the virtual action space for users [51]. The physical and virtual structures of tangible interaction systems invite particular interactions but can also restrict them by placing *embodied constraints*, which Hornecker discusses as instrumental tools for tangible interaction in collaborative settings (e.g. operating a larger spatial board shown in Figure 4, rather than a smaller one prevented a single user from operating the full board but prompted greater tool hand-offs and user collaboration across different parts of the board) [51].

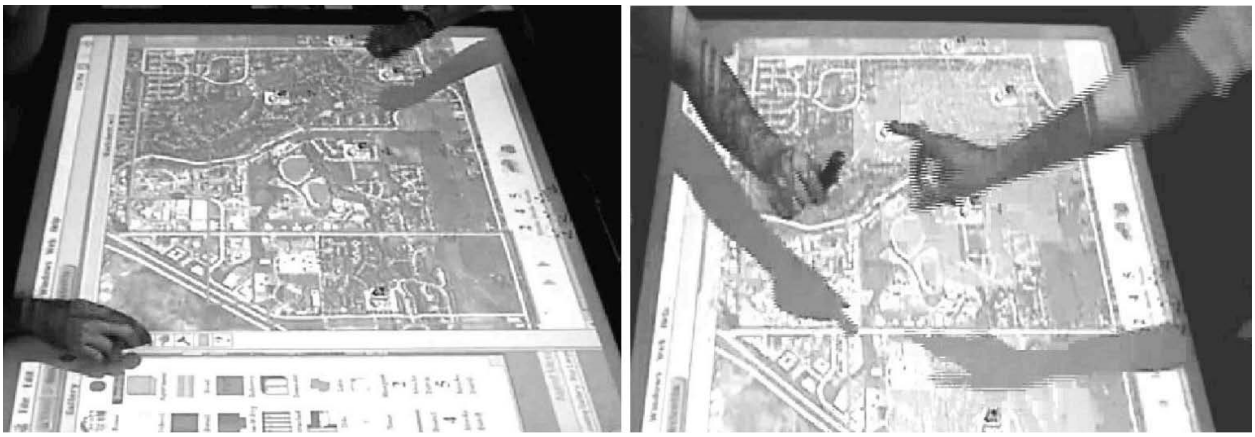


Figure 4: Smartboard whose structure and size pose embodied constraints causing users to engage in collaborative behavior [51]

I transfer Hornecker's idea of embodied constraints to a non-collaborative context, where the physical design of social media experiences limits certain physical and digital affordances, prompting new user behavior patterns. Hornecker posited that "constraints that at first sight seem restrictive and hinder usability have positive effects on social interaction" [51]. I extend Hornecker's claim to the context of an individual user, where I hypothesize embodied constraints may provoke and inspire reflection, discussed further in Section 2.2.1.

2.2 Designing Physical Limitations

Several HCI researchers, particularly in the field of *critical design*, have designed physical systems leveraging embodiment to probe insights from users. The field of *critical design* is

a research space that expresses tension, conflict, and resistance in conversation with mainstream HCI research, which emphasizes building and improving functional, usable computational systems. Tools that counter rapid, reliable, and efficient information access demonstrate potential to elicit reflective insights from users. In the following subsections, I discuss approaches to designing physical limitations in technology that inform how embodied constraints can provoke reflection on social media use.

Figure 5: (top row, left to right) *Capsule Camera*, a counterfunctional digital camera with a concrete enclosure that requires sawing and breaking apart to access the SD card [105]; *Drift Table*, an interactive coffee table that adjusts qualities of an embedded aerial landscape view based on shifting physical weight on the table [40]. (bottom row, left to right) *Reflexive Printer*, a physical device that prints one halftone image a day and deletes the corresponding digital copy [133]; *Photobox*, a domestic device that prints old photographs at random intervals over months [97]

2.2.1 Reflective Design

Dourish et al. call for an intersectional critical technical practice within the field of HCI, for building reflective tools that explore "the assumptions and attitudes that underpin ideas

about technology and humanity" [33]. Sas & Dix argue that the purpose of technology is negotiated by its users throughout the interaction process, and that the design of technology can play a role in promoting user reflection on their emotions and behavior [114]. Understanding "technology as experience" is a paradigm for decoupling technology from a productive end goal and recentering its potential around the reflective interactive experiences it can produce [81].

My work aims to achieve reflective design of social media technology by focusing a user's physical effort toward operating the digital social media experience. Unlike the examples from Sas et al., my work does not explicitly encode information for reflectionabout "body physiology, body movement and body posture" into the user interface [114]. Instead, my social media interventions implicitly require embodied participation by design, which I hypothesize will increase users' physical awareness of the social media experience. Through the designs of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*, I uncover how increased physical awareness of social media experiences causes users to actively question the purpose of social media and negotiate value from the experience.

2.2.2 Counterfunctionality, and Functional Oppositions

Pierce and Paulos propose the concept of "counterfunctional things" as a possibility in designing digital limitations that counter a physical object's supposed functionality, to tease apart layers of value that a user derives from a device or interaction [105]. Similarly, Gaver et al. argue that blocking "expected functionality" by leveraging ambiguity is a design technique to force users to comment on familiar products [39]. Gaver et al. study how design choices that "block or disguise utilitarian functionality" can motivate curiosity, exploration, and reflection in interactions with the *Drift Table*, a dynamic surface for ludic interactions in a home context [40], shown in Figure 5.

In my work, I show how requiring continuous physical action from social media users can convert social media interactions from "familiar" to "strange" [40, 105]. Designs that function by *not* working pose an opportunity to make users question the purpose and operation of the designed interaction. I propose using non-digital "functional oppositions" [105] as a new paradigm for social media interface design, to enable user reflection on the value of social media.

2.2.3 Slow Technology

One approach to enabling reflection involves designing physically limiting technology that is *slow*, or designed to "initiate changes towards a more reflective environment" [45]. Hallnas describes slowness as "a consequence of a techno-aesthetical design philosophy" [45] that decenters the function of a technology and foregrounds how its appearance, aesthetics, and form may promote conscious and reflective use. Odom et. al designed the *Photobox* (Figure 5), a domestic device that prints old photographs operating at random intervals over months to support reflection and re-visitation of the past [97], which is a cornerstone of the slow

technology design philosophy [45]. Tsai et al. designed the *Reflexive Printer* (Figure 5), a physical device that prints one halftone image a day from a user's smartphone and deletes that image from the smartphone. I leverage Tsai et al.'s technique of "perceived drawbacks" as a design quality of interactive physical artifacts to provoke users to reflect on and change their behavior [133].

Traditional social media experiences can be understood as a piece of what McLuhan terms *hot media* [83], where content flows easily, quickly, and with little manipulation from the user. "Perceived drawbacks" [133] may serve a chilling, slowing effect on social media, making it less easy, more frictionful, and slower for users to engage with social media. Whereas the culture of capitalism and productivity values *hot media* for its rapidity and throughput, the culture of slowness values *cold media* for its capacity to provoke thoughtfulness, deliberation, and concentrated value [83].

I follow the *slow technology* design philosophy in my work by converting a high-tech digital social media experience into a low-tech, physically operated social media experience. When using my proposed social media interventions, users must spend time cranking, shaking, and tilting the devices to interact with social media. The shift of social media from a rapid, easy-access medium to a *slow*, frictionful medium creates a "reflective environment" [45] for social media users to evaluate their own motivations for using social media in the moment of interaction.

2.2.4 Exertion Interfaces

In 2003, Mueller et al. introduced the genre of *exertion interfaces* to counter the mainstream approach of building interfaces that minimize physical work [88]. *Exertion interfaces* require significant physical and mental effort to operate and interact with, and extended interactions can create physical exhaustion. Borg distinguishes *exertion* from exhaustion or fatigue, which is a "state of the individual that might mean 'drowsiness' or a high level of tiredness or exhaustion from hard work" [17]. *Perceived exertion* of an activity is a quantifiable subjective rating of the "intensity of work being performed" [8, 17].

Mueller et al. demonstrate how *exertion interfaces* can serve "fun," "sport," and "leisure" activities [88]. For example, Mueller et al. built *exertion interfaces* for games, like the *Breakout for Two* [88] game and the *Remote Impact* game [90], pictured in Figure 6. Brainball, another game also pictured in Figure 6, is a physical two-player game from 2003 that monitors players' brain activity via EEG levels to control the movement of tabletop rolling balls, which gradually move away from the most "relaxed" player [47]. In Brainball, a player's objective is to to be as "relaxed" as possible, or to achieve "nothing," to score points by moving the balls toward the opposing player [47]. Oppositional to the mainstream concept of physical *exertion*, Brainball is a game of play between mental exertion and mental relaxation.

Additionally, Weinberg & Gould argue that *exertion* activities have potential to produce varying amount of "purpose and meaning" for interactive users compared to mundane and repetitive forms of exercise [141]. Mueller et. al propose that providing humans with physical, kinesthetic feedback is a way to achieve more meaningful interactions in *exertion*

interfaces [90]. I propose that combining the space of social media interactions with *exertion interfaces* has potential to infuse physically exertive interactions with meaningful digital interactions, and vice versa.

Figure 6: (left) *Breakout for Two*, an *exertion interface* with two remote users playing a game involving soccer and tennis moves with life-sized projections of the other player [88]; (center) *Remote Impact* game, which allows users to engage in combat sport-inspired interactions with virtual projections of opponents' shadows [90]; (right) Brainball, a tabletop game that requires users to "relax," as measured by EEG levels, in order to control rolling balls on a table to acheive the game objectives [47]

I draw on the physical and mental labor elements of *exertion interfaces* but position my work outside the space of games, scoring, and competition. I employ the exertion interfaces approach in the space of social media, which is otherwise abundant with smooth, frictionless, low-effort interfaces. Typically *exertion interfaces* must be used for an "extended period of time" [88, 89] to be a cause for physical exhaustion, but I attempt to cause a degree of mental and physical exhaustion within short time frames of interaction with social media. I achieve the effects of mental and physical exhaustion within short time spans because the existing frame of reference for social media usage is at the stark opposite end of the spectrum of user effort. I demonstrate how converting a social media interface into an *exertion interface* need not introduce an intensive form of physical activity to cause exhaustion, since even relatively mild forms of physical input are a vast departure from typical low-friction social media interfaces.

2.3 (Over)use of Digital Screens and Social Media

2.3.1 History and Definition of Social Media

The emergence of digital tools for communication and information dissemination, like search engines, browsers, and web directories, preceded the existence of social media as we know it today [29]. With a growing global audience of consumers, main actors in the space of information technology approached data sharing and "connectivity" as an opportunity to

expand horizons of the profitability. Van Dijck writes about connectivity as a resource that helped brand and make profitable a form of "online sociality" in a global market [29]. Subsequently, the nature of social media emerged from the transformation of "networked communication" to "platformed sociality," as a "participatory culture" shifted to a "culture of connectivity" on the internet [29].

Today's popular social media platforms grew from a desire to "make the Web more social" and making the world more "open and connected" in the words of Facebook CEO Mark Zuckerberg [148]. Following a period of enthusiastic user adoption in the early 2000s, social media gradually became an essential fixture in the lives of over 970 million global users in 2010, growing to over 3.81 billion global social media users in 2020 [26]. The enormous growth in user adoption of social media platforms fuels and responds to drastic changes in the design of social media interfaces, like the design evolution of Twitter, shown in Figure 7. While serving a narrative global digital connectivity, social media companies pursue business goals that capitalize on users' data, commodify users' attention [129, 138], and use algorithms to amplify hate speech, spread misinformation, and deliver sensational content [135, 84]. Today, the scale and impact of social media algorithms ranges beyond the original hopeful visions of social media. While social media is capable of spurring revolution, protest, and monumental change at unprecedented scales [123, 134], it is also pervaded by "catastrophic" political and structural threats [84].

Figure 7: (top row, left to right) an early sketch of Twitter by CEO Jack Dorsey in 2001 [136]; Twitter in March 2006 [136]; two screens of Twitter in July 2006, launched as public service called "twttr" [136]. (bottom row, left to right) Twitter in November 2006 [136]; Twitter in 2015 [136]; Twitter desktop web and mobile app in 2021

How we understand and define *social media* today is an unsettled topic among communications researchers. According to Carr & Hayes, many contemporary definitions rely on

vague qualifications of digital communication, interaction, content generation, and content sharing or loosely cite examplar social media platforms to articulate what constitutes a *social medium* [22]. Researchers have defined *social media* as "digital technologies that allow people to connect, interact, produce and share content" [73] or "Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" [58]. Carr & Hayes claim that such definitions fail to distinguish social media from any other communication technology and are not robust enough to remain applicable in the future [22]. Instead, Carr & Hayes define social media as "Internet-based, disentrained, and persistent channels of masspersonal communication facilitating perceptions of interactions among users, deriving value primarily from user-generated content" [22].

As an alternative to technical definitions of social media, I additionally present a theoretical definition of social media using Deleuze & Guattari's rich vocabulary for understanding unstructured networks [27]. Whereas the algorithms and computational roots of social media are *arborescent*, or structured, tree-like lineages of mathematical multiplications encoded in zeros and ones, the social media phenomenon they produce is the sheer opposite: a *rhizome*. A *rhizome* is a laterally networked, unstructured space with non-hierarchical connections and links across entities in the space. Understanding *social media* as a *rhizome* captures the intricacy of online identities, internet histories, and linkage of digital artifacts across space and time enabled by social media.

2.3.2 Motivations for Using Social Media

Motivations for using social media vary across individuals, change with time, and are sometimes unclear, even to users themselves. Prior studies [4, 122, 56] on what users value about social media platforms like Facebook, Twitter, Instagram, and Snapchat have used a Uses & Gratifications approach [59] to uncover various motives for use, including social connection and interaction, shared identities, entertainment, social investigation, social network surfing, status updating, information sharing, self-documentation, self-expression, passing time, medium appeal, and convenience. Lupinacci also describes the emotional effects of the "continuous connectedness" that comes from social media use, including feelings of excitement, anxiety, reassurance, fatigue, and responsibility [76].

Tiidenberg et al.'s studies of college students' attitudes towards social media in 2014 to 2016 found that while many individuals feel compelled to always be online and find value in the ease of accessing information digitally, they also label their social media experiences as "the ultimate procrastination," "kinda stupid," and "a waste of time" [131]. Lukoff et al. similarly found that while some individuals derive value in smartphones' ability to provide "micro escapes" from difficult social or emotional situations, users find habitual, instinctive, or less intentional engagement particularly meaningless [75].

In my work, I aim not to generalize valuable aspects of social media across users but to equip individual users with a physical mechanism for personal reflection on their usage patterns. Instead of prompting a user to reflect on their social media experience as it

exists, my proposal is to defamiliarize and port their social media experience from a digital screen into a new physically operated *territory* [27], or environment, which allows them to inspect their transformed social media usage in a new context with a fresh lens. Such a *deterritorialization* [27] – a rupture in a stream of habit, followed by a *reterritorialization* [27], a new pattern of engagement, poses the unique opportunity to uncover not only what users value about social media but also the aspects of their prior social media experience that they are willing to forgo or renounce in their new unfamiliar social media context.

2.3.3 Social Media "Addiction"

Several published medical studies have described the complex psychological result of excessive habitual social media usage as an *addiction* [42, 113, 66, 6], understood in the broader context of *internet addiction* [147, 41] and attachment to mobile phones [12]. However, apart from extreme medical cases, a challenge with quantifying excessive usage of digital screens is that the threshold of reasonable usage varies across individuals, who have unique agency to determine the behaviors and experiences that bring them value.

I consider a social media *addiction* to be distinct from a general, even frequent, desire to interact with social media. Addiction engages mental and physical phenomena in a relation of insatiable desire for an object, where consuming or interacting with the object increases rather than fulfills the desire [144, 94]. Likening all frequent or prolonged use of social media to *addiction* reduces the concept of social media to a source of unquenchable desire that wields unreasonable control over humans. Existing discourses on addiction bear similarity to perspectives in human-computer interaction in a way that illustrates this reductive stance. Opposing viewpoints on addiction (the *moral model* and the *disease model*) [144, 94] pose a similar contention as the conflicting perspectives on whether humans have *agency* in interactions with technology, or whether interactions are dictated by the *structure* of "persuasive technologies" like social media [138]. Just as the *moral model* of addiction blames individuals as responsible for their addiction-driving behavior, *agency* arguments place the burden of "self-control" from "addictive" technology wholly on individuals [138]. On the other hand, the more widely accepted *disease model* for addiction, which discusses addiction as a disorder for which afflicted individuals should not be blamed, parallels the narrative of *structure* arguments that lean on techno-deterministic discourses to call for more ethical design of consumer technology.

In her book, boyd additionally problematizes the casual use of the term *addiction* to describe extensive use of social media by teenagers [18]. Rather than characterizing their behavior as demonstrating a lack of control, boyd argues that what others term *addiction* of teens to social media is better understood as an extension of typical human engagement driven by a need for entertainment and socialization [18]. Based on boyd's analysis, I entertain the possibility that even seemingly mindless social media experiences may be valuable to users in some ways.

To allow users to individually determine what brings them value in social media experiences, I consider social media as a phenomenon with varied potentials and impacts beyond

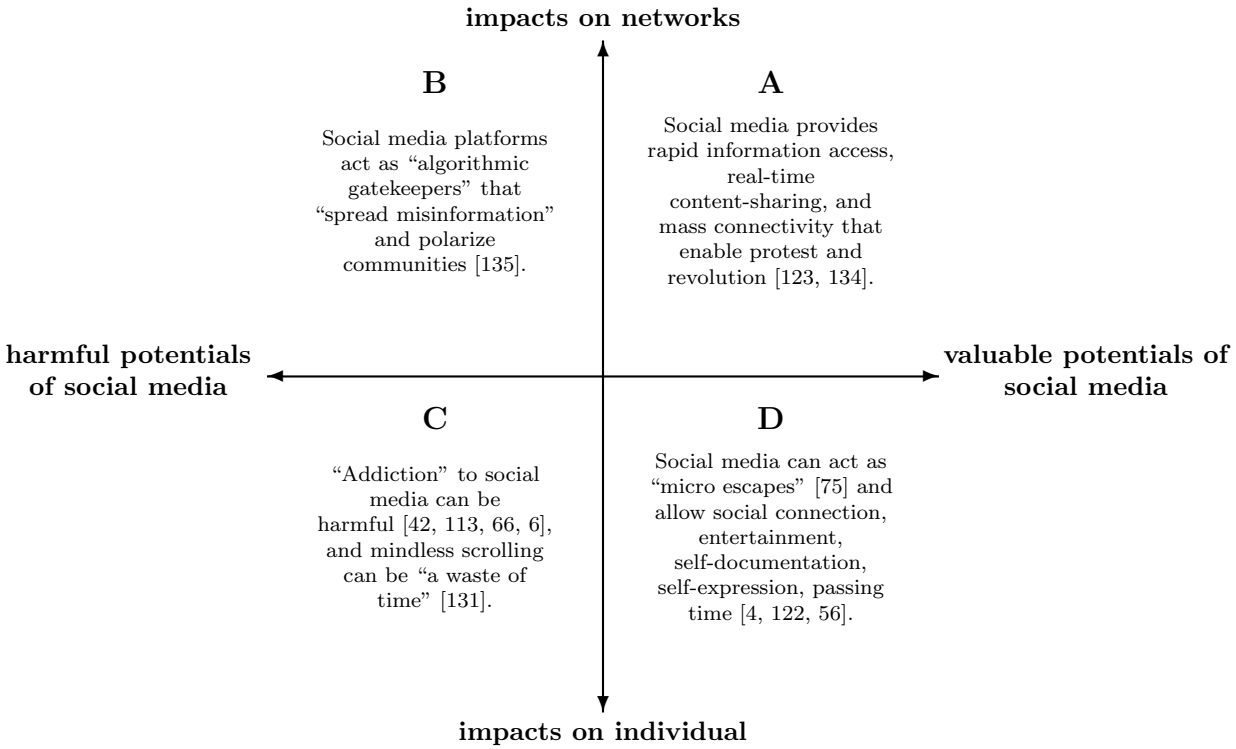


Figure 8: Social media expresses a spectrum of potentials, ranging from harmful to valuable, with impacts ranging from the individual level to a larger network and community scale.

creating *addiction*. As presented in Figure 8, social media can be potentially harmful to individuals (Quadrant C), but it can also add value to their lives (Quadrant D). Mass adoption of social media amplifies these impacts at the scale of communities and networks of individuals, with the ability to propagate inequity, misinformation, and other systemic harms (Quadrant B) while simultaneously enabling mass connectivity and rapid content-sharing (Quadrant A).

Most strategies and tools for regulating social media usage (discussed further in Section 2.3.4) adopt a narrow view on social media limited to Quadrant C. For such approaches, mitigating the harmful impacts of social media equates to reducing, deterring, and preventing social media use altogether. I take an oppositional approach that centers the valuable potentials of social media (Quadrants A and D) by provoking users to understand and articulate the aspects of social media that generate value for them as a way of shifting away from passive use (Quadrant C) without cutting social media out entirely.

Using Deleuze & Guattari's vocabulary [27], I pose a theoretical frame for contrasting addictive, mindless, and healthy patterns of social media use. Deleuze & Guattari define a *body without organs* as a space where matter – tangible, ideological, or imaginary – can

flow with no surrounding structural constraints. I model a desirable, free-flowing social media experience as a "healthy" *body without organs* – an unstructured chunk of time for browsing and generating content, floating through the social media *rhizome*, as an unruly but productive[2] assemblage of thoughts, emotions, intentions, reactions, and impressions. An addictive experience can be understood as an "empty" *body without organs*, where the user is wholly dependent on the flow of social media to enliven them. On the other hand, a mindless social media experience can be modeled as a "cancerous" *body without organs*, where the user uses social media for no other reason than to use social media, and is unaware of any value that it brings or strips from their life. My work broaches how to cleanse a "cancerous" *body without organs*, or a social media experience that is dysfunctional but not necessarily an addiction. I propose an interactive system to bring users clarity on what they value about social media as a way for them to reform toxic, "cancerous" tendencies of their social media usage into more positive, healthy tendencies.

2.3.4 Countering Excessive Use of Digital Screens

In the Digital Realm

A growing public and corporate interest in "digital well-being" has prompted companies like Google and Facebook to build tools that help "strike a more balanced interaction with devices" [112]. For example, Roettgers reported in 2018 that over 70 percent of Google users expressed a desire for help with "striking a balance between their digital life and real-world interactions," which led to Google's development of an Android digital well-being dashboard and app timer [112]. Today, there exist several digital systems that encourage users to become more mindful of their behavior on social media to counter the harms of excessive social media use.

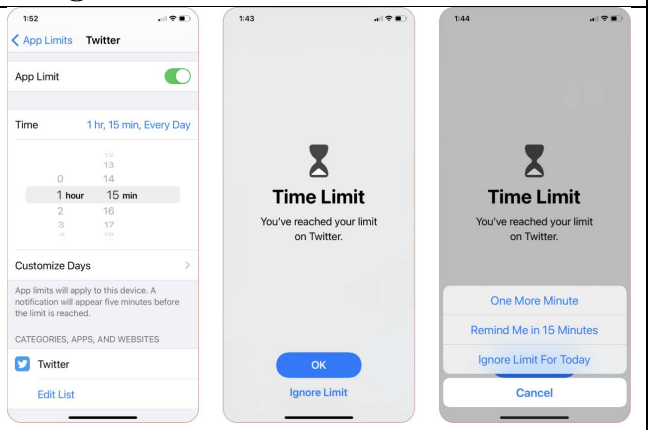
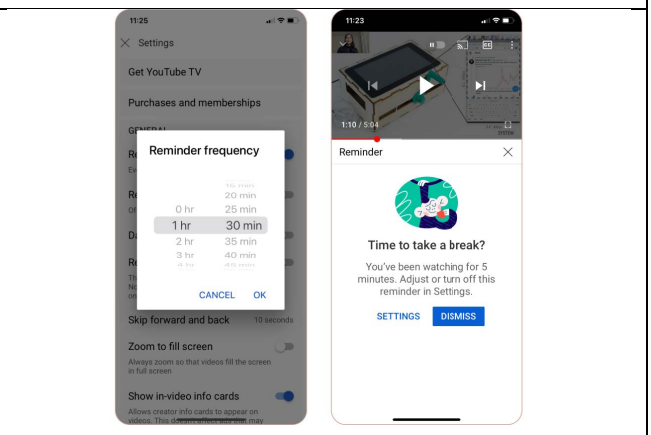
Examples of systems for digital well-being, pictured in Table 1, include browser extensions and apps that limit screen time and block sites to reduce and prevent social media use. The YouTube mobile application has a *Take a break reminder* feature that pauses the users' video at customizable time intervals [126]. Screen time limits are also built into some popular mobile operating systems, like iOS and Android [137, 102]. Other website-blocking applications include *Blocksite* [15], *Block Site* [14], *StayFocusd* [85], and *Opal*, which completely disconnects users from certain apps by blocking certain web traffic during user-defined focus sessions [104, 98]. Such apps have the potential to time-bound social media usage. Though these apps may be successful and effective in reducing social media usage, in practice they simply separate the user from their desired experience with a layer of additional digital screens, which are overrideable.

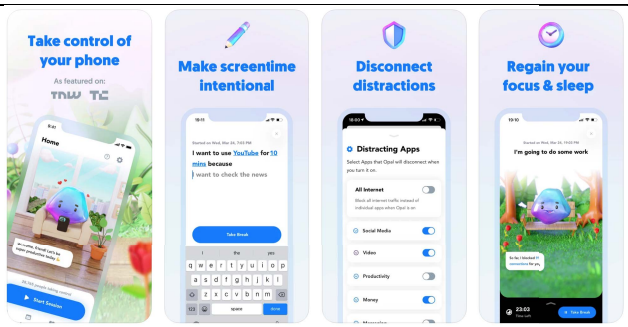
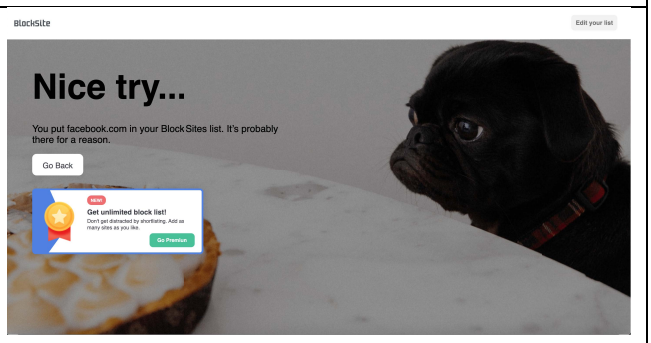
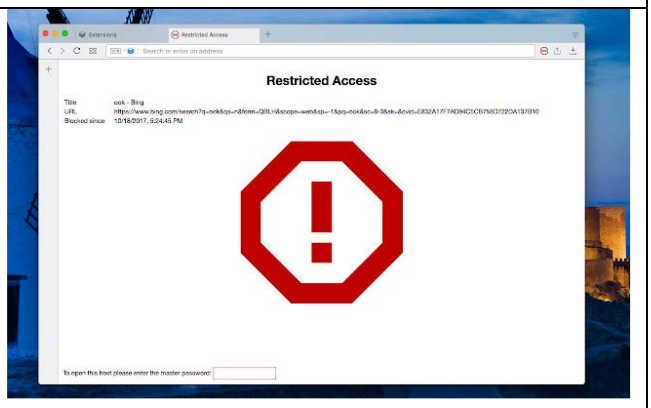
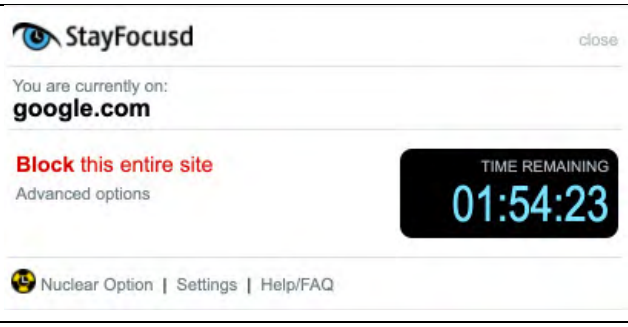
Other examples, also pictured in Table 1, change specific parts of a social media experience to deter use. *Nudge*, a browser extension developed by Purohit et al., makes actions like clicking on triggers, seeing likes and comments, and infinite scrolling more difficult [109].

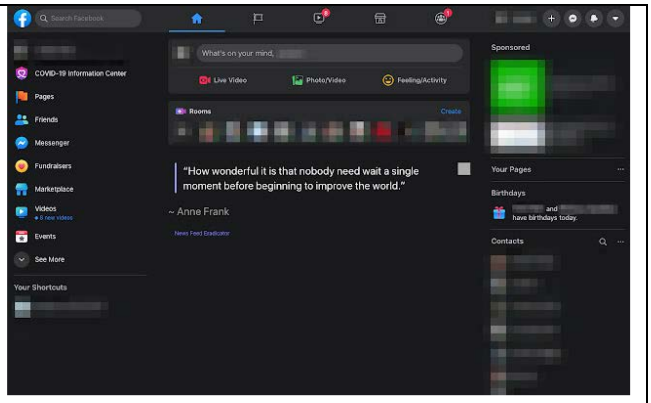
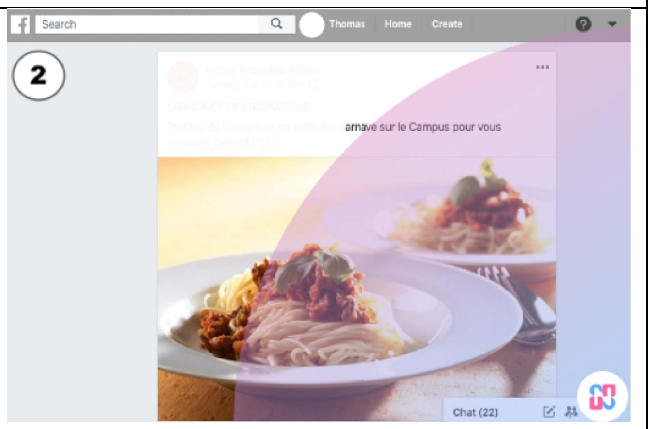
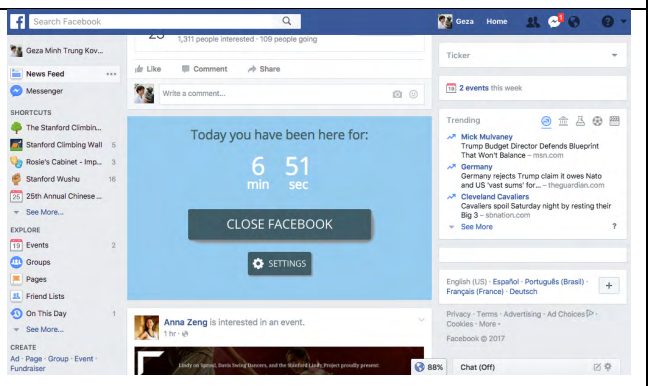
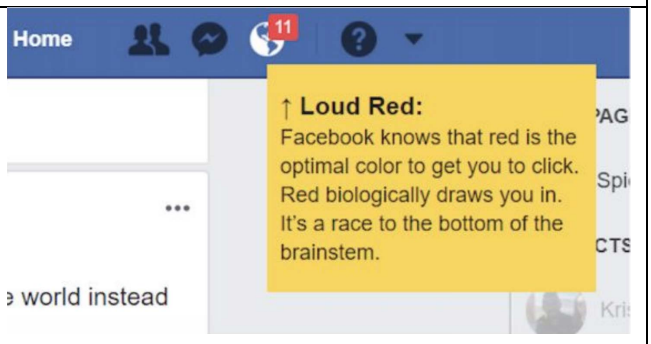
[2]Here, "productive" does not imply a value for production in a capitalistic sense but rather for creative, generative production that serves the user's goals and desires.

The *News Feed Eradicator* browser extension replaces the user's social media feed with an inspiring quote [143]. The HabitLab Chrome extension provides a suite of interventions including embedded timer displays, media scroll freezes, and loading delays [44]. The *Nudget* intervention labels persuasive design techniques used by a social media, with inline callouts on a desktop website, as a deterrent for users to continue their session and build awareness about the design of the platform [138]. While such efforts have produced interesting results, they are limited to the digital realm and rely on assumptions about what constitutes "good" and "bad" behaviors. Such digital interventions are also easy to override, and circumventing them without much effort can become habitual and render the digital intervention ineffective.

Another type of digital intervention is one that operates synchronously for multiple users rather than a single user. For example, *Lock n' LoL*, pictured in Table 1, is a mobile application developed by Ko et al. that synchronously blocks all notifications and other applications from multiple co-located users' mobile phones when they are engaged in a social group activity [63]. I further investigate the space of social dynamics that are produced as a result of engaging in a social media intervention in my user evaluation of physical social media interventions, even when users are not co-engaging in an intervention.

Name	Type	Description	Image
iOS Screen Time Limits	screen time limit	"You can set daily limits for app categories with App Limits. For example, you might want to see productivity apps while you're at work, but not social networking or games." [137]	
Take a break reminder (YouTube)	in-app time limit	"The take a break reminder lets you set a reminder to take a break while watching videos." [126]	

Opal	site-blocking app	"With Opal, you can block distracting apps and sites like Facebook, Instagram, TikTok, Reddit, Snapchat, Twitter and a lot more in one tap and end the doomscrolling." [104, 98]	
BlockSite	site-blocking browser extension	"Stay focused and improve productivity. Easily block any distracting or harmful website. Stop procrastination once and for all!" [15]	
Block Site	site-blocking browser extension	"A customizable, password-protected website blocker and redirector. This extension will block access to websites of your choosing." [14]	
StayFocusd	site-blocking browser extension	"StayFocusd increases your productivity by limiting the amount of time that you can spend on time-wasting websites." [85]	

News Feed Eradicator	interface-modifying browser extension	"News Feed Eradicator removes the most addicting part of Facebook and Twitter - the feed - and replaces it instead with an inspirational quote." [144]	
Nudge	interface-modifying and screen-time limiting browser extension	With about six different interventions, Nudge is a "browser extension that aims to make social media less addictive by delivering digital nudges founded on behavioral science." [109]	
HabitLab	interface-modifying and screen-time limiting browser extension	"Use over 20 interventions to help you regain control of your browsing. Find out what works best for you: hiding feeds, removing clickbait, blocking videos, or one of many others." [44]	
Nudget	interface-modifying browser extension	"Nudget is a Google Chrome extension that annotates users' Facebook feeds on their desktop computers, showing informational popup messages about persuasive theory at play in-situ." [138]	

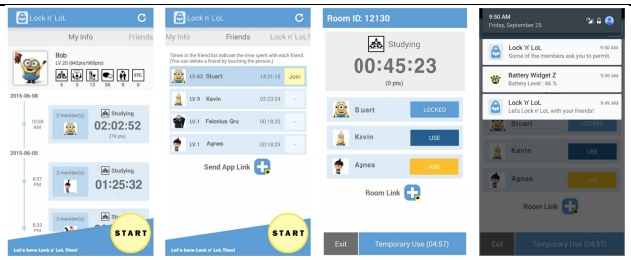
Lock n' LoL	time-limiting app	Lock n' LoL "helps users focus on their group activities by allowing group members to limit their smartphone use together" [63]	 (a) My Info (b) Friends (c) Group Limit mode (d) Co-location reminder

Table 1: A brief survey of existing tools for digital well-being and productivity, including browser extensions, interface modifications, and time-limits.

Beyond the Digital Realm

The space of countering excessive use of digital screens extends beyond digital interventions. Simple interventions like placing one's mobile phone out of reach while working on another task or putting one's phone in another room before going to bed are some folk remedies that can prevent scrolling through social media apps at undesirable times. A more complex social media intervention is *Kit*, a belt tourniquet that interfaces with a browser extension to deliver "prick-like shocks" to users whenever they visit Facebook [99]. *Kit* physicalizes the pain of social media addiction with a harsh reaction intended to deter social media use. My work grasps the opportunity to alter social media use by requiring mild physical input rather than producing harsh physical output.

Additionally, "digital detoxes" [130, 78], planned "tech Shabbat" days [118], apps for mindfulness and mediation [21], and other ways to unplug from digital screens [96, 48] are increasingly popular ways to manage and break away from the attention-gripping experience of interacting with digital screens. However, the commodification of mindfulness by corporate tech entities and popular media has also resulted in a culture that values digital well-being strategies because they help manage the stresses of capitalism while fueling increased eventual productivity. Odell discusses approaches including a vocabulary of removal, pause, retreat, refusal, and detachment from the digital online world as ways to resist the attention economy and counter the narratives of productivity, growth, and novelty that internet thrives on and fuels. Odell is critical of "digital detoxes" for the sake of engendering higher future levels of productivity, but places value in being rooted in the physical "present" as a way of "gaining control of" one's attention, which is fluid and variable [96].

Such approaches present valuable individualistic strategies to moderate excessive digital activity, reclaim control of our attention, and be more physically present. However, these approaches often describe being physically "present" as something that is most achievable outside the realm of a digital social media experience, for example by refocusing attention toward non-digital activities like meditation or immersing oneself in the subliminal folds of nature [96]. Instead, my work explores how users may regain physical presence and

situatedness without being removed from the realm of a digital social media experience. In doing so, I investigate how foregrounding physical presence in social media experiences may affect users' perspectives and attachment toward their digital screens and experiences.

Chapter 3

Intervention Systems with Embodied Constraints

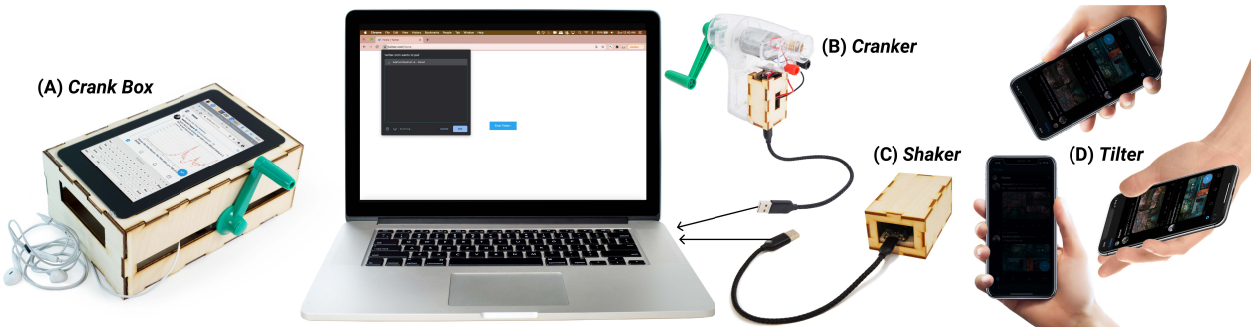


Figure 9: I present four social media intervention systems: the *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. These systems require users to provide continuous physical action – such as cranking, shaking, or tilting a device – to control the onscreen visibility of social media content.

In this chapter, I present designs and protoypes of four social media interventions: The *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. Pictured in Figure 9, these interventions require active physical participation from the user to engage with social media. Each intervention design can support various social media applications. These four designs consist of varying degrees of additional physical infrastructure and require different physical motions (like cranking, shaking, and tilting). In each section, I describe one of the prototypes and its hardware, software, constraints, and limitations.

The metaphor of significance in these interventions is an *unconcealment* [46], in two senses, of the complex phenomenon of social media via forced operation of mechanical technology. As users work to unconceal – in a literal sense – the social media on the digital screens of the prototypes, I hypothesize that they will simultaneously be able to unpack – in a metaphorical sense – their own notions and values toward social media.

3.1 Crank Box

The *Crank Box* is a social media intervention device with a screen interface and hand crank attachment mounted on a hand-held plywood box. To operate the *Crank Box*, the user must continuously turn a hand crank to maintain visibility of the screen displaying social media content. If the user stops cranking, the screen gradually dims and fades to black until the user starts cranking the device again.

Motivation

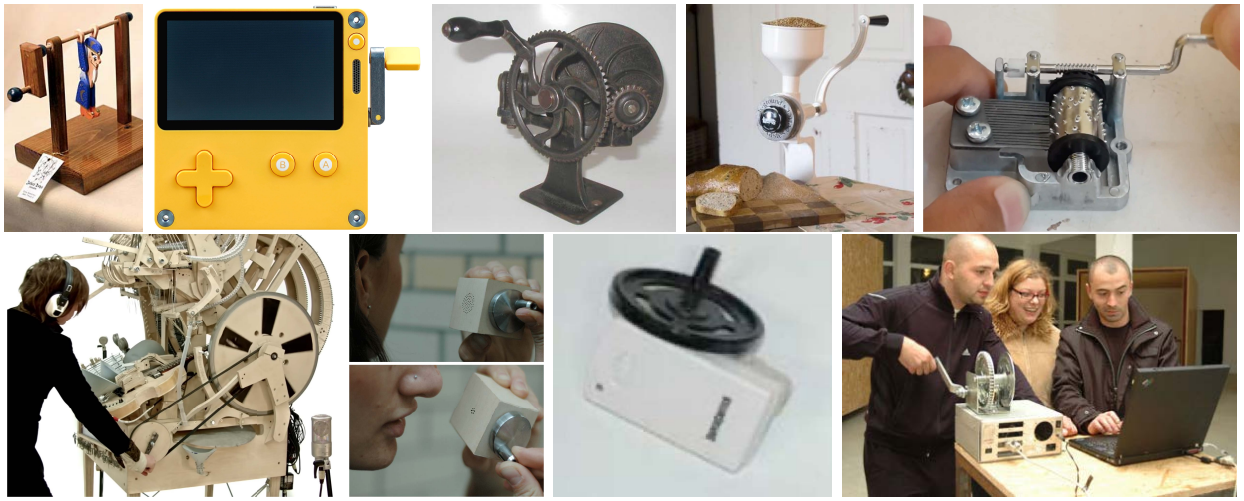


Figure 10: (top row, from left to right) crank flipping toy [117]; *Playdate* gaming console developed by Panic [79] Gould & Cook Gem pencil sharpener, patented in 1886 [7]; handheld music box [86]; hand-cranked grinding mill [72]; (bottom row, from left to right) Wintergatan Marble Machine [146]; Crank-Sound Box [107]; Crank remote outlet switch [106]; Crank the Web [19]

The design of the *Crank Box* is inspired by the intuitive and familiar hand crank mechanism for translating mechanical energy into various functional and entertaining outcomes, as pictured in Figure 10. For example, hand cranks are a popular component of childrens' toys [117, 67], gaming consoles like the *Playdate* [79], and manually powered tools like cylindrical "planetary" pencil sharpeners [7], crank-powered flashlights [125], and grinding mills [72]. Cranks are also widely used in handheld, hand-powered musical instruments like the music box, which traditionally has a revolving cylinder with small pins that pluck thin metal prongs to produce sounds [92]. In 2016, Swedish musician Martin Molin also used a hand crank to power the Wintergatan Marble Machine, a life-sized music box instrument that activates sounds using the mechanical movement of marbles [111]. Cranking has also

been explored as a way to power digital screens, like the unsuccessful One Laptop Per Child cranking prototype [110].

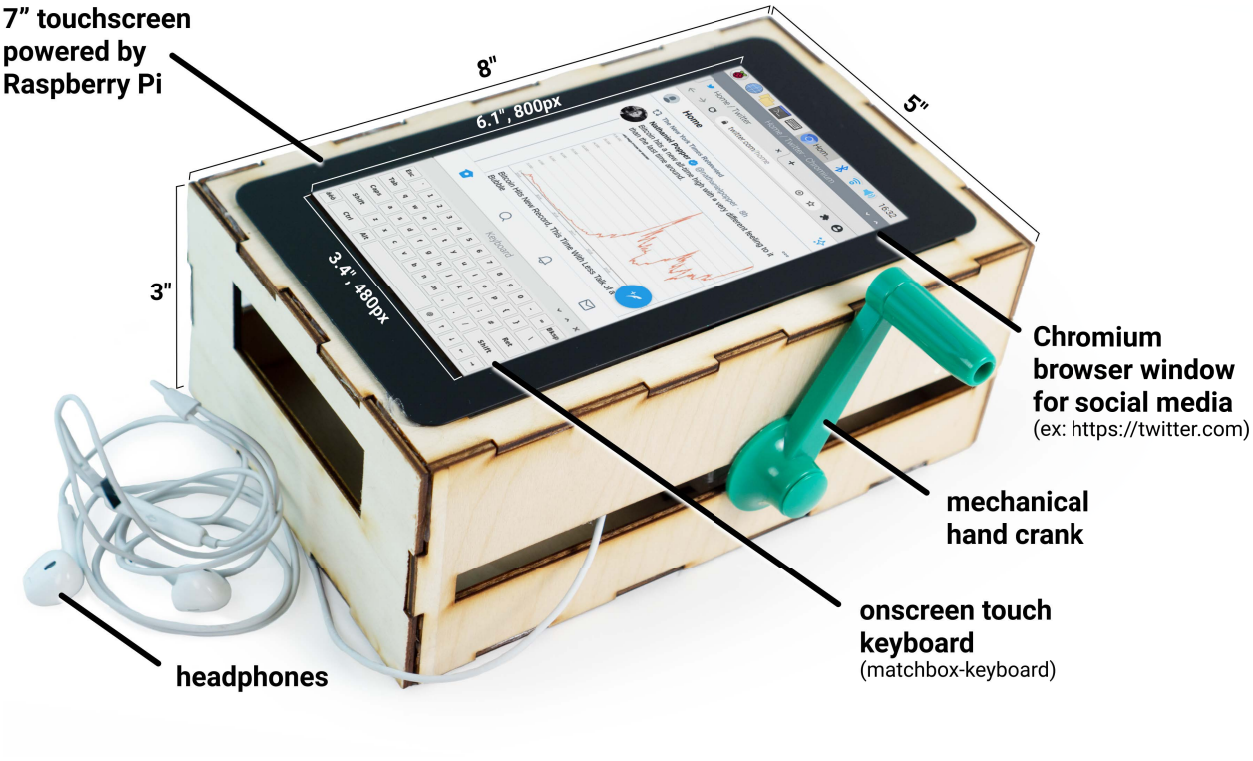


Figure 11: The *Crank Box* device is a 3" x 5" x 8" touchscreen device in a plywood case with a plastic hand crank mounted on the right-hand side. A USB power cable (not pictured) leads out of the left side and must be plugged into an outlet or portable USB charger to power the device. Earbuds connected to the device allow the user to listen to audio content. Upon startup, the graphical user interface is populated with an onscreen touch keyboard and a Chromium browser window opened to a social media website, which the users can navigate and scroll through using their finger via the touchscreen interface.

Pierce & Paulos also propose cranking as one of the several forms of *human-powered microgeneration* for critical interaction design projects [106]. Pierce & Paulos explore the cranking interaction in the design of a remote outlet switch that turns an outlet on or off based on the direction of cranking [106] and the design of the Crank-Sound Box "energy memento," which records audio when cranked in one direction and plays back the recorded audio when cranked in the opposite direction [107]. In a critical design project from 2001 titled *Crank the Web*, Brucker-Cohen designed a web browser that requires people to "physically crank their bandwidth" in order to load a webpage [19]. Brucker-Cohen designed *Crank the Web* as a way to produce internet connection dependent on "personal strength" rather

than "personal wealth" that grants access to infrastructure for high bandwidth.

Similarly to *Crank the Web* [19], the *Crank Box* prototype, shown in Figure 11, provides access to social media webpages based on the input of mechanical cranking motions from the user. Unlike crank-powered flashlights, which use cranking motion to charge a battery that powers the flashlight asynchronously, the *Crank Box* design uses real-time cranking input to control a screen display; cranking the *Crank Box* extra hard does not store extra screen power. Instead, cranking rapidly causes the screen to gradually take on a higher brightness while the user cranks, and the brightness gradually lowers if the user stops cranking or slows their speed of cranking. Therefore, the user must continuously crank the *Crank Box* to see their social media.

Hardware

Figure 12 illustrates the hardware setup of the *Crank Box* system. The *Crank Box* is powered by a Raspberry Pi (RPi) Model 3 B+ with built-in WiFi. An RPi 7" touchscreen is connected to the RPi via the built-in Display Serial Interface (DSI) port for signal exchange as well as 5V and GND General Purpose In/Out (GPIO) pins for power. A manual DC generator with a hand crank[3] is connected to the RPi such that its low-side terminal is connected to the RPi's GND and its high-side terminal is fed as an input into one of the RPi's GPIOs. The resistance of the hand crank is calibrated by adjusting a potentiometer on the generator to ensure that turning the hand crank both requires intentional user manipulation (and does not spin freely without much friction due to its own weight) and also does not require an excessive amount of effort.

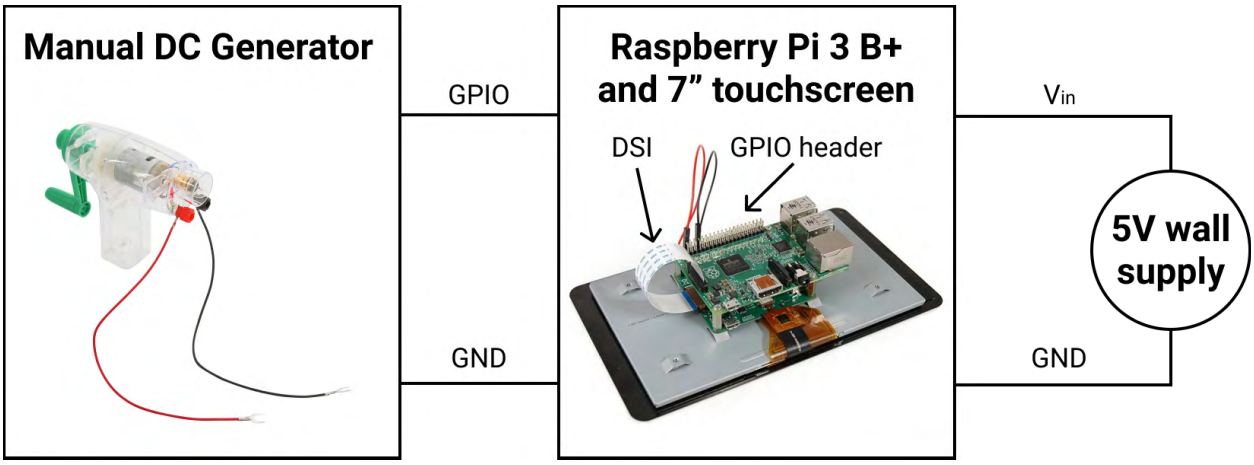


Figure 12: The *Crank Box* hardware consists of a hand-cranked DC generator that provides an input control signal to a Raspberry Pi, which controls a 7" touchscreen.

[3]An off-the-shelf part costing $9.82 via online Amazon order in 2021, `https://www.amazon.ca/Yaegarden-Generator-Emergency-Electricity-Powered/dp/B07W2VQMGQ`

Software

Startup Script

The setup for each user begins with a fresh install of the latest version of RPi OS (kernel v5.4), a Debian-based OS with a built-in Lightweight X11 Desktop Environment (LXDE). The device is configured to be in portrait mode to resemble the default configuration on most mobile and portable devices. Upon startup, the LXDE opens a new Chromium[4] window that loads a social media website, such as `https://twitter.com` or `https://www.facebook.com/`. Additionally, the startup sequence loads an onscreen touch keyboard from the Debian OS `matchbox-keyboard` package[5]. After the device completes the startup sequence, the user may re-position the the Chromium window and onscreen touch keyboard into different layouts, including the recommended sample layout shown in Figure 11.

```
DELTA = 2                                # interval to sample hand crank
CHANGE_FACTOR = 2                        # controls speed of brightness change
total = 0                                # initialize 'amount' of cranking
t0 = time.time()


while True:
  total += readCrankGPIOInput()          # crank GPIO input (0 or 1)
  t1 = time.time()
  if t1 - t0 > DELTA:
    total /= CHANGE_FACTOR
    t0 = t1
    if total > 1:
      logUserIsCrankingTimeStamp()       # log time stamp in a local file
  brightness = min(100, total * 5)
  setBrightness(brightness)
```

Figure 13: Code sample of background script that handles reading crank data, changing screen brightness, and data logging for the *Crank Box*.

Background Script and Data Logging

Partly shown in Figure 13, the LXDE also loads a custom Python script that samples the hand crank input stream every 2 seconds to check for user action (i.e. if the selected GPIO pin registers a high voltage). If so, the device's screen brightness is maintained at a high level, and the current timestamp is logged to a local text file on the RPi. If not, the device's

[4]Chromium is an open-source browser that provides the basis for popular web browsers like Google Chrome.

[5]https://packages.debian.org/jessie/matchbox-keyboard

screen brightness gradually dims until the user begins cranking again. The logged timestamps indicate when the user attempted to access Twitter during the study.

Constraints and Limitations

Intentional constraints built into the *Crank Box* include the mediation of screen brightness via continuous hand crank input, the low-resolution of the RPi screen[6], and the separation of social media onto a different device than other digital online activities. However, some constraints were induced to simplify the nature of user interaction. For example, the *Crank Box* lacks compatibility with a camera interface connected to users' social media, which prevents users from using the device to take photographs to publish on social media platforms like Instagram (although users who solely consume content on such a platform may still use the *Crank Box* without experiencing this limitation). Additionally, the small onscreen keyboard makes the *Crank Box* especially limiting for users who rely on social media to type extensive long-form content. To operate the *Crank Box*, users must hold it with one hand and use the other hand to operate the crank. Section 5.1 discusses in detail the user evaluations of the *Crank Box* and other interventions described subsequently.

3.2 Cranker

The *Cranker*, shown in Figure 14, is a social media intervention consisting of a desktop browser extension and an auxiliary hand crank device that pair via Bluetooth connection to interface with social media web pages on laptop and desktop browsers. Upon visiting a social media site, the user must pair the browser extension with the hand crank device via Bluetooth, then continuously turn the crank to prevent the browser window from dimming.

Motivation

Similar to the *Crank Box*, the *Cranker* requires a cranking interaction motivated by popular crank-cranked toys, tools, musical instruments, and devices discussed in Section 3.1. However, whereas the *Crank Box* separates a user's social media usage onto a new physical screen interface separate from their other online activities, the *Cranker* introduces a constraint on an existing screen interface that already belongs to the user and serves their other typical digital activities as well.

[6]The 7" RPi touchscreen has a resolution of 800 × 480 pixels, at approximately 133 pixels per inch. This is lower than the resolutions of many popular modern Retina-display mobile devices and laptops, such as the 16-inch MacBook Pro laptop, released in 2019, which has a resolution of 3072 × 1920 pixels, at 226 pixels per inch.

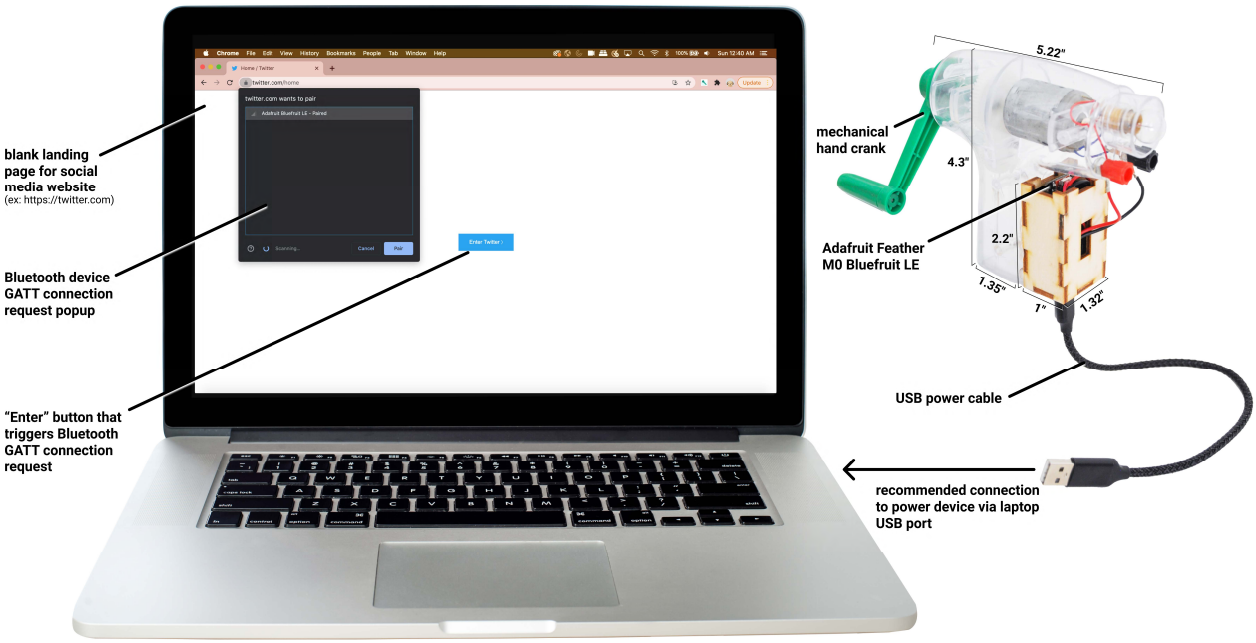


Figure 14: The *Cranker* consists of a Chrome browser extension and a Bluetooth-equipped auxiliary hand crank device that is approximately 5.2" x 4.3" 1.3". When the user visits a social media website for which the browser extension is enabled, the browser extension displays a landing page prompting the user to connect the browser with an auxiliary Bluetooth device, namely the hand crank, which is powered via USB connection. Once paired with the hand crank device, the browser extension brightens the screen to display content when the user cranks the device and dims the screen when the user pauses cranking.

Hardware

As shown in Figure 15, the *Cranker* hardware consists of a manual DC generator with a hand crank that is connected to an Adafruit Feather M0 Bluefruit LE board via a GND pin and an input GPIO pin. The device has a USB cable attachment that must be connected to a power source to turn on the device, either via a USB power adapter attached to a wall outlet or via a USB port on the user's laptop or desktop, which is the recommended configuration.

The Adafruit Feather M0 Bluefruit LE is an Arduino-compatible Bluetooth Low Energy peripheral capable of establishing a Generic Attribute Profile (GATT) connection with a central device. When connected to a central device, the Bluetooth peripheral is programmed to send a message every 200 milliseconds via its UART service, with a signal of either `1` if the user is operating the auxiliary device (e.g. a hand crank, in the case of the *Cranker*) or `0` if not, via its universal asynchronous receiver-transmitter (UART) service[7].

[7] `https://learn.adafruit.com/adafruit-feather-m0-bluefruit-le/uart-service`

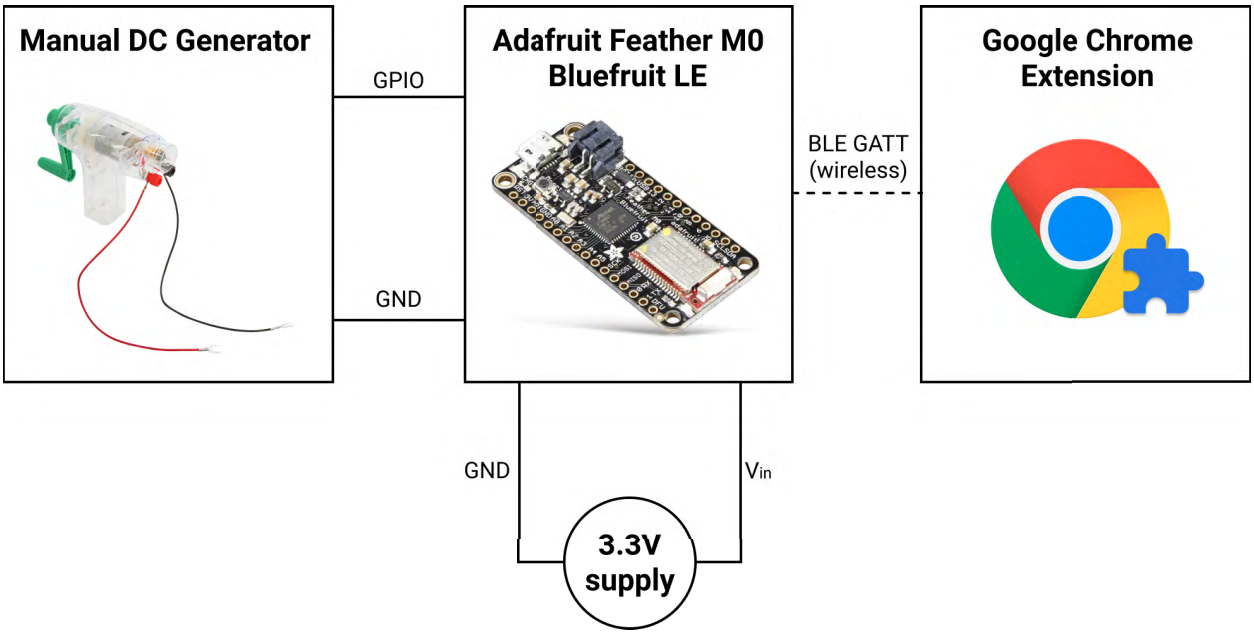


Figure 15: The *Cranker* hardware consists of a manual hand crank connected to a Bluetooth Low Energy microcontroller, which communicates to a connected Google Chrome extension whether the user is sufficiently cranking the *Cranker* device.

Software

Landing Page and Bluetooth Connection

The Cranker operates via a Chrome browser extension distributable as a .zip file to test users, who may install the browser extension by enabling "Developer Mode" on the Chrome extension menu, loading the unpacked .zip file, and enabling the extension. The extension may be configured for any set of websites articulated by a match pattern string[8] or list of match pattern strings listed in the manifest configuration file of the Chrome extension code. For example, the match pattern `https://twitter.com/*` captures all of the user-facing Twitter social media pages on a web browser.

Figure 16 displays the initial screen that a user sees each time they visit the targeted social media website on their Chrome browser. Controlled by a content script[9] in the Chrome extension code, this screen displays an "Enter" button, which, when clicked, prompts the user to establish requisite Bluetooth connection. If the auxiliary crank device is plugged into a power source when user clicks the "Enter" button, the Chrome browser recognizes and lists the Bluetooth identifier of the crank device in a popup on the top left of the browser window. The user may resolve the popup by selecting the Bluetooth identifier of the crank

[8] `https://developer.chrome.com/docs/extensions/mv2/match_patterns/`
[9] `https://developer.chrome.com/docs/extensions/mv3/content_scripts/`

device and selecting the "Pair" option, which establishes a GATT connection between the browser window and the Bluetooth microcontroller in the crank device.

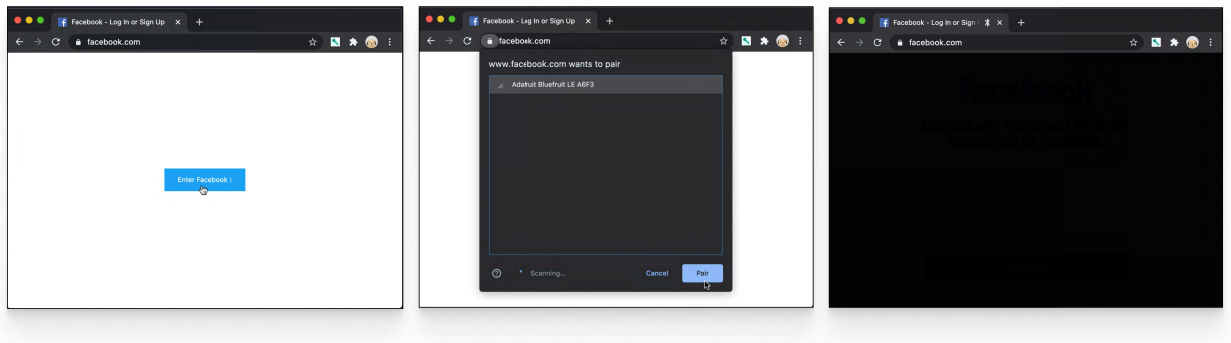


Figure 16: When the *Cranker* Chrome extension is enabled and the user visits the targeted social media site, the user must click on an "Enter" button, select the auxiliary device in a Bluetooth device list, and click "Pair" to connect the auxiliary device with the browser. The user arrives at a screen that appears blank and must begin to crank to make onscreen content visible.

Once a GATT connection is established between the browser window and the crank device, the Chrome extension's content script displays a blank "overlay," a HTML `div` with a black background at full opacity spanning the full screen area, on top of the user's onscreen social media content in the browser window. As the user operates the auxiliary device, the opacity of the overlay is reduced incrementally each time the crank device sends the message `1` to the Chrome browser. When the user halts operation of the auxiliary device, the opacity of the overlay increases incrementally each time the device sends the message `0` to the Chrome browser. Based on informal testing of various increments for opacity variation, the opacity was calibrated to decrease in increments of 3% and increase in increments of 20% based on the corresponding signals. Figure 17 shows various levels of brightness resulting from varied opacity of the black overlay.

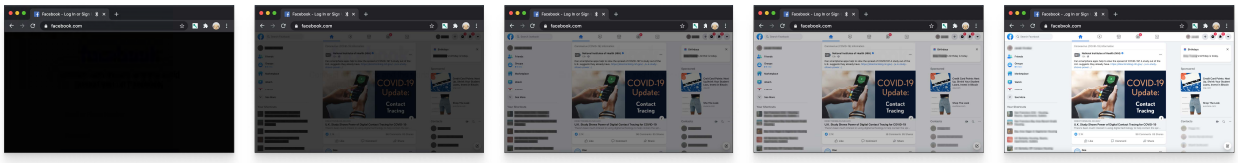


Figure 17: Screenshots of a social media browser window at various brightness levels when the *Cranker* extension is enabled. The overlay opacity from left to right is: 100%, 75%, 50%, 25%, 0%.

Additionally, the design of the *Cranker* browser extension is such that it may interface with any auxiliary device that is capable of sending binary data over a Bluetooth GATT connection. In Section 3.3, I discuss the design of the *Shaker*, another social media intervention that leverages the modular nature of this browser extension by attaching a different auxiliary device.

Background Script and Data Logging

While the Chrome extension content script handles communication with the Bluetooth crank device and opacity adjustments to the overlay, it also communicates with a Chrome extension background script[10] that logs relevant user actions, or events, using the Amplitude Analytics Javascript SDK[11]. In particular, the logged user events include when the user clicks the "Enter" button on the initial landing page, when the user successfully pairs the browser window with the Bluetooth crank device, when the user starts cranking, and when the user stops cranking. When logging the cranking actions, the Chrome extension also records the current opacity of the overlay, to indicate how visible social media content is to the user when they start or stop cranking the device. The Amplitude Analytics user event tracking also reports data on how long each user session is based on tracking the time spent on the social media site in the web browser.

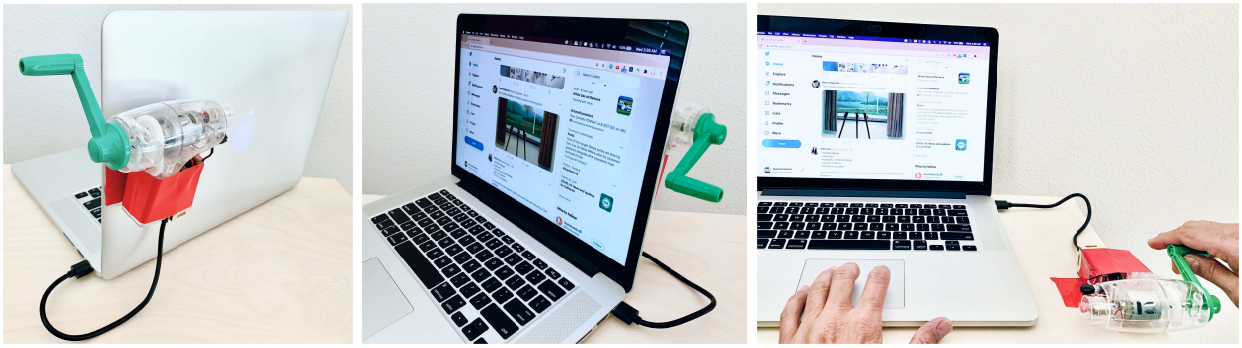


Figure 18: Two configurations for using the *Cranker* device with only one hand, allowing the user to type or scroll with their other hand. (left and middle) The user may tape the crank to the back of their laptop. (right) The user may tap the crank to a flat surface (e.g. edge of a desk) next to their laptop or computer.

Constraints and Limitations

While the mediation of screen brightness via continuous hand crank input is an intentional constraint of the *Cranker*, the operation of the crank introduces an additional challenge. In

[10] `https://developer.chrome.com/docs/extensions/mv2/background_pages/`
[11] `https://developers.amplitude.com/docs/javascript`

particular, the *Cranker* requires two hands to operate the device – one hand to hold the device steady and another hand to turn the crank. This requirement poses a limitation for individuals who wish to type or scroll while simultaneously cranking the device, which is a desirable interaction. To mitigate this limitation, I provided two alternative physical configurations of the crank device, shown in Figure 18, so that users may operate the auxiliary crank with one hand, while the other hand is free to interact with their laptop keyboard, trackpad, or mouse.

3.3 Shaker

The *Shaker*, shown in Figure 20, is a social media intervention consisting of a desktop browser extension and an auxiliary motion tracking device that pair via Bluetooth, similar to the Cranker. Whereas the *Cranker* requires users turn a physical hand crank to gradually unconceal their social media screen, the Shaker requires the user to continuously shake a small wooden box with motion-tracking hardware to similarly control the visibility of their social media content.

Motivation

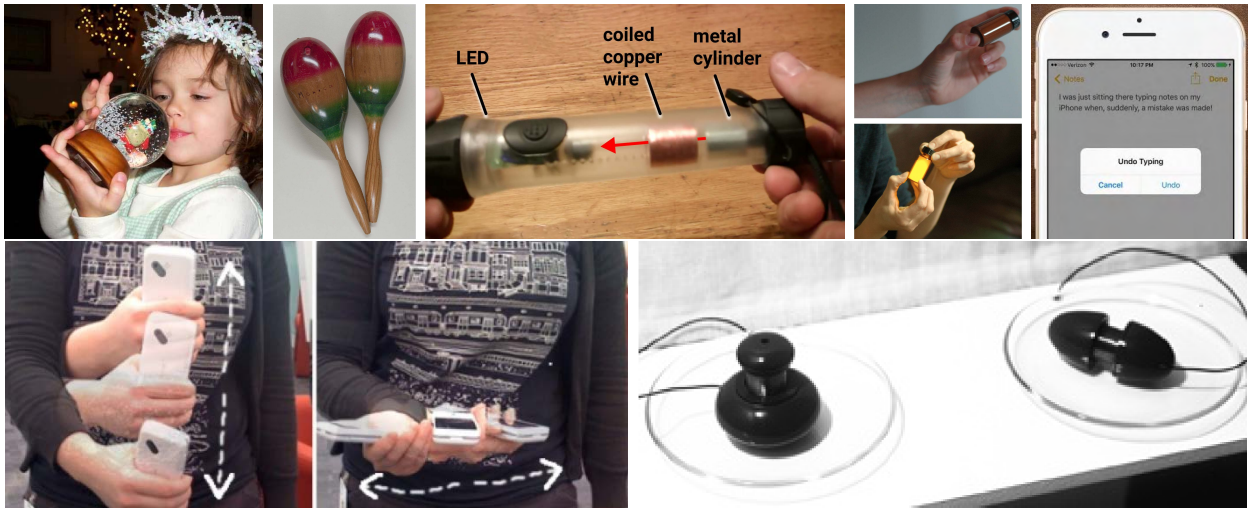


Figure 19: (top row, from left to right) snow globe [71]; rattles (maracas) [43]; Shake-to-power flashlight [128]; Shake-Light Bottle [107]; iPhone Shake to Undo feature [127]. (bottom row, from left to right) Privacy-Shake, for enabling and disabling mobile location-sharing [55]; "Shaker" sender and receiver device for symmetrical communication between friends [124]

Shaking is a common motion used in the design of toys, tools, and instruments to generate power or produce entertaining experiences, as shown in Figure 19. For example, snow globes are a type of toy that requires users to hold and shake it in order to reveal a snowy landscape [119]. Rattles, maracas, and egg shakers are percussion instruments that produce auditory output when a user shakes them [50]. Beyond the domains of entertainment and music, the motion of shaking a device is prevalent in functional tools as well. Shake-to-power flashlights [128] produce light via an internal battery that charges from the repeated movement of a metal cylinder through a coiled copper wire when the user shakes the flashlight.

iOS mobile devices treat shaking as a user input gesture that triggers the "Undo" action [65, 127]. Jedrzejczyk et al. designed the *Privacy-Shake* system in 2010 to explore how different types of mobile shake gestures (horizontal, vertical, away from body, close to body) can be used to change mobile privacy settings for location-sharing [55].

Pierce & Paulos identify shaking as one of several actions that can be used as a form of *human-power microgeneration* in self-powered devices [106]. In 2012, Pierce & Paulos built the *Shake-Light Bottle*, an "energy memento" that collects energy when shaken and activates a light when its cap is removed [106, 107]. Strong & Gaver built a system with a Sender and

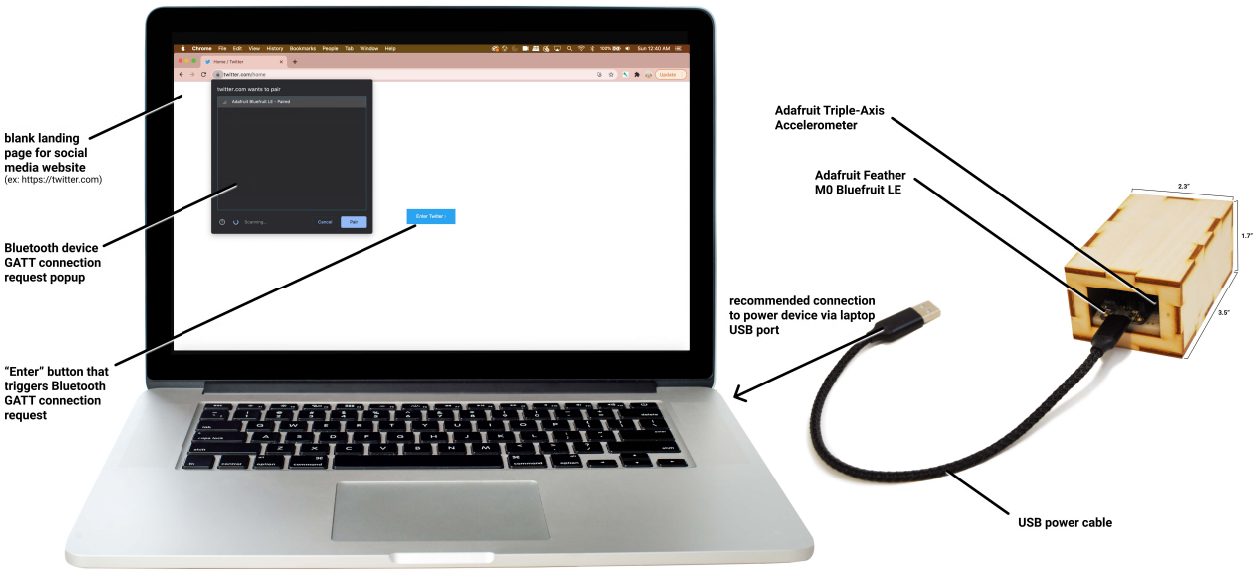


Figure 20: The *Shaker* consists of a Chrome browser extension and a Bluetooth-equipped auxiliary device that is approximately 3.5" x 2.3" 1.7". When the user visits a social media website for which the browser extension is enabled, the browser extension displays a landing page prompting the user to connect the browser with a Bluetooth device, namely the auxiliary Shaker device, which is powered via USB connection. Once paired with the hand crank device, the browser extension brightens the screen to display content when the user is shaking the device and dims the screen when the user pauses shaking.

Receiver device for symmetrical communication between friends; when one user shakes the Sender device, its moving rod induces a current in its coil and prompts a digital message to the Receiver, which activates its own solenoid to shake proportionally [124]. Similarly, the *Shaker* requires a user to shake it in order to simulate the experience of powering their social media experience; as the user shakes the *Shaker* auxiliary device, their social media browser window will gradually and proportionally reveal their social media content. However, unlike discussed examples that store energy generated via shaking a device to power it, the *Shaker* controls screen brightness based on real-time readings of whether the user is sufficiently shaking the device or not.

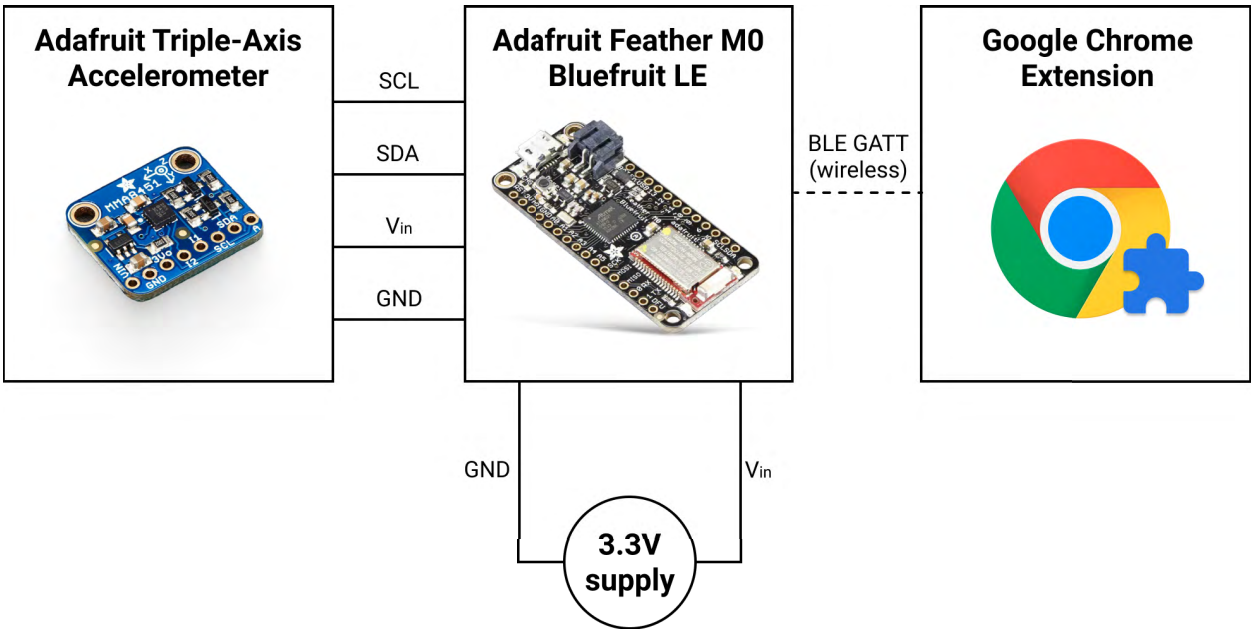


Figure 21: The Shaker hardware consists of a triple-axis accelerometer that provides data about user motion to a Bluetooth Low Energy microcontroller, which communicates to a connected Google Chrome extension whether the user is sufficiently shaking the Shaker device.

Hardware

The hardware for the Shaker includes an Adafruit triple-axis accelerometer connected to an Adafruit Feather M0 Bluefruit LE board as shown in Figure 21. The accelerometer tracks velocity and acceleration Similar to the *Cranker*, the Shaker device has a USB cable attachment that must be connected to a power source to turn the device "on." Once the device has an established Bluetooth connection to a central device, the Bluetooth peripheral sends a message every 200 milliseconds via its UART service indicating the status of sufficient

motion with a signal of `1` or insufficient motion with a signal of `0`. The motion-tracking device sends the signal `1` indicating sufficient motion if its acceleration along each of the three axes (x, y, and z) is greater than 5m/s^2, which is a threshold determined by trial and error during the development phase.

Software

The software component of the Shaker is the same as that of the *Cranker*, described in Section 3.2.

Constraints and Limitations

Shaking the device is an intentional requirement of using the Shaker to access social media content. While the one-handed operation of the device leaves the other hand free for most users to type, scroll, and navigate through their social media website, this is an additional constraint induced by the Shaker.

3.4 Tilter

The *Tilter* is an iOS mobile app that allows users to engage with social media including Facebook, Twitter, Instagram, TikTok, Reddit, YouTube, and LinkedIn with an added constraint: the user must physically tilt their phone at specific angular orientations randomly chosen by the application at fixed time intervals, otherwise the application dims the onscreen display.

Motivation

Mobile phone users and laptop users are familiar with *tilting* their devices to reduce onscreen glare and improve the visibility of content in various lighting conditions. Devices like the iPhone and iPad also offer a feature called *auto-brightness*, which adjust the screen brightness of the device according to "changing light conditions" [3]. In practice, this feature makes onscreen content more visible and easy to view, by making the screen brighter when tilted to face a bright light source and darker when tilted to be in a darker region. Prior work has also explored *tilting* as a user gesture to enter text input in mobile phones [145], to maneuver virtual reality settings [34], and to interact with distant displays [25].

Certain optical illusions also involve *tilting* motions to reveal content that is otherwise hidden. As shown in Figure 22, *Tilt your phone* optical illusions, popular on social media in 2013, are meant to be viewed on a mobile phone held perpendicular to a user's face, with one eye closed, and with the open eye aligned with the phone's charging port at the bottom of the phone [120, 132]. When holding the phone at a typical distance and angle parallel to one's face, the text on such illusions appears like abstract vertical lines and black rectangles,

Figure 22: (left to right) *TiltText*, a system that lets users tilt their mobile phone to indicate characters to type [145]; tilt gestures used to control distant displays [25]; *Tilt your phone* optical illusion reading "YOU'RE DOING GREAT AND I'M GLAD YOU EXIST" [132]

but in reality consists of vertically stretched letters positioned close to each other. Changing the viewing angle of one's phone reveals the written message, because the shifted perspective counteracts the onscreen distortion of the text.

The *Tilter* mobile application harnesses the *tilting* motion as a mobile user gesture to control the visibility of onscreen content. Rather than prompting the user to tilt their phone to a known, predictable configuration where the content is visible, the *Tilter* mobile application requires the user to tilt their phone to various angles and configurations until they discover a randomly generated unknown holding angle that satisfies the condition for content visibility.

Hardware

The *Tilter* mobile application is compatible with iPhones with an operating system of iOS 14.1 or higher [12]. The mobile application is distributable via TestFlight[13], an iOS application for distributing version of iOS applications for beta testing. The *Tilter* application was built on the iOS platform for ease of distribution to users participating in my study (Chapter 4), and similar applications can be built for other operating systems like Android.

Software

The *Tilter* iOS application is built with the UIKit framework[14], WebKit framework[15], and CoreMotion API[16]. In particular, the application consists of a `SFSafariViewController`

[12]The *Tilter* system can be modified to support lower iOS versions as well
[13]`https://apps.apple.com/us/app/testflight/id899247664`
[14]`https://developer.apple.com/documentation/uikit`
[15]`https://developer.apple.com/documentation/webkit`
[16]`https://developer.apple.com/documentation/coremotion`

Figure 23: The *Tilter* iOS mobile application randomly generates a target holding angle that the user must discover and match at various time intervals throughout a session in order to reveal the onscreen display. When the user is far from the target holding angle, the display is dim; when the user tilts the phone closer to the target the display brightens.

element[17] that renders mobile web interfaces for various social media websites using features of the Safari web browser.

Definitions

α value. A property controlling the opacity of a UIKit element (`UINavigationController`)[18] that is a high-level container of onscreen content displayed by the *Tilter* application. The value of α ranges from 0.0 (fully transparent view) to 1.0 (fully opaque view). [19] When the α value is low, the view appears dim and difficult to see, because it is nearly transparent on a black background; when the α value is high, the view appears bright and easier to see, because it is nearly opaque.

Device attitude. The orientation of a user's iPhone device, specified relative to a fixed reference frame. *Device attitude* captures the varying angular orientation of a device along

[17] `https://developer.apple.com/documentation/safariservices/sfsafariviewcontroller`
[18] `https://developer.apple.com/documentation/uikit/uinavigationcontroller`
[19] `https://developer.apple.com/documentation/uikit/uiview/1622417-alpha`

pitch, yaw, and roll axes (Figure 24) but does not capture translation of the device in three-dimensional space.[20]

Target attitude. A set of values for pitch, yaw, and roll that are randomly selected by the Tilter application at the start of a new *period*, defined below. When the user's *device attitude* is close to the *target attitude*, up to a certain *tolerance*, the α *value*, or opacity, of the `UINavigationController` increases, making the content easier to view. The Tilter app samples the user's *device attitude* every 0.25 seconds to update the α *value*, or opacity of the screen.

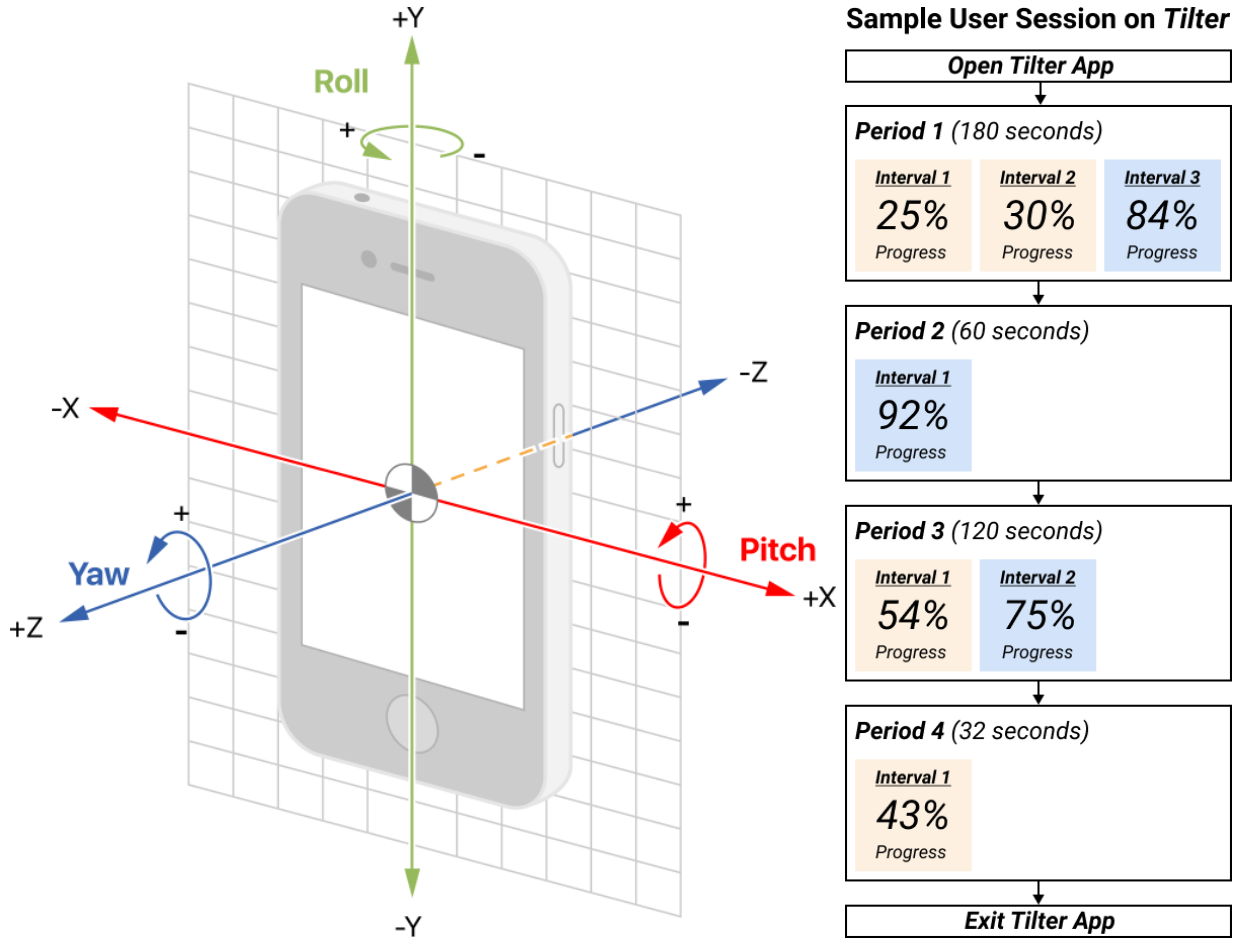


Figure 24: (left) The yaw, pitch, and roll axes for an iOS mobile phone. (right) A sample user session for the *Tilter* mobile app, where the user completes 3 *periods* with varying amounts of *intervals* and exits the app during the fourth *period*.

[20] `https://developer.apple.com/documentation/coremotion/getting_processed_device-motion_data/understanding_reference_frames_and_device_attitude`

Tilting progress. A percentage indicating how close the user has gotten their *device attitude* to the *target attitude* over an *interval*, defined below. Based on informal testing to tune this parameter, sufficient *tilting progress* is achieved when the user tilts their phone 75% of the way to the *target attitude*.

Interval. At every recurring *interval*, the Tilter application checks if the user has made sufficient (75%) *tilting progress* toward the current *target attitude*. At the end of an interval, if the user has made sufficient (75%) *tilting progress* toward the current *target attitude*, the Tilter application generates a new *target attitude* and commences the start of a new *period*, defined below. If the user does not achieve sufficient *tilting progress* toward the *target attitude* at the end of an *interval*, a new interval begins, tracking their *tilting progress* toward the same *target attitude*. Based on informal testing, the *interval* duration for the Tilter application was set to 60 seconds.

Period. The duration for a user to complete a successful *interval* for a single *target attitude*. A *period* is comprised of one or more intervals. Upon completion of a successful *interval*, the Tilter application starts a new *period* with a new *target attitude*. A user may take many *intervals* to complete a *period* for a particularly challenging *target attitude*, while another *target attitude* that is easier to maneuver may take fewer *intervals* to achieve.

Tolerance. When the user is tilting their phone toward the *target attitude*, the *tolerance* is a range of *device attitudes* close to the *target attitude* for which the α value increases by a higher factor (0.45) than the factor (0.3) at which it increases at other points. Based on informal testing, the *tolerance* for the Tilter app included *device attitudes* with 10% of the *interval* completion threshold (75%). The reason for including this *tolerance* was to reward the user with a sharp increase in content visibility when they are close to the *target attitude*.

Session. Comprised of one or more *periods*, a user *session* is the total span of time that a user spends actively using the *Tilter* application, as shown in Figure 24.

Modularity of Code

The modular design of the *Tilter* application provides the software infrastructure for various intervention conditions other than requiring the user to tilt their phone. Shown in Figure 25, the *Condition Session Manager* is a general interface for any *Condition Service*, which defines the criteria for successful user achievement of intervention conditions (i.e. the *Attitude Condition Service*, which senses the "attitude," or angular tilt of users' phone and generates a *target attitude* for the *Tilter* user to meet). Future work may include creating various *Condition Services* that interface directly with the *Condition Session Manager* to enforce intervention conditions requiring different user actions, like shaking their phone, capturing certain input from their camera, or traveling to particular locations.

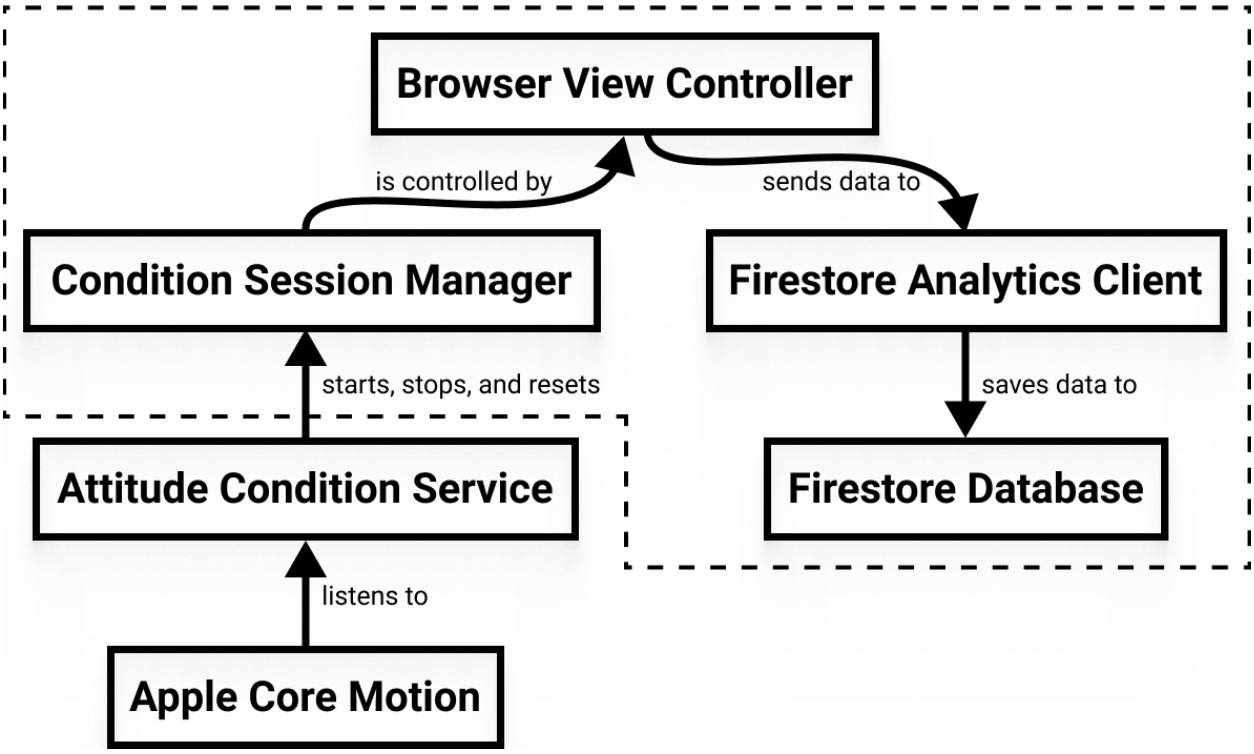


Figure 25: Software system architecture for the *Tilter* iOS mobile application, showcasing the modularity of code that enables various *Condition Services* to communicate with the general *Condition Session Manager* interface.

Constraints and Limitations

The *Tilter* mobile app constrains the user's mobile social media access to occur only when they hold the phone at particular angular orientations that illuminate the screen, whereas holding the phone at other orientations renders a much dimmer screen that obscures the onscreen social media content.

Additionally, for most social media platforms, the mobile web experience is not as smooth and easy to use as their native mobile applications. Because the *Tilter* app relies on an embedded web browser view to render social media content, the web interface for browsing certain social media via the *Tilter* app may be less smooth than the experience on the native mobile application experiences for those social media platforms.

Chapter 4

Methods

In this section, I share my method for evaluating the hypothesis that using social media interventions with embodied constraints will affect user behaviors and values toward social media.

The goal of my study is to assess the effects of engaging with the interventions described in Chapter 3 on participants' social media behaviors and the value they attribute to social media. In addition, I asked participants to evaluate the intervention prototypes and share their feedback on design and usability of the prototypes.

4.1 Study Design

I performed a user study with 12 participants using a mixed methods design. In my study, the PRESENCE OF INTERVENTION (pre-intervention, intervention, and post-intervention conditions) was a within-subjects factor and TYPE OF INTERVENTION (*Crank Box*, *Cranker*, *Shaker*, and *Tilter* conditions) was a between-subjects factor. The intervention was imposed on a single social media platform (the intervention-specific platform) determined individually for each participant, which is an extraneous variable.

I collected data to evaluate the effects of a physical social media intervention on a participant's value toward a social media platform and identify differences in their social media behaviors before, during, and after the intervention. Data sources include:

- transcripts of two 45-minute interviews (pre-intervention interview conducted before Week 1 and post-intervention interview conducted after Week 2) over video call[21],
- daily diary studies for the duration of participation,
- records of mobile and desktop screen time, and

[21] All interviews took place remotely over Zoom, due to social distancing protocols during the COVID-19 pandemic.

- manually tabulated records of participant activity on the social media platform selected for their intervention.

4.1.1 Presence of Intervention

Each participant engaged in a week-long intervention (Week 1) followed immediately by a week-long post-intervention period (Week 2). Additionally, I collected pre-intervention data[22] corresponding to a week within a month of and prior to the start of Week 1.

Pre-Intervention. I conducted a 45-minute pre-intervention interview with each participant before Week 1 to understand how they use social media, the value they attribute to various social media platforms, and their attitude toward their own social media usage. During the pre-intervention interview or in follow-up conversations with participants, I also collected a week of relevant pre-intervention mobile and desktop screen time statistics for social media apps and websites. Depending on the participant's value assessments of various social media platforms and the device(s) they typically use to access them, I selected a single social media platform on which to impose the following week-long intervention, as indicated in Table 3.

Intervention (Week 1). Before Week 1 for each participant, I delivered or shipped any necessary intervention device via postal mail and sent any corresponding software via email, along with setup instructions. During Week 1, I instructed participants to direct all of their social media usage for the selected platform via the intervention, and I recommended logging out of or deleting existing apps and shortcuts to the social media on their other devices. Each participant was asked to complete a daily diary study via a Google Form for the duration of the week-long intervention. I sent each participant daily reminders to complete the diary study at night via text message or email depending on the participant's preference.

Post-Intervention (Week 2). During Week 2, I instructed participants to freely resume their social media usage via their usual means and devices, and remove the intervention from their social media experience. I continued to request daily diary study responses via a Google Form and sent reminders as in Week 1. After Week 2, I conducted a 45-minute post-intervention interview with each participant about their reflections on the intervention and post-intervention experience as well as their evaluation of the intervention prototype.

[22] P1, P2, and P3 were participants in an earlier pilot version of my study with Song et al. [121] that took place over a 3-week window (Week 0, Week 1, and Week 2) instead of a 2-week window (Week 1 and Week 2), where Week 0 was explicitly enumerated as a pre-intervention week and required daily diary study responses. In the revised study design used for participants P4 through P12, I eliminated Week 0 diary studies and collected pre-intervention screen time data during the pre-intervention interview or asynchronously rather than synchronously over the span of a full pre-intervention week. Additionally, I incorporated feedback from P1, P2, and P3 on the diary study prompts and edited them for clarity and brevity before distributing them to participants P4 through P12, who demonstrated overall higher completion rates and quality of responses in daily diary studies than P1, P2, and P3.

Condition	Description	Image	Participants
A	*Crank Box*: a box-shaped device with a screen interface and hand crank attachment that must be continuously turned to reveal onscreen content		• **P1** (Twitter) • **P2** (Twitter) • **P3** (Twitter) • **P6** (Facebook)
B	*Cranker*: a desktop browser extension and an auxiliary hand crank device that pair via Bluetooth to require a user to crank the auxiliary device in order to prevent the browser window from dimming		• **P5** (Facebook) • **P10** (Twitter)
C	*Shaker*: a desktop browser extension and a handheld auxiliary accelerometer device that pair via Bluetooth to require a user to rapidly shake the auxiliary device in order to prevent the browser window from dimming		• **P4** (Reddit) • **P12** (Reddit)
D	*Tilter*: an iOS mobile application that requires users to tilt and hold their phone at specific target angles unknown to the user in order to illuminate their social media screen		• **P7** (Reddit) • **P8** (Instagram) • **P9** (Twitter) • **P11** (Twitter)

Table 2: Description of intervention modalities across four treatment groups, and the participants for each treatment.

4.1.2 Type of Intervention

Table 2 describes the four conditions (A, B, C, and D) for the type of intervention that a participant may be assigned to use during Week 1. The design and implementation of each intervention is described in detail in Chapter 3. Participants were assigned to conditions based on the following considerations:

- If the participant is located within a reasonable range for package delivery or shipment from my team's location, then they are a candidate for Conditions A, B, and C.
- If the participant is an iPhone user, then they are a candidate for Condition D. If the participant is not an iPhone user, then they cannot be assigned to Condition D, since the Tilter is only compatible with iOS mobile devices.

#	Age	Pronouns	Description	Social Media	Condition
P1	22	she/her	PhD student of information technology	Facebook, Instagram, [Twitter]	A
P2	25	she/her	product manager	Facebook, LinkedIn, [Twitter]	A
P3	22	she/her	data scientist	Facebook, Instagram, Reddit, Snapchat, TikTok, [Twitter]	A
P4	27	he/him	product manager	Facebook, Instagram, [Reddit]	C
P5	31	she/her	undergraduate student of engineering	[Facebook], Instagram, Twitter	B
P6	22	she/her	medical assistant	[Facebook], Instagram	A
P7	20	he/him	undergraduate student of engineering	Facebook, Instagram, [Reddit], Snapchat	D
P8	21	she/her	undergraduate student of computer science	Facebook, [Instagram], Snapchat, Twitter	D
P9	18	she/her	undergraduate student of economics and statistics	Facebook, Instagram, Snapchat, TikTok, [Twitter]	D
P10	19	she/her	undergraduate student of data science	Facebook, Instagram, Snapchat, Tiktok, [Twitter]	B
P11	21	she/her	undergraduate student of computer science	Facebook, Instagram, Reddit, Snapchat, TikTok, [Twitter]	D
P12	19	he/him	undergraduate student of public health	Facebook, Instagram, [Reddit], Snapchat, TikTok, Twitter	C

Table 3: Participants' demographic information, social media platforms (where the social media platform selected for the intervention is encircled), and assigned intervention type.

4.2 Participants

I recruited 12 participants, labelled P1 through P12, through a combination of snowball sampling and a voluntary participant screening survey distributed via student mailing lists and Slack groups. P1, P2, and P3 were participants in a pilot version of my study [121] catered to Twitter users, in which they were not offered any compensation for participation. P4 through P12 were participants in a revised version of the study about usage of various social media platforms and included compensation via a $20 Amazon E-Gift Card distributed to each participant upon conclusion of the study.

Table 3 summarizes brief profiles of each participant, including a list of their self-identified top social media platforms.

P1 and P9 describe themselves as avid Twitter users satisfied with her Twitter usage behaviors. P2 and P3 describe themselves average Twitter users compared to their peers and indicated dissatisfaction with multiple aspects of their Twitter experience, including the total time they spend on Twitter. P10 is a daily Twitter user who uses Twitter to keep up with content creators on other platforms and would like to reduce her total social media usage by about 50%. P11 describes spending most of her social media time scrolling through Twitter, and while she doesn't feel "particularly guilty or shameful" about it, she would like to reduce her Twitter usage.

P4 and P12 are regular Reddit users who describe being "disciplined" (P12) and "relatively content" (P4) with their usage of the platform but acknowledge that there are "more productive ways" (P4) to spend time and would like to use Reddit more "constructively" (P12). P7 is an avid Reddit user who describes Reddit as something he "may enjoy in the moment" but that "doesn't have a lasting impact on [his] life" and is "kind of a waste of time."

P5 and P6 describe using Facebook as their main social media platforms to "stay connected" (P5) with friends mostly via Facebook Messenger and scrolling through the Facebook News Feed.

P8 is an active Instagram user who feels the need to decrease her social media usage with, in an ideal world, "at least a 50% reduction, if not more."

4.3 Analysis

I analyzed the quantitative social media usage data by exploring trends in social media usage metrics including total usage time, platform-specific usage time, and counts of platform-specific user actions (e.g. Likes, Tweets, and Retweets on Twitter; Searches, Reactions, Comments, and Posts on Facebook). I identified trends by calculating weekly averages and graphing daily values of social media usage metrics. For example, I computed percentage increases and decreases between in the time users spent on their intervention-specific platforms before, during, and after the intervention period. I report further on the quantitative evaluation results of the user study in Section 5.2.

I prepared qualitative data for analysis by the transcribing the pre-intervention and post-intervention interviews and diary study responses. To identify themes in the data, I used the process of open-coding, in which I inductively annotated interview transcripts and diary studies with an evolving set of codes about users' behaviors, attitudes, and values around social media. After iterating on the set of codes and systematically applying them to all participants' interview transcripts and diary studies, I performed thematic analysis to extract significant patterns of discussed user behavior and values around social media. In addition to comparing instances of certain coded results across participants using different intervention systems (Conditions A, B, C, and D), I also identified results varying across pre-intervention interviews, diary studies, and post-itervention interviews. I report further on the qualitative thematic results in Section 6.

Chapter 5

Evaluation

The user study described in Chapter 4 revealed how users interacted with the intervention systems. In this chapter, I present user evaluations of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* systems as well as the quantitative ways in which these interventions affected users' social media usage. In Section 5.1, I describe how users evaluate the usability of all four intervention systems along the criteria of comfort, portability, operability, and accessibility. In Section 5.2, I describe how using these intervention systems affected users' social media usage metrics, including their time spent on social media and their platform-specific behaviors like liking, posting, and searching for content. The next chapter, Chapter 6, reports the key findings from the user study beyond the user evaluations and quantitative results.

5.1 Intentional Limitations Affected Usability

McCarthy & Wright argue that the "felt life" and the "felt or emotional quality of action and interaction" can help researchers interpret how humans experience and relate to technology [81]. I report on users' "emotional" and "felt" responses to using the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*. In particular, this section presents user evaluations regarding comfort, portability, operability, obtrusiveness, and accessibility.

5.1.1 Comfort: Form factors caused discomfort

Participants in my user study evaluated the *comfort* of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* by identifying form factors that caused *discomfort* and other aspects like device size that seemed agreeable. Jansen & Slob define *comfort* as "the subjective positive perception of the nature and intensity of the load, resulting from using or operating an object" [54] whereas *discomfort* can be understood as "a phenomenon of perception, related to pain, fatigue, and perceived exertion" [13]. User evaluations of comfort are important because though the intervention designs deliberately add mild friction and discomfort to the social media experience, the designs must be comfortable enough to hold.

Participants were satisfied with the size of the *Crank Box* device, with P2 commenting that "it's awesome how compact everything was." However, P1 noted that the "crank gets in the way" of resting the prototype on a table and that "it's hard to get into a good position to crank and scroll at the same time," recommending that the *Crank Box* come with a list of "suggested postures" for cranking. Other *Crank Box* users also found the device uncomfortable to position and use, which they cited as a contributing factor to their decrease in social media usage during the intervention.

Shaker users mentioned design aspects of the device as deterrents for use, citing the "texture of the wood" (P12) and "form factor" (P4) of the device as "weird" (P12), "uncomfortable" to hold (P12), and "an extra barrier" (P4) to using the device.

5.1.2 Portability: Unwieldiness of devices limited mobility and location of use

Users found the *Crank Box*, *Cranker*, and *Shaker* annoying to transport between locations. For this reason, a surprising result of the user evaluation is that these interventions restricted users' mobility. On the other hand, since the *Tilter* intervention system operates solely on users' mobile phones rather than moving their usage onto a separate physical device, users did not find the *Tilter* to have portability issues.

While *Crank Box* participants were told that they were free to use a portable battery pack rather than a wall outlet, all participants reported keeping the device restricted to one or two locations where they had a convenient wall outlet for the duration of the study. Participants were annoyed that keeping the device in certain locations of their home prevented them from freely using Twitter during small "in between moments" (P3) when waiting in line, waiting for someone, or idling between events.

Cranker user P5 exclusively accessed Facebook while having breakfast at her kitchen table, since she stored the *Cranker* device in her kitchen. Additionally, *Shaker* user P12 found it "difficult" to transport his laptop and the *Shaker* device to his bed when he wanted to scroll through Reddit at night, since he was used to using Reddit comfortably from bed on his phone. P4 remarked that having the *Shaker* connected to his personal laptop rather than his work laptop or his mobile phone made him less likely to use Reddit during breaks between meetings during the workday.

Participants using the *Cranker* also remarked on its restrictions around mobility during the intervention week. P10 explained how the *Cranker* was "annoying" because it made her stay "stationary" while on her laptop:

> *P10*: It depends on how I feel – usually I'll spend most of my day at my desk. During meals I'll bring my computer with me – I live in my parents house right now, so I would move downstairs to the dining table if I'm really like not feeling 'inside', I'll go– I'll bring my computer outside. I think that was probably another reason the crank was so annoying for me because I had to stay stationary. Usually I try to move around, as much as I can, like I'll go outside or move around levels of the house.

While the portability limitations of the intervention systems were not an intentional design feature of the interventions, these limitations emerged as a a surprising outcome of user evaluations with potential for future study. The charging requirements and portability limitations of the *Crank Box* support the idea that the physical constraints of a device may play a role in increasing mindfulness of Twitter usage. P2 observed that as a result of keeping the *Crank Box* in a single location, she became "a lot more planned about how [she] went about it rather than serendipitous." P3 similarly reported that she "had to be very intentional" about her Twitter usage.

5.1.3 Operability: obfuscation of onscreen content frustrated users

A critical feature of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* is their obfuscation of onscreen content when the user halts providing physical input. This intentionally limiting feature elicited significant frustration from users. Users also commented on the obtrusiveness of the physical input – cranking, shaking, and tilting – required to operate the intervention devices.

Crank Box participants expressed that cranking on its own was "not too difficult" (P3) and felt the "right amount" of obtrusive, confirming that the calibration of cranking effort posed enough friction to mildly hinder users but not render the device unusable.

> *P2*: [there was] just the right amount of time to get value out of it before having to go back to crank. So it wasn't like I can just crank it, sit there, and like read the feed, or like it wasn't too short where I couldn't even see like a single letter.

Surprisingly, one *Crank Box* user, P6, even described interacting with the *Crank Box* as "fun" on multiple occasions in spite of the intentional limitations:

> *P6*: It became a fun thing to crank.

On the other hand, *Cranker* users expectedly expressed frustration around the amount of effort it took to make screen content visible:

> *P10*: It took way too much effort and time to keep the screen lighted up and see anything.

> *P5*: It was very difficult to keep the screen on. So I basically wanted to get in and out as fast as possible. More because I was annoyed with the crank than because I felt like I was aware of my time spent on FB.

> *P10*: It just reverted back to the black screen screen too quickly for me to like really digest or read anything. So I kind of just gave up on it and I didn't use Twitter for like the remainder of like most of the days.

> *P10*: Not only did I spend less time on it because there was so much set up, but I interacted less with sites as well because I didn't have enough time to read it or like [Tweets], etc before [the screen] faded.

Calibrating the screen brightness using the physical controls was challenging for users of each intervention type. For Tilter users, it was "a really frustrating ordeal" (P8) to find the angle at which the screen lights up to display content.

> *P8*: It was just really frustrating – like, I would spend probably literally like 5 minutes just just doing that *[demonstrates motions]* with my hands, trying to get it to look clear, and even when I did get it to stay in like a position for a little bit after, maybe 30 seconds or a minute, it would go dark. I don't know if that was part of the app's functionality or just how I was holding it, but then it would be like a really frustrating ordeal to, to get the screen to light up again and I would end up just closing the app and trying to reopen it, and then just closing it and leaving it.

On the whole, *Crank Box* and *Cranker* users found cranking to be disruptive and "extremely annoying to deal with" (P10). Most notably, the noise that the crank made was "really annoying" (P1) and disruptive of social activities. P1 had to apologize to her roommate for potential "noise coming from my room every 5 minutes," and P2 reported not being able to hold a conversation with a friend who was in the same room. Such effects contributed to the rise of new social dynamics and methods of communication (Section 6.2.1).

All *Crank Box*, *Cranker*, and *Shaker* participants additionally found it very challenging to operate the intervention devices, which require one or two hands, while simultaneously typing or scrolling through social media.

> *P5*: I cannot type and operate the crank at the same time. Also, I am pretty weak, so I get tired really quickly.

> *P6*: Whenever I crank, I'm not able to type so I had to time the typing and the cranking.

As a speculation during his diary study, P4 mentioned that if there were instead a hands-free foot pedal that would control his screen, he imagined that it would not have decreased his time on Reddit as much as the *Shaker* did.

For both *Cranker* users, the suggested setup of taping the crank to the laptop or to a flat surface near the laptop were difficult to implement. P5 explained her concerns about strong duct tape damaging her hardware or countertop, and less adhesive painter's tape not being able to sufficiently secure the crank.

> *P5*: I had to have [my dad] tape it, and then that was kind of a long process, because my mom didn't want it to be taped to the counter... blue tape, which comes off like right away [was] the only thing she was like okay with because otherwise she was like "oh it's gonna mess up the counter". And so, yeah after that that I just had my dad hold and crank it.

Similarly, P10 was not able to secure the device with regular tape, and ended up operating the crank with two hands, though she mentioned feeling "it was too annoying to use" altogether at times.

> *P10*: I was trying to like pin down the device with regular Scotch tape, which didn't really work out– like, it would move everywhere, and it was hard to crank.

5.1.4 Accessibility: Physical requirements may disadvantage some users

Though the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* are designed to require mild amounts of continuous physical input, these requirements may disadvantage some users more than others. The physical interactions posed by embodied constraints may by inaccessible to some users.

P5 described how being weak prevented her from being able to effectively operate the crank, due to the physical participation it requires, and suggested that the current design is not suitable for some disabled people.

> *P5*: I was physically tired, like my arm was getting very tired cranking it...I was getting, like, winded, like actually short of breath and I was like 'oh my god!' but I'm also pretty anemic, and like, I'm not very strong, so those two factors combined, are probably what contribute to it. Yeah, if you had like, a crank for like disabled people...

The other intervention prototypes also share similar constraints that makes them excessively limiting and inaccessible for people with mobility limitations, among other disabilities. For example, when using the *Tilter* application on a mobile phone, tilting the phone rapidly may cause onscreen lighting changes similar to a strobing effect, which may cause nauseating and disorienting symptoms for prone users.

5.1.5 Discussion

Users found aspects of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* to be uncomfortable, obtrusive, and difficult to operate. Simultaneously, some users found the amount of required physical interaction to be well-calibrated and agreeable for accessing limited amounts of social media experiences. In contrast to the easy portability of traditional devices for social media access (e.g. phones and laptops), the unwieldiness of these intervention systems imposed limitations on users' mobility and the locations where they interacted with their intervention-specific social media platform. Additionally, user evaluations raised concerns about accessibility of the social media interventions.

User concerns around discomfort and annoyance signal a successful application of "perceived drawbacks" [133], "added discomfort" [54], and "functional oppositions" [105], which are intentional design qualities that introduce limitations in physical interactive design to create novel, unusual interactions. In the subsequent chapter, Chapter 6, I discuss the behavioral and reflective impacts of using the four critical intervention system.

5.2 Interventions Reduced Social Media Usage

I found that using presented intervention systems to access a single social media platform caused participants to change their social media usage behavior in various ways, during and

after the intervention. Notably, all participants for all four intervention systems expressed a drop in their social media usage for the intervention-specific platform, reported via time spent on that platform and the volume of specific user actions they performed on that platform.

In the following sections, I describe results varying across the TYPE OF INTERVENTION factor (*Crank Box*, *Cranker*, *Shaker*, and *Tilter*). Within each section I address how participants' social media behavior changed with respect to the PRESENCE OF INTERVENTION factor (pre-intervention, intervention, and post-intervention)[23].

5.2.1 Crank Box: Rebounded vs. Reduced Social Media Usage

During the intervention week, all *Crank Box* users experienced a dip in usage time for the social media platform that was controlled by the intervention. In the post-intervention week, some users maintained relatively low usage times for their intervention-specific platform while others gradually rebounded increased usage times.

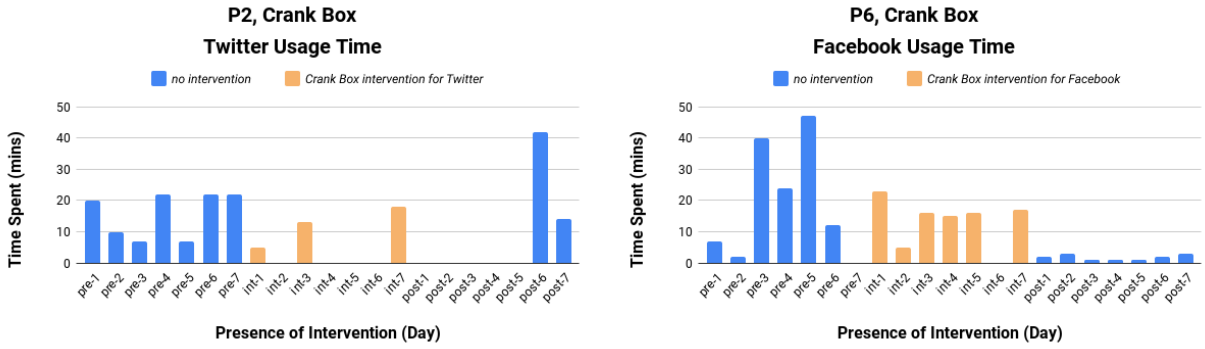


Figure 26: Intervention-specific social media usage time for *Crank Box* participants P2 and P6.

For example, P3 only went on Twitter twice during Week 2, spending a total of 2.5 minutes. Even P1, one of the most active Twitter participants who estimated her normal Twitter usage as 2-3 hours/day, only spent an average of 9 min/day on Twitter during the intervention week, even forgoing Twitter entirely on 2 out of those days. As shown in Figure 26, P2's Twitter usage dropped from an average of about 16 minutes per day on her mobile phone pre-intervention to only 5 minutes per day during the intervention, with zero Twitter usage on more than half of the days during the intervention week. After the intervention, P2 stayed off of Twitter for 5 days before "rebounding" by spending 42 minutes on Twitter the next day.

[23]Graphs in this section indicate the PRESENCE OF INTERVENTION on the horizontal axis, with labels pre-1 through pre-7 corresponding to the pre-intervention week, labels int-1 through int-7 corresponding to the intervention week, and post-1 through post-7 corresponding to the post-intervention week.

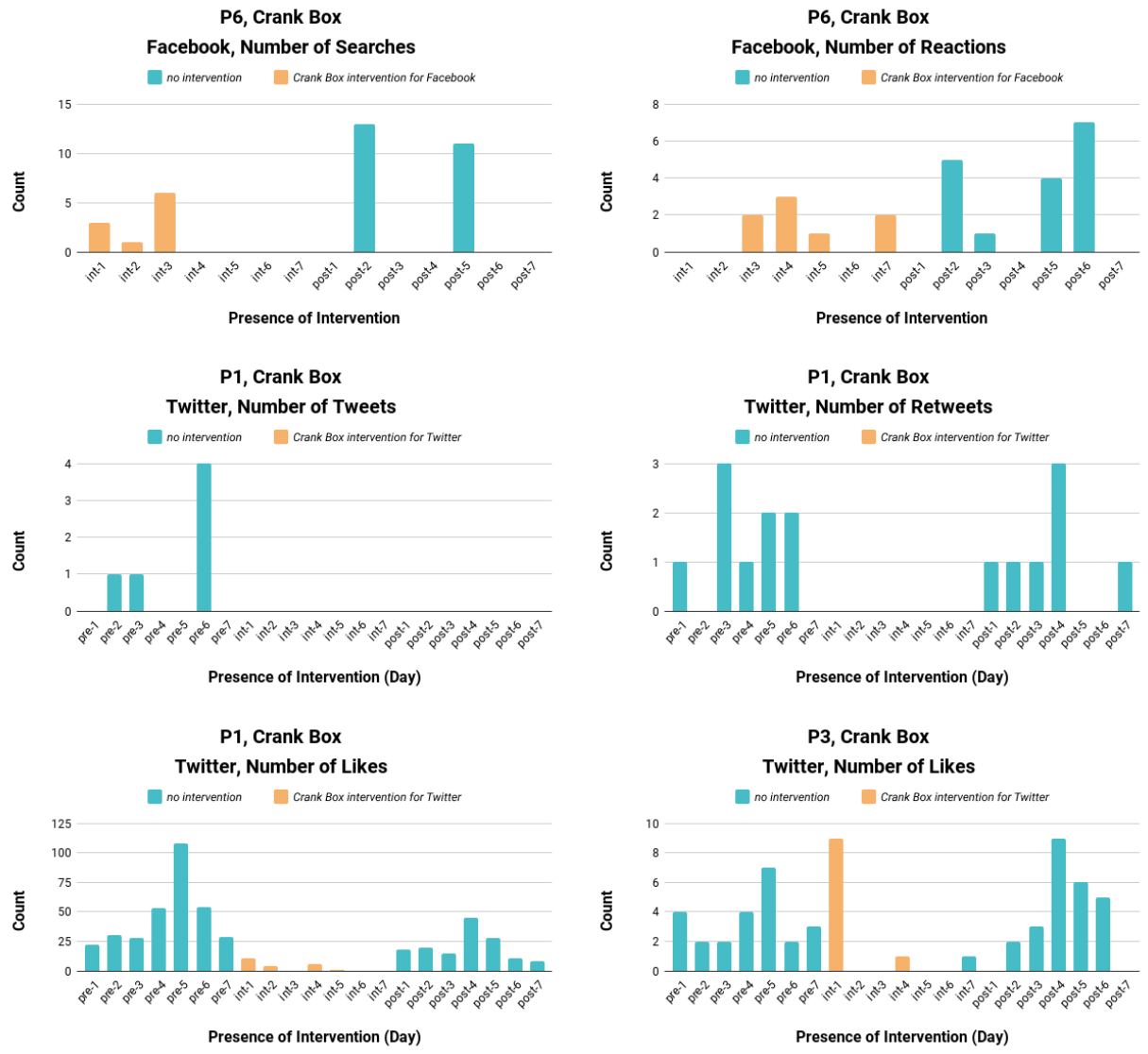


Figure 27: Number of Facebook Searches and Reactions for P6; Number of Tweets and Retweets for *Crank Box* participant P1; and Number of Twitter Likes for *Crank Box* participants P1 and P3.

On the other hand, P6 experienced a drop in her daily Facebook usage, from an average of 22 minutes per day pre-intervention to about 13 minutes per day during the intervention. In the week after the intervention, P6's average Facebook mobile app usage time dropped even further, to less than 2 minutes per day. Instead, P6 began accessing Facebook on her laptop in the post-intervention week (not captured in Figure 26). As shown in the first row of graphs in Figure 27, switching from the *Crank Box* to her laptop corresponded with

P6 performing more Facebook searches, for a total of 24 searches in the post-intervention week compared to 10 searches performed during the intervention. Based on P6's qualitative interviews, this shift is indicative of an easier typing experience on her laptop compared to the *Crank Box* as well as a more intentional approach to using Facebook, to deliberately seek content that is of interest.

Along with the unanimous drop in time spent on the intervention-specific social media platform, users also experienced a decrease in the quantity of certain actions on with the social media platforms. In particular, P1, P2, and P3 all decreased the number of Likes, Tweets, and Retweets performed during the intervention.

As pictured in Figure 27, P1 published no Tweets during and after the intervention, compared to the 6 Tweets she published in the pre-intervention week. P1 also performed no Retweets during the intervention, compared to her 9 Retweets in the pre-intervention week. However, P1 "rebounded" in her Retweeting behavior after the intervention concluded, with a total of 7 Retweets in the post-intervention week.

During the intervention, P1 also reduced her amount of Twitter Likes by over 93%, from an average of over 46 daily Likes pre-intervention to a mere average of about 3 daily Likes during the intervention. In the post-intervention week, P1 performed an average of 20 daily Likes, which is an approximate 57% decrease in Twitter Likes from pre-intervention to post-intervention. In contrast, P3 experienced a 50% decrease in her amount of Twitter Likes from the pre-intervention week to the intervention week but "rebounded" her Twitter Likes in the post-intervention week, with a slight (2%) increase in Likes compared to the pre-intervention week.

5.2.2 Cranker: Effects of Hesitancy and Motivation on Rebounded Usage

Participants using the *Cranker* system experienced notable decreases in their usage of their intervention-specific social media platform during the intervention. Both participants using the *Cranker* system demonstrated a "rebound" effect of their social media usage time for the intervention-specific platform in the post-intervention week.

P5 describes herself as a minimal social media user, evidenced by her low average of 6 minutes of daily Facebook usage in the pre-intervention week. During the intervention week, P5 accessed Facebook via the *Cranker* system for an average of only 1.75 minutes per day. However, P5 also mentioned temporarily breaking the intervention to access Facebook without the *Cranker* on the the third day of the intervention week (int-3). I discuss this intervention effect further in Section 6.2.3. During the post-intervention week, P5's Facebook usage increased to a daily average of almost 8 minutes per day, amounting to an approximate 30% increase compared to the pre-intervention week, as shown in Figure 28. While there was an increase in P5's Facebook usage in the post-intervention week, P5 reported feeling that she had in fact decreased her Facebook usage after the intervention, which suggests that using the *Cranker* system may have potential to distort users' impressions of their social

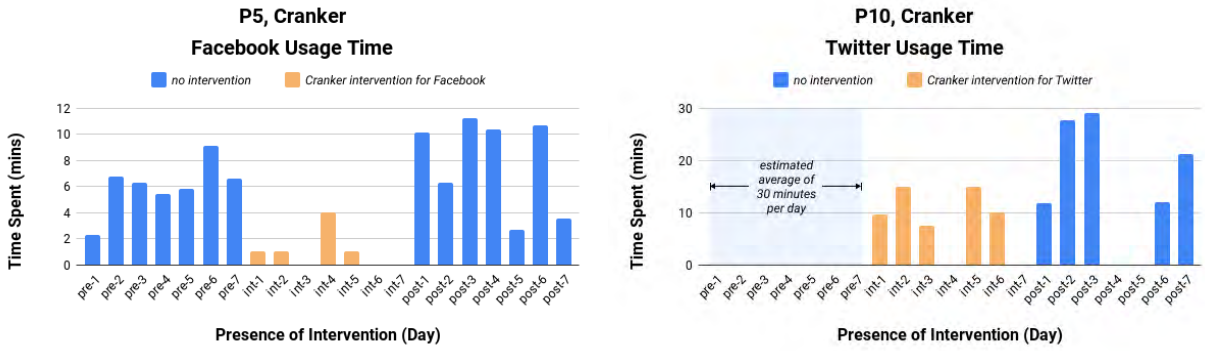


Figure 28: Social media usage time for *Cranker* participants P5 and P10.

media usage.

> *P5*: I feel like since I stopped the crank thing I haven't really been on Facebook that much anyway. Like, it kind of did change my behavior on Facebook, I guess, because now I just kind of look at notifications in the morning and then get on with my day instead of spending more time.

Additionally, Figure 29 shows how P5 searched for more Facebook content during the post-intervention week than the pre-intervention week, and performed no Facebook searches during the intervention. P5's surge in Facebook searches post-intervention after a period of no Facebook searches may stem from her desire to catch up on missed content from friends and Facebook groups. However, P5 also described searching for free things on Facebook groups like *Free and For Sale* as a "guilty pleasure" and explained that she would feel self-conscious if someone saw her performing Facebook searches for people she hasn't met for years on Facebook. As such, P5's Facebook searching behavior may be related to a pattern of collaborative social media operation that emerged in her usage of the *Cranker* (Section 6.2.2). Specifically, P5 reflected on how using the *Cranker* system to access Facebook made her "more aware of what other people are thinking" regarding her Facebook usage, because she enlisted a partner to operate the *Cranker* and be present throughout her Facebook use during the intervention week. In particular, P5 expressed hesitancy around performing Facebook searches about friends and content on Facebook while others were watching her because she supposed that "they would probably be like 'What is she doing? Like, is she just stalking people?'." P5's experience with the *Cranker* demonstrates its potential to reduce specific actions on certain platforms, without explicitly encoding dissuasion against any specific actions.

Using the *Cranker* to access Twitter caused P10 to reduce her Twitter usage, as shown in Figure 28. In the pre-intervention interview, P10 estimated her typical daily Twitter usage to take an average of 30 minutes per day. However, during the intervention, her Twitter usage dropped to an average of about 11 minutes per day. In the post-intervention week,

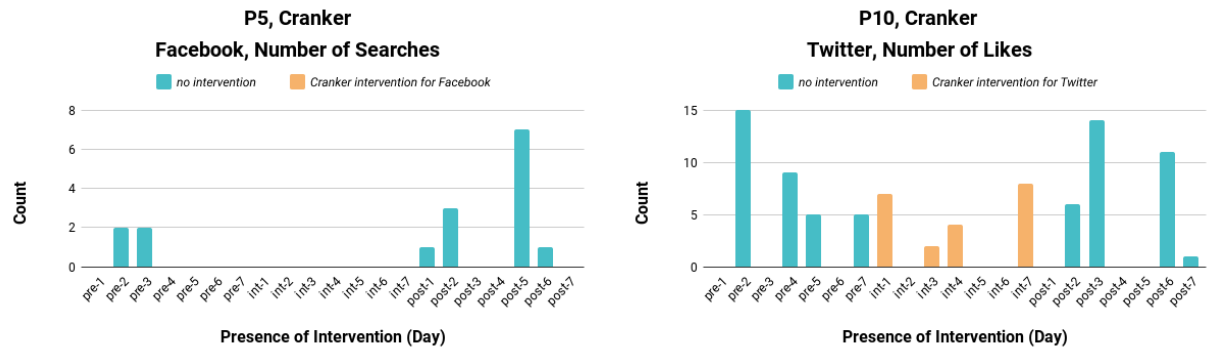


Figure 29: Number of Facebook Searches for P5; Number of Twitter Likes for P10

P10's Twitter usage increased by approximately 28% compared to the intervention week. However, compared to the estimated time she spent on Twitter pre-intervention, P10's post-intervention time spent on Twitter decreased by roughly 50%, at an average of less than 15 minutes per day. P10 attributed this decrease in overall time spent on Twitter to a lack of "motivation" to use social media in general after reflecting on the value it adds to her life (Section 6.3.1).

5.2.3 Shaker: Intervention Effects on Other Social Media Usage

Like users of the *Crank Box* and *Cranker* systems, both participants who used the *Shaker* experienced a significant decrease in the amount of time they spent on Reddit – the intervention-specific platform for both *Cranker* users.

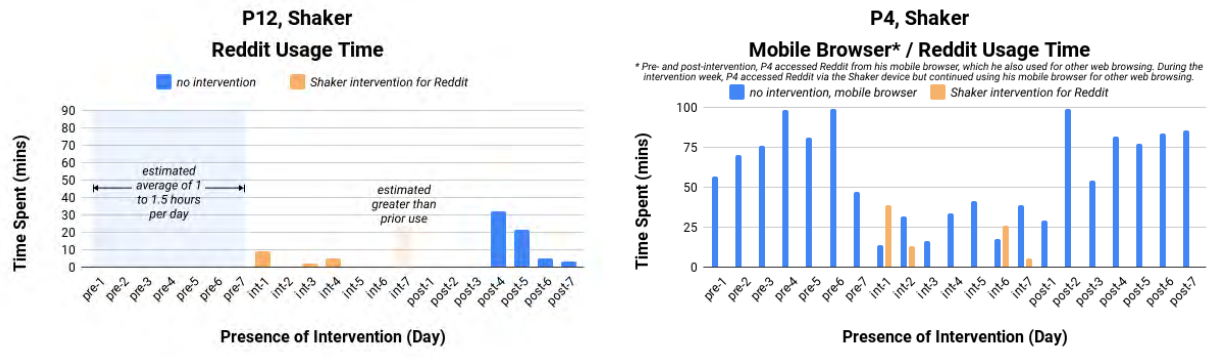


Figure 30: Reddit usage time for *Shaker* participants P4* and P12.

* P4 typically accesses Reddit via his mobile browser, which he also used for other web browsing throughout the study.

While P12 estimated spending between 1 and 1.5 hours on Reddit each day pre-intervention,

his Reddit usage was in the range of 0 to 10 minutes for most days of the intervention. During the intervention, P12 reported limiting his Reddit usage to consuming important informational content that only Reddit could provide, rather than spending time to explore other non-essential content (Section 6.1.2). In the post-intervention week, P12 spent three days without accessing Reddit at all on his mobile phone, and spent a total of one hour in the next four days combined.

P12: For my second week, I actually didn't use social media as much as I thought I would.

P4 expressed a similar experience to P12, where his Reddit usage dropped significantly from an estimated daily pre-intervention usage lasting 1 to 2 hours. During the intervention week, P4 spent an average of less than 12 minutes per day, with no Reddit usage on three out of the seven intervention days as shown in Figure 30.

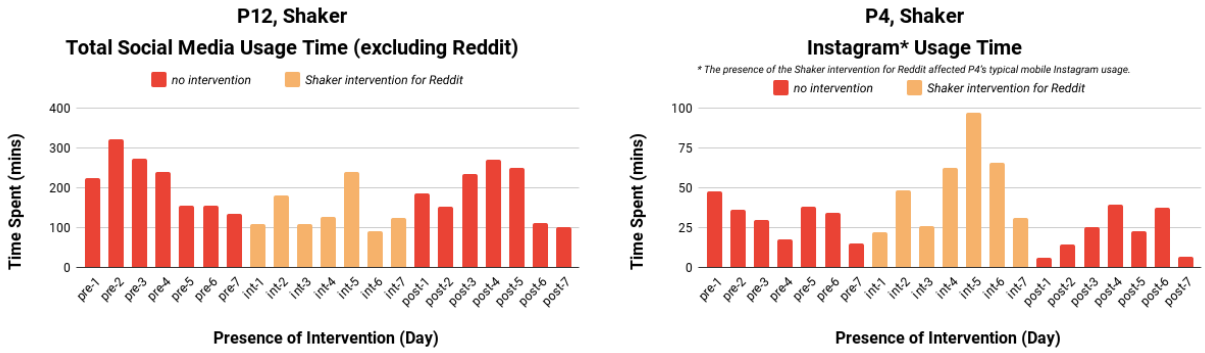


Figure 31: Total social media usage time (excluding Reddit) for P12 and Instagram* usage time for *Shaker* participant P4

* The presence of the *Shaker* intervention for Reddit affected P4's typical mobile Instagram usage.

While using the *Shaker* intervention to access Reddit decreased P4's time spent on Reddit, his time spent on his mobile Instagram app increased, as shown in Figure 31. P4 spent an average of approximately 31 minutes per day on Instagram pre-intervention, but during the intervention his time spent on Instagram increased to an average of over 50 minutes per day. In the post-intervention week, P4 deliberately reduced his Instagram usage to an average of less than 22 minutes per day. I address the theme of redistribution of social media time in more detail in Section 6.1.5.

On the other hand, P12's overall time spent on social media slightly decreased, just like his time spent on Reddit, during the week of the intervention. P12 experienced an approximate 35% decrease in his time spent on social media other than Reddit, from an average of over 3.6 hours daily on social media pre-intervention to an average of about 2.3 hours daily on social media during the intervention. In the week after the intervention, P12's time spent on social media other than Reddit increased to approximately 3.1 hours daily.

P12 described his experience as "pretty productive," reflecting that "it felt kind of good not to be on social media all the time" during the week of the intervention.

5.2.4 Tilter: Overcoming Learning Curves and Extreme Usage Reduction

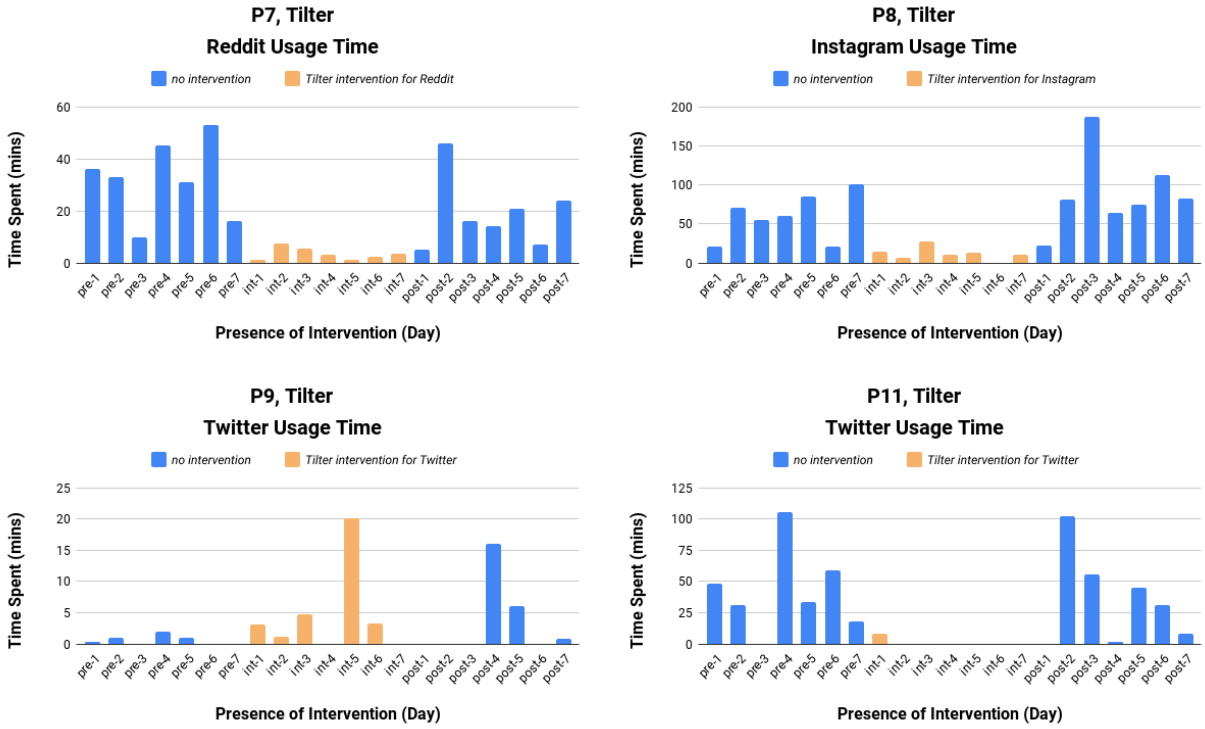


Figure 32: Intervention-specific social media usage time for *Tilter* participants P7, P8, P9, and P11

Participants who used the *Tilter* mobile application during the intervention week experienced the most extreme drops in intervention-specific platform usage time out of the four TYPE OF INTERVENTION conditions. As shown in Figure 32, P7's Reddit usage dropped by 90% and P8's Instagram usage dropped by 80% from the pre-intervention week to the intervention week. Both P7 and P8 show a "rebound" behavior in the post-intervention week, with P7's daily average Reddit usage increasing from less than 3.5 minutes during the intervention to 19 minutes (a 450% increase) and P8's daily average Instagram usage increasing from less than 12 minutes during the intervention to almost 90 minutes (a 660% increase). However, one notable difference between P7 and P8's behavior is that P7's Reddit usage decreased overall by over 40% from pre-intervention to post-intervention, whereas P8's Instagram usage increased by more than 50% from pre-intervention to post-intervention.

P9 is the only participant out of all participants across all four TYPE OF INTERVENTION conditions who demonstrated an increase in her intervention-specific platform usage time during the intervention week. As shown in Figure 32, P9's Twitter usage during the pre-intervention week was minimal, with an average of less than 1 minute per day. P9 described her Twitter usage as a function for getting concise information about political news and current events. During the first three days of the intervention week (int-1, int-2, int-3), P9's Twitter usage increased to an average of 3 minutes per day, where the extra reported usage time was likely spent figuring out how to use the application. In the first few days of the intervention, P9 mentioned being "frustrated with the angle" and how the *Tilter* made content "harder to view on a normal level." After four days of feeling extremely frustrated with the *Tilter* mobile application, P9 commented on Day int-5 that she felt "better" using it because she "figured out the screen thing" and became more accustomed to the tilting motions required to operate the intervention. On Day int-5, P9 spent over 20 minutes on Twitter compared to the average 1 minute per day that she spent on Twitter pre-intervention. P9 spent more time on Twitter during the post-intervention week, at an average of over 3 minutes per day compared to the less than 1 minute per day pre-intervention. P9 encountered a learning curve to operating the *Tilter* and successfully overcame the learning curve to access Twitter during the intervention.

On the other hand, P11 was unsuccessful in surmounting the learning curve to operating the *Tilter* during the intervention. Like other participants who used the *Tilter*, P11 felt frustrated when trying to use the *Tilter* application. However, unlike other participants, the extreme frustration of trying to access Twitter through the *Tilter* drove P11 off of Twitter for almost the entire intervention week. In particular, P11 typically spent an average of over 42 minutes per day on Twitter pre-intervention but only accessed Twitter for about 8 minutes and 20 seconds on the first day of the intervention, int-1. In her diary study, P11 mentioned being "pretty intrigued by the app" and "curious on how to work it and figure out how to use it" at first. However, she expressed growing frustrations with the *Tilter* app after trying to use it:

> *P11*: It felt hard to access Twitter and use it. I tried to read one tweet and DM it to a friend and it took a lot of effort to figure out how to do that. It made me want to go use a different app so I could use the normal app.

> *P11*: Definitely was starting to get really irritated trying to use the app today. Couldn't figure out how to get the tweets to be bright enough to actually be able to read it or use the app at all. Got really irritated and just used Instagram for most of the day.

Eventually, during the intervention week, P11 felt completely "locked out" of the Twitter experience due to the *Tilter* intervention. P11 described feeling "irritated" and "tired", and she mentioned that she "honestly kind of lost hope" that she would "be able to use twitter" so she "didn't even try." Instead, like the the *Shaker* participant P4, P11 resorted to using other social media applications instead of Twitter.

P11: I was super annoyed and couldn't use Twitter the way I wanted to at all. I ended up just using other apps instead.

In particular, P11's Instagram usage increased from a total of 6 hours and 52 minutes pre-intervention to 11 hours and 59 minutes during the intervention – an almost 75% increase. Her Instagram usage continued to rise, amounting to a total of 15 hours and 22 minutes post-intervention whereas post-intervention Twitter usage decreased by over 17% from pre-intervention to post-intervention. P9 experienced a similar redistribution of social media usage time (Section 6.1.5), where her TikTok usage went up more than 80%, from a total of 5 hours and 14 minutes pre-intervention to a total of 9 hours and 26 minutes during the intervention. However, P9's TikTok usage decreased to a total of 7 hours and 37 minutes during the post-intervention week.

5.2.5 Discussion

Using the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* caused users to provide additional physical labor to access their social media, which in general reduced all aspects of social media usage, from the time spent on social media to specific user actions on social media platforms (i.e. Tweeting, Liking, Retweeting on Twitter and Searching, Posting, Commenting, and Liking on Facebook). The *Tilter* caused more drastic disruptions and decreases in social media usage during the intervention week compared to the other designs. Out of all participants, users of the *Cranker*, P5 and P10, and two *Crank Box* users, P1 and P6, were the most consistent in continuing to access their intervention-specific social media platform throughout the intervention, albeit for significantly reduced amounts of time. Other participants, like *Tilter* user P10 and *Crank Box* user P2 and both *Shaker* users P12 and P4, showed significant disruptions in their social media access, including entire days of forgoing access to their intervention-specific platform during the intervention week. Participants like *Crank Box* user P2, *Shaker* user P4, and *Tilter* users P9 and P11 demonstrated increased in other social media usage time outside of their intervention-specific platform during the intervention week. In summary, all four proposed interventions have the potential to disrupt social media users' regular patterns of use not only for social media platforms explicitly rerouted through the intervention systems but also for other social media that they may access habitually throughout the intervention.

Chapter 6

Findings

In this chapter, I present thematic findings from my user study[24] with the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*. I identify three sets of themes that emerged from qualitative user interviews and diary studies about how the four intervention systems affected users' values and behaviors toward social media.

Firstly, I present a thematic category (Section 6.1) on how using interventions with embodied constraints transformed user patterns around social media access. The second thematic category (Section 6.2) includes themes about novel social dynamics that emerged through users' interactions with the physical social media interventions. Lastly, the third thematic category (Section 6.3) presents themes about how users developed new levels of awareness and insights about their relationships with social media.

6.1 Transformed Uses of Social Media

Through interacting with the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*, users experienced changes in their usage patterns of social media. Specifically, users changed type of content they valued (Section 6.1.1), how they spent their time on social media (Section 6.1.2), why they started and ended social media sessions (Section 6.1.3), when they used social media (Section 6.1.4), and what they did outside of using social media (Section 6.1.5) during and after the intervention.

6.1.1 Shift in Focus on Preferred Content

Using the *Crank Box* and *Cranker* interventions motivated users to identify and selectively focus on high-value content. While users tended to consume a variety of content before the

[24]The TYPE OF INTERVENTION varies across 12 participants, and each participant's method of social media access varied with the PRESENCE OF INTERVENTION factor – a pre-intervention week with their regular method of social media access, an intervention week using their assigned intervention method, and a post-intervention week with their regular method of social media access. Further details about the experimental design, participants, and analysis are in Section 4.

intervention, they interacted with fewer and specific types of content during the intervention.

All *Crank Box* users found providing consistent physical input to be tiring, which forced a time constraint on their social media usage. In response, they made trade-offs to deliberately consume content that added more value than other content and aligned better with their goals for using Twitter:

> *P2*: I just focused so much more on [the celebrity fandom] when I was using the device, because I was like, at the end of the day, I only have a few minutes — I'd rather just know the good news related to my fandom and the upcoming music releases and everything, [...] instead of looking at politicians.

In some cases, the value-based trade-offs that users made during Week 1, about specific accounts and content, persisted to Week 2.

> *P2*: I only focused on [...] maybe the top 10 accounts that add value to my life. And now I don't even care about some of [the other] people [...]. I'm like, I could not see their Tweets for a year and it probably wouldn't make a difference to my life in the grand scheme of things.

> *P10*: I was at first in the beginning, looking at multiple creators Tweets and replies and then I was like, 'This is really useless! This is almost stupid!' And then I was looking at like the trends and those were pretty disappointing or not as interesting as I previously perceived them to be. Yeah so I ended up by the end of the week, if I ever went on Twitter, it was like just to look at like a specific thing that happened or look at Tweets and replies and see if there is anything I missed with...literally just one creator and then pretty much getting out of there within less than five minutes.

Using the *Cranker* caused P10 to reflect on the culture and community of certain creators she followed, one of whom was "a really major reason" for why she initially joined Twitter but whom she became critical toward and "less interested in" during and after the intervention.

Although P1 and P3 did not explicitly state that they felt that the intervention had lasting changes on how they used Twitter, differences in their pre- and post-interviews revealed that they emerged in Week 3 with a clearer definition of the Twitter content they found valuable. During the pre-interview, P3 indicated that she felt that Twitter was more "news-oriented," and she appreciated having access to "experts or prominent people." However, during the post-interview, she said that she did not in fact feel more behind on the news during Week 1, but she did repeatedly indicate that she "missed Twitter" for her friends' posts.

> *P3*: I feel like my friends are good at curating content that I want to see...more than like getting any getting any like piece of news I'm just curious to see what like they are reading and what they're liking or retweeting or sharing.

Before the intervention, users had general ideas about their topics of interest when browsing social media content. Engaging with physically restrictive social media systems during the intervention caused users to identify and focus on the content that they truly valued most. During the intervention, users avoided or missed out on content that would typically

be interesting to them but felt non-essential during the intervention. This interruption to their routine caused users to shift their attention toward content that is more important and interesting to them.

6.1.2 Physical Interventions Prevented Exploration

The physical interventions added "barriers" (P6) to various aspects of the social media experience; in particular, many participants emphasized feeling blocked from exploring social media content for leisure. Though some of the *Crank Box*, *Cranker*, and *Shaker* users reflected positively on how the intervention prevented what would have been a "waste of time" (P10), most Tilt Mobile App users felt it was a "really frustrating ordeal" (P8) to try to access social media for content exploration.

> *P8*: So, normally I go on Instagram to kind of kill time and just scroll through things, and I was doing the same thing – going on the prototype killing time – but instead of getting new content or information, it was just this dark screen and me struggling with it.

P4 reported that the exploration of content outside of his usual interests was the element of his Reddit usage that decreased the most due to the *Shaker*.

> *P4*: I guess the way [the *Shaker*] affected me was not so much how much time I spent on the subreddit I cared about, but more so, how much I explored outside of the ones I cared about.

P4 was sometimes able to overcome the "barrier" of the intervention to access content that was essential, but when it came to scrolling or exploring other content, he asked himself "do I have enough energy to actually push through this barrier to get that?" In fact, P4 turned to Instagram during Week 1 to satisfy his desire to be exposed to new content and even found himself briefly using the Instagram Explore page, which he described as a platform "where there's just content that's thrown at you." In the week after the intervention, P4 shared feeling more "in control of how long" he spent on social media and did not feel the need to "restrict" himself to the basic Reddit content and instead found himself doing more "exploring."

In her reflection after Week 2, P5 shared feeling "more relaxed," being "better able to focus on the content" on Facebook, and "feeling more free to explore if I want, or to get off if I want, and just knowing I have those options."

> *P5*: I do feel like I think I have the option now I guess, of like scrolling through my news feed, whereas before I felt like very constricted like I had to like, get on and off.

The freedom to access content without the intervention made participants like P5 feel more enabled to consume social media content that was more exploratory rather than essential. On the other hand, the *Crank Box* seemed to have the opposite effect on P2's Twitter experience, where she ended up inadvertently exploring content more when using the intervention that she typically did on the Twitter mobile app.

P2: I focused more on the feed rather than searching up specific people's Tweets, which I typically do a lot more on the mobile app, because I know what I want to see and the feed sometimes doesn't, but since it was so hard to type on the device I avoided doing that and just hoped that good things would show up in the feed so I could just click on them instead of having to type people's handles.

While the majority of participants felt deprived of content exploration during the intervention, adding a physical cost to using social media may have potential to control the level of exposure that users have to new, exploratory content tangential to their main interests.

6.1.3 Intentional Rather than Boredom-Driven Sessions

All intervention systems caused users to be more intentional about starting and ending their social media sessions, rather than choosing to access social media out of boredom.

Participants motivated their typical social media use with a variety of reasons – to stay informed about politics and news (P2, P3, P4, P9, P12), to keep up with fandoms (P2, P10), to be entertained by funny content and memes (P1, P3, P4, P12), to learn about new topics (P7, P12), to keep up with friends and acquaintances (P1, P3, P5, P6, P8) and to share content (P1, P8). In spite of these specific functions of social media, most participants (P1, P2, P4, P5, P6, P7, P8, P11, P12) described typically visiting social media when they were "bored" of their other activities, like working or attending classes. P2 described the mechanics of what "pulls' her into social media:

P2: I think [for] big news events [...] I definitely just want to be on Twitter getting the latest – it's a quality experience and helps you stay informed, so those would be the things that definitely pull me back in. [Or in] a moment of weakness you know like when you're tired – it's kind of like when there's candy in front of you, or like candy somewhere in the house, and you have a moment of weakness and you're like alright I'm just gonna go eat it, because maybe you didn't have anything else to do, or you just fell for it. So, it could be something as simple as that where I'm like feeling bored. And I just open the app, and then like, I'm trapped.

Participants also cited feelings of boredom from content on their social media apps as a reason for ending their social media sessions, among other reasons like ending because of an interruption, because they have another upcoming event, or because they feel they have been on social media for too long.

P3: Either I get bored of the content that I'm looking at or have something else to do.

P7's pre-intervention reasons for ending social media sessions included a technique for using the temperature of his mobile phone device as an indicator for how long he had been on social media.

P7: Either I realize I need to get a lot of work done, so I feel like I force myself to stop it, or my phone gets very hot – it gets hot, so then I just stop. When it gets hot, I know I've used it too long so then I stop using it.

P7 described a much different approach to ending social media sessions during the intervention when he was using the *Tilter* application:

> *P7*: During classes, or at night ...if I wanted to check on something on Reddit, I might open up the app and then I try and search for whatever and look for it, but then soon [the screen] would kind of go off. If it was something important, then I would continue trying to tilt it to check for something, otherwise I'd just, like, not use it [...] Normally I use it even if I don't need it, just like entertainment. Um, but during the week of the study I only used it if I needed to check something.

Instead of ending sessions because he had other work to do or because his phone was heating up, P7 started using Reddit more intentionally and made decisions to end the session based on how "important" his use case was. P7 described that the element of tilting made the Reddit experience less entertaining, and therefore a less appropriate use of his time when he felt bored.

Similarly, P12's pre-intervention reasons for ending sessions included boredom and intentional time-bounding ("when I get bored of it mostly, like when stuff in my feed isn't super interesting, or sometimes I'll actually set a timer for myself or my phone" (P12)). During P12's intervention using the *Shaker* system, he changed his session-ending behavior to exit Reddit promptly after he got the specific information for which he intentionally visited Reddit. Even in the post-intervention week, P12's reasons for ending his social media sessions differed from his typical ones; P12 mentioned ending a session after manually checking the time, because even though he was browsing interesting content, he decided that sleep would bring him more "value" and "happiness."

> *P12*: I was like okay it's like 1 o'clock, like I should honestly probably go to bed. And so there was a part of me before then, which would have been like 'No, just like keep going! It's only 1 o'clock what are you talking about? Like it's early!' But then I think I was just like, 'You know what? This really isn't worth it. It's not going to get me anything so I just went to bed. Its value was worthless,' so I think I sort of approached it as like 'How much value is this thing going to give me, right? Is another 30 minutes going to give me a lot of value in terms of happiness, or whatever, or is it better to like just sleep earlier?' So I did that, yeah, I slept.

The *Crank Box*, *Cranker*, *Shaker*, and *Tilter* interventions caused users to confront their boredom in other ways besides using social media (Section 6.1.5). Instead, participants resorted to social media for more intentional purposes than simply to escape from boredom. Participants tended to exit social media when they achieved their intentional goals, rather than ending social media sessions only when they had other tasks or when they felt bored of social media.

6.1.4 Temporal Change in Social Media Use

The intervention made it more difficult for users to access social media at certain times of day when they would typically access it before the intervention. Alternatively, many users established new temporal patterns for accessing social media.

Whereas before the intervention P4 would typically browse Reddit several times on his mobile phone in between daily meetings, the intervention prevented him from accessing Reddit on his phone throughout the day, since the *Shaker* device made Reddit accessible only through his personal laptop rather than his phone or his work laptop. Instead, P4 waited until the evening (between 7pm and 9pm) to access Reddit via the *Shaker* on his laptop or desktop.

For P12, accessing Reddit at night when he was in bed became more challenging, since he was used to the easy portability of his phone but found it a burden to transport his laptop and the *Shaker* device to his location at night.

> *P12*: It was more difficult using a night because I had to sort of drag my laptop and the device to my bed, and then shake it in my bed.

Prior to the intervention, P8 bookended her day with social media usage because she believed that using Instagram or Snapchat "helps" her to wake up "but not necessarily get out of bed" in the mornings and gets her "relaxed and ready for bed." At the same time, she claimed that this behavior keeps her awake and in bed for a longer time both at the start and end of the day, which she feels is "really bad."

> *P8*: I guess, using Instagram has definitely made me get out of bed later, and go to sleep later. ...it helps me to wake up, but I'll stay in bed for like an hour more than I would otherwise. And it also helps me fall asleep, but I also will take longer to decide to go to sleep than I would otherwise.

During the intervention, P8 rarely checked Instagram in the mornings, because she "kind of knew that it wasn't really functional." Instead, she accessed Instagram through the intervention in the afternoons when she had more time to interact with the *Tilter* mobile application, which required continuous physical motion to find the target angles required by the application. P8 also mentioned how her typical Instagram usage was previously distributed across several frequent 5-minute chunks throughout the day, but using the *Tilter* has potential to reduce the number of individual social media sessions a user has throughout the day.

6.1.5 Redistribution of Social Media Time

The increased threshold of physical effort to access a specific social media platform often deterred users from accessing that platform during Week 1, and several participants found other ways to spend time they would typically spend on the specific social media platform affected by the intervention.

> *P12*: It was really annoying honestly, having to continuously shake the [Shaker] device, and it really pushed me to try and find other things to do (either more work, socializing with friends over Zoom, other ideas).

P12 ended up "listening to a lot more music" to keep himself "occupied," and P8 started cooking, drawing, and texting people "a lot" to de-stress because she did not have the "accessible escape" of the Instagram app. Both P4 and P12 reported also browsing and reading articles from other news sources more frequently instead of spending time on Reddit during the intervention.

> *P4*: I felt better about going to New York Times and Wall Street Journal in filling up that same gap that I would have... filled with Reddit.

Similarly, in her diary study responses from Week 1, P6 mentioned reading more as an alternative to checking social media when she had time to spare.

> *P6*: [The intervention] has created more barriers that let me pause and think. For example, I got to finish reading a chapter in [redacted], a book that I [had] put on pause since December 2020.

For P6, devoting her time to reading had a positive effect on her mental health and wellness throughout the intervention week, as it reminded to "pursue a balance and to be more aware."

> *P6*: I felt more at ease now than before, because I started to focus on enjoying my book and less on what is online.

> *P6*: I remember feeling well since I set into a pattern of checking occasionally and not too much since I was reading a [book] and ... shopping.

On the other hand, some participants redistributed their time to other social media platforms.

> *P5*: I feel like some in some ways I just compensated and like spent more time on Slack...

For P2, diverting her Twitter usage to YouTube introduced her to new content that she was previously unaware of.

> *P2*: I think [YouTube] just took the chance to suck me into a whole new wormhole where I was spending a lot more time because I started watching all of these new vloggers– ...these people that I literally didn't know before the past few weeks, and now I know all about their lives. I actually watched new content on YouTube, alongside my staple of looking at cooking and recipes.

For P11, using the *Tilter* was a deterrent from using Twitter at all for most of the intervention. Within her first two days of using the app, P11 shared that she resorted to using her Instagram app, which had a far more pleasant interface:

> *P11*: Definitely was starting to get really irritated trying to use the app today. Couldn't figure out how to get the tweets to be bright enough to actually be able to read it or use the app at all. Got really irritated and just used Instagram for most of the day.

P4 described using Instagram to "replace the void" that Reddit had left on his phone for the first few days of Week 1, as a sort of "muscle reflex."

> *P4*: You know when you have a gap, something else fills it. So I found myself, the first few days, on Instagram more than I wanted to be on Instagram.

However, after a few days of his increased Instagram usage, P4 remarked that spending time on Instagram felt more like "an involuntary drone state as opposed to an active conscious decision." He started "mindlessly browsing" through the Instagram Explore page, which he described as "a very obvious behavioral change" since the Instagram Explore page is a feature he rarely used in the past. Upon making this realization, P4 made a "conscious decision" to lower his Instagram usage for the rest of the Week 1, which made him feel less "fidgety" and "a bit more calm."

Kovacs et al. studied how *productivity interventions* may have various outcomes in the following categories: *isolated effects* (an intervention may have no effect on a user's other goals), *redistribution* (an intervention may cause a user to spend more time on other "unproductive" goals), or *reduction* (an intervention may reduce a user's time spent on other "unproductive" goals) [64]. I found that the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* interventions caused *redistribution* effects and reduction effects for users. Additionally, my four intervention designs allow users to determine what behaviors they determine to be productive or valuable, rather than prescribing encouraged and discouraged user actions within the interface. As such, the findings of this thesis may be considered as contributions within the broad space of *productivity interventions*, though my designs do not define "productivity" for the user in the way that many *productivity interventions* do.

6.2 Novel Social Dynamics and Collaboration

The presence of the physical interventions led to new social dynamics around users' social media usage and off-platform communications. Due to the added friction of operating the intervention systems, users generated side channels for social communication outside of social media (Section 6.2.1). Users also created original methods to collaboratively operate social media, revealing an opportunity to explore collocated social experiences involving digital social media (Section 6.2.2). The new social dynamics also gave rise to tensions between privacy and publicity of social media use, as well as a range of reasons users might choose to "cheat" on the interventions (Section 6.2.3).

6.2.1 Side Channels and Off-Platform Communication

The social media interventions affected users' content sharing behavior. Users and their social connections adapted to the constraints of the physical intervention by finding side-channels like alternative messaging platforms to share interesting content rather than direct messaging within the affected platform.

P2: [My sister] actually started texting me Tweets on iMessage or WhatsApp, but only the really particularly good ones or funny ones that she wanted me to see.

P1: My boyfriend sent me a screenshot of a meme that he also DM'ed me on Twitter, because he knew it could be hard for me to see it, so he just texted it to me.

The presented interventions enabled new social dynamics that I attribute to the physicality of the user experience. For example, the form factor of the *Crank Box* and the "annoying" sound of the crank are obtrusive and attention-grabbing. P1 reported the crank become the subject of FaceTime conversations and jokes with her roommate and among her friend circles, and P3 noted that during a video call with a friend, the friend saw the *Crank Box* on P3's desk and was intrigued to know more. P8 also had her housemate briefly try to find the target angle on her mobile application and "complained" to her about "how difficult it was," to share her frustration with someone else.

While the presence of the intervention caused new social dynamics between some participants and their network of friends, it also continued to affect participant behavior in social settings after the intervention. For example, P6 noticed being more present in the moment when with others.

P6: If I'm with people, I'll be off my phone.

The presented social media interventions also affected the social dynamics of users' existing off-platform communication patterns. For example, P1 mentioned being clueless and feeling out of the loop during a FaceTime call with her friends when they referenced content that they had shared in a Twitter direct message group.

P1: I feel like our group Twitter DM is just another way to bond.... on that FaceTime call, people were referring stuff that they like had sent throughout the day, so I was like, 'Oh, I haven't seen it guys!', and then we were talking about like a post that somebody else had made and I'm like, 'Ugh I missed one day of being online because of this crank and I'm like behind on everything now.'

For P8, conversations with her housemate about interesting Instagram content from her friends similarly left her feeling like she "was missing out on major things" that her friends were making.

The inconvenience of connecting with friends through social media using the proposed physical interventions caused some participants to opt for off-platform communication with close friends. In the pre-interview, P6 mentioned that with her three close friends, the conversation shifted from typed out messages to phone calls and video calls, which have always been P6's preferred format of social connection, since she can "see the person's face, and the body language."

During the intervention, P6 even started doing daily study sessions over video call with one of her close friends, based on an idea that came up in one of the video calls that week. At the same time, her communication with weaker ties or acquaintances in different time

zones dwindled during the intervention week, due to the difficulty of typing on the *Crank Box* device.

> *P6*: ...he's in Thailand, so it's hard to do the video call when there's a different timezone. So I kind of just stuck to messaging, just to check in and to see how he's doing. [...] I can't type very long messages on the keyboard without making it look very odd. So I just put like happy stickers. I think it was pretty short and brief. [...] It felt shorter than usual because usually I'd be like, "Oh, how was application season? How's your family?", but then it was like, "How are you? *sticker sticker*."

In this way, interventions increased participants' reliance on off-platform communication for close friends, but demonstrated some limited evidence toward dwindling or less substantial conversations with acquaintances, or weaker ties. In some cases, off-platform communication with friends about social media content also created feelings of missing out.

6.2.2 Collaborative Social Media Operation

Users of the *Crank Box* and *Cranker* emphasized the challenge of operating the crank while simultaneously scrolling or typing. To interact more effectively with their social media, some participants created a pattern of social, collaborative, co-located content consumption.

P2 transformed using Twitter into a shared experience using the *Crank Box* by splitting the work of cranking and scrolling across two individuals. She described her experience in a diary study from the middle of Week 1:

> *P2*: Today I got to see a friend, and I had the idea of having them crank the device for me as I scrolled on Twitter! I know this is a bit of a hack, but it got me excited about using the device and it was actually a great way for both of us to browse together and be physically involved in the activity.

P5 similarly enlisted a family member within the first day of her intervention week to operate the *Cranker* device for her.

> *P5*: Almost right away, like when I was on Facebook, I realized I had to just keep cranking it, and I couldn't do anything else basically, so it was like a waste of time–like I couldn't check my Facebook anyway, and I ... physically like couldn't do both and so, I was just like, I'm either like not going to use Facebook for the whole like week, or I'm just gonna get someone to do it for me. I just felt like, ... I guess self-conscious... It made me more aware of what other people are thinking about my Facebook usage.

For P5, her choice of collaborator affected her social media experience. In particular, she chose her dad to crank the device for her, partially because it "happened to be convenient" due to her location but also because his lack of interest in her Facebook activity made her feel more comfortable using Facebook in front of him.

> *P5*: [My dad] didn't really pay attention to what I was doing, I guess. Like if I thought it was someone like really interested in what I was doing on Facebook I probably wouldn't ask that person. But since my dad didn't really... care about whatever I was doing on a computer, anyway, like I just felt okay.

Even so, when collaborating with her dad to use Facebook, P5 felt "rushed" to not "waste" his time and felt "self-conscious" because certain aspects of her social media usage "feel more private." In a diary study from Week 2 when she no longer had to engage her dad to use Facebook, P5 reflected:

> *P5*: I felt less self-conscious about reading other people's timelines and looking at their pics than if I had someone next to me cranking the device.

On the other hand, P5 speculated that it would be an enjoyable "social experience" to have her sister crank the device instead of her dad, and that she may even prefer using Facebook together with her sister over using it alone.

> *P5*: I just feel like, then we could like use Facebook together, you know, she would be interested in the same posts, and the same content, and then like, she also probably wouldn't like care if I'm like writing a PM (private message), or like, if I'm like scrolling on a website to buy free stuff because she like, that's like our inside joke between us too. Anyway, so like, yeah, I would feel like it would be like more, it would be like a social experience on a social media site.

> *P5*: ...sometimes I show other people that are in the room or around me like, 'oh look at this,' 'watch this video, it's funny,' and my sister and I know the same people too, so if I find something interesting, she probably, like, will at least read it [even] if she doesn't think it's interesting. So yeah, I just think it'd be like actually kind of more fun to be on Facebook with her at the same time, than like just by myself.

When the social media interventions were too difficult to operate on their own, participants resorted to collaborating with others around them. Though born out of necessity in the case of P5, the collaborative mode of social media operation could also become an enjoyable form of socialization. The emergence of social media as a collaborative experience raises copious opportunities for future study. For example, researchers may investigate building collocated social aspects to virtual social media interactions, treating social media use as a collaborative sport, and gamifying social media into multi-player interactions.

6.2.3 Tensions between Private & Public, and Reasons to Cheat

Several participants (P1, P2, P5, P10, and P11) emphasized tensions between the 'public' and 'private' aspects of social media usage. In some cases, private tasks or public commitments became reasons for users to "cheat" during the intervention.

On one hand, social media provides tools to connect with other individuals and networks of information; on the other hand, users expressed wanting to keep the details of their social media actions and usage private from others around them and others in their digital networks. P11 described her use of Twitter as more of an observer rather than someone who produces or interacts with content, because curating a public profile felt like "too much work for something that I'm doing to avoid other work" to her. P2 mentioned mitigating the effects of social media publicity by having one public-facing Twitter account and another

more private Twitter account for her close friends, which is an effective setup that makes her more comfortable in sharing specific types of content with the audiences for both Twitter accounts.

The tension between public and private social media usage is more challenging to mitigate in collocated collaborative social media settings, like the one that P5 created during her intervention week of using the *Cranker*. P5's pattern of collaborative social media usage caused her to feel that her social media usage inevitably became more public due to the intervention. P5 described one instance during the intervention week where she opted to use Facebook without the *Cranker* intervention, because she did not want the added gaze of a partner cranking the auxiliary *Cranker* device.

> *P5*: I actually unplugged the device today in order to respond to my friend. It was more personal and I didn't want to have my housemate there cranking the device while I was reading and writing.

P5 elaborated on her motivation for wanting to temporarily break the intervention to concentrate on a serious response to a friend.

> *P5*: It was a friend who posted something about being depressed, and I just felt like I wanted to actually be able to think,very more deeply than like, if someone's hovering...If someone's hovering over you, you're like kind of distracted the whole time and you're not being true...I just felt like I could just kind of say something more insightful, more true to what I felt if I was able to actuallyconcentrate and be introspective, instead of just being distracted.

For P5, using the *Cranker* while trying to respond to a friend about a serious topic would offer more of a "distraction" rather than a productive friction. Instead, the presence of the *Cranker* intervention helped P5 realize what she values about direct messaging on Facebook for serious conversations: the ability to "concentrate" and "be introspective."

Similarly, P6 also opted to use Facebook on her personal device rather than the *Crank Box* twice during the intervention week in order to do essential work like coordinating official public events and searching for housing on Facebook. The obligation to use social media for essential tasks that affect others was a reason to "cheat" for P6 because she wanted to be able to type and view content reliably.

For conventional social media interventions, such transgressions from the intervention are considered "cheating," and intervention interfaces typically respond with the goal of making users feel guilty or punishing them for opposing the intervention. However, the design of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* interventions considers such "cheating" to be a part of the intervention. When the user makes a conscious decision to use a device other than the intervention system, they make a trade-off to break the rules of the intervention in order to pursue another goal related to social media. In such a case, the user effectively identifies certain social media goals that are important enough to them to break the rules of the intervention. Such realizations support the hypothesis that using the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* interventions may help users identify what they value about

social media – not only when users engage with the intervention systems but also when they decide to not use the intervention systems.

6.3 New Awareness and Relationships with Social Media Use

By interacting with the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*, users gained clarity on their relationships with social media. In particular, users became more aware of the roles that social media plays in their lives (Section 6.3.1) and reflected on the varying levels of temptation that they experience with social media (Section 6.3.2). Users also encountered tipping points that made them reason about why they use social media (Section 6.3.3). Uses also expressed a love-hate relationship with the intervention systems, similar to how users express dichotomous beliefs about enjoying but also disliking their typical social media use (Section 6.3.4).

6.3.1 Increased Awareness about the Roles of Social Media

The physical intervention made users more aware of the role their target social media plays in their lives. Accessing their target social media exclusively through devices with embodied constraints forced users to actively reflect on their goals in real-time. Users' reflection about social media helped them form new conceptions of the value that their intervention-specific social media platform adds to their lives.

P2 entered the intervention with a sense that Twitter was valuable for her but also indicated that she felt that "about one-third" of her Twitter time was not well-spent. After one week of using the *Crank Box*, she indicated a heightened awareness of the role that she wanted Twitter to play in her life:

> *P2*: On the spectrum of being a utility to a frivolous pleasure, I think I was more on the frivolous pleasure entertainment side before, and Twitter, in my mind, has switched on this spectrum to being more of a utility, [...] like I know the difference of modes of Twitter when I use it for those two purposes.

P5's perspective on Facebook changed to seeing it as more of a "source of entertainment" rather than a way "stay connected to people," and her new awareness affects the way she spends her time on Facebook now.

> *P5*: I guess I'm... seeing Facebook now as... a source of entertainment, but in a limited– like, there's a point where it's not satisfying anymore and I don't have to reach that limit in order to log off... I can just look for a couple of minutes, and then that usually like satisfies me enough, or gives me enough of a break to like just sign off.

Similarly, P6 now recognizes Facebook as a "distraction" as a result of her changed interaction patterns from Week 1 and is able to clearly weigh the benefits and harms of using Facebook for that purpose.

> *P6*: I still recognize that I use it as a means of distraction, instead of using that time to process the emotions. And I guess it's nice to be distracted so I don't have to think about it as much and let it take more emotional energy, but the bad part is like, it will accumulate later on.

Using the *Tilter* made P8 reflected similarly on her increased Instagram usage post-intervention, and how social media provides a distraction from anxiety and pressure related to academics.

> *P8*: I have definitely spent a lot more time on my phone scrolling on Instagram, to sort of distract myself, and I think like the more anxious I am about school, the more I fall back onto this app.

P1, on the other hand, reported nearly complete satisfaction with her Twitter usage before the intervention, stating that she would never sign up for a study that explicitly limited her Twitter usage. Using the *Crank Box* further heightened P1's awareness of the importance of Twitter to her daily routines (during Week 2, she found herself trying to type "twitter.com" into her web browser out of habit when bored in class and trying to access Twitter on her phone right after waking up), friendships (she realized she hadn't seen the Tweets that her friends were talking about during a group FaceTime conversation because the crank had made it too difficult to keep up), and general sense of self. She reported being "happy to have [Twitter] back" in Week 3.

Before the intervention, P3 characterized herself as a lightweight Twitter use but indicated that she felt that she "could spend less time" on Twitter. However, at the end of the study, she noted that her frustration with using Twitter through the *Crank Box* made her think that she "was a little more dependent on Twitter" than she initially thought. She was able to clearly identify that Twitter was an important addition to her life for "in-between moments" in various locations and returned to her normal Twitter usage very "glad to have Twitter again."

For some participants, like P10, the intervention not only increased their awareness of the role of social media but also changed the role it plays in their life altogether. For example, the *Cranker* intervention caused P10 to "evaluate the worth of Twitter" and "make a value judgement" that gave her an "articulated" perspective on Twitter's "decreased worth" for her. P10's realization had lasting effects on her post-intervention "motivation" and "curiosity" to use Twitter:

> *P10*: The motivation or interest to use social media isn't there, even though there's no blocker.

> *P10*: My theory is that using the device kind of made me make a value judgment on how important [Twitter] is in terms of my time and how important those posts were...I feel like now that I've thought about like the value of Twitter and how much time I spend on Twitter, I really am just not motivated to use it. It feels kind of like a waste of time.

P10: [Before,] Twitter was to me a way more significant way to connect and look at other creators' Tweets and stuff and it was like really important for me to continue looking at it every day if that makes sense, like it being like a consistent part of my day. But I think like using the device really disrupted that and then realizing that, oh, I don't need to be caught up on what this this creator is doing every day.

P10: The information gained from using social media doesn't feel as important anymore, so I seem to spend less time on it at one time.

Using the physical intervention systems caused users to question why they use social media. Users became more actively aware of the ways that social media adds value to their lives, as well as the ways in which social media may not be useful for them.

6.3.2 Users Compared Increased Temptation with "Cold Turkey" Approaches

Users compared their experience of the physical interventions with prior experiences of digital interventions and experiences of having unrestricted social media use. Notably, users remarked on how their levels of temptation for accessing social media changed as a result of the intervention.

Some common existing social media interventions (like deleting an app off of a personal device, deactivating an account, using a news feed eradicator, or using a screen time limiter) completely remove or time-bound users' access to social media. My four proposed interventions allow users the freedom to access social media whenever they want and for any amount of time, but they must do so at an increased physical cost. The promise of social media access was at first a glimmer of hope for the participants, that they might be able to access social media.

P8: Deleting it off my phone entirely gave me no temptations, and I didn't even attempt to go back on it, really. But with the intervention, I would have the temptation and then I would get really frustrated. I tried to use it, and I would like still kind of see people's content, and then it would make me crave wanting to use it even more.

For P8 and P11, the fact that their social media content was sometimes slightly visible through the *Tilter* mobile application drew them back to the application again and again but soon became frustrating when they realized that it was difficult to unobscure their feeds for long enough to derive value.

P11: The few moments where I... was holding my phone differently, I might get a flash of a Tweet but it would disappear before I could read it. I was like, why is this app teasing me right now!?

P8: The fact that I could see content on my screen that I wanted to learn more about and then it would immediately go away, would make me frustrated because instead of not seeing it at all... now I was curious about it, and now I wanted to learn more, but I couldn't learn more. Or I would have to really struggle to learn more.

In these examples, the slightly visible screen acts as cookie crumbs luring the participants into the intervention, only to be let down when the satisfying treat of their social media feed is gated by a hidden, secret angle that they must discover by moving their phone around. The task of physically tilting the phone at different angles until the screen brightness changes is one that requires an ambiguous amount of effort; finding a target angle could take one user 3 minutes and another only 10 seconds, and it could even take the same user varying amounts of effort to find different target angles. For the *Tilter* mobile application users, the technically possible but practically difficult access to social media created a dissonance between the users and their devices.

For P11, knowing that her Twitter content was right there on her phone but that she could not find the correct angle made her feel "locked," like the intervention was "kind of taunting" her:

> *P11*: I would feel locked, like I couldn't even do anything. And then there were other times where I would open it and then it would very quickly dim to complete blackness or just enough light that I knew that there were Tweets still there, but I couldn't make [them] out. And that would also make me feel super locked out because it would happen so quickly that I didn't even really feel like I got to use the app. It felt like it was like kind of taunting me. Like it's right here and it's on your on phone and you can't use it at all. So I think that for me, it [was] worse than just like deleting the app completely and going cold turkey because it's there and I can sort of access it, but I can't actually access it enough to do what I want to do.

On the other hand, P12 described the *Shaker* as a "much healthier way" of using social media compared to his prior social media break, which he described as "going cold turkey" and which resulted in him feeling "pretty disconnected." For him, the *Shaker* allowed him to "go on social media, but only for the things that [he] needed and maybe a little bit more," whereas the social media break countered the entire "point of social media," which is for him "to feel connected to the world."

6.3.3 Tipping Points in Social Media Use Caused User Reflection

All participants attempted to access social media at least once at the start of the intervention week, but many eventually encountered a tipping point within the next few days, at which they determined that the physical barrier to accessing social media was too high to even attempt accessing it for the rest of Week 1. On the flip side, some users experienced a tipping point where they decided to use social media in spite of the physical barriers posed by the interventions.

> *P12*: I don't need Reddit enough to justify shaking the device anymore.

Participants who encountered a tipping point made a definitive trade-off against accessing social media with an added physical cost, and instead opted to suppress their desire to use social media for the rest of the week. For most participants who decided to forgo

accessing their social media platform, the complete drop-off in usage at the tipping point persisted throughout Week 1. One participant, P12, stood out because in the later days of the intervention, he reverted back from the tipping point to a state where he was willing to access Reddit by using the *Shaker*.

> *P12*: I just sort of got over my hesitancy because I really wanted to scroll Reddit.

> *P12*: [The *Shaker*] made me use [Reddit] less the past few couple of days, and so today I just sort of decided to end up going against that bump and used it for a bit more than usual.

P12 partially attributed his motivation to having "more free time" to use Reddit after a few days of not using it at all. For P12, the pull, or attraction, of Reddit came from P12's desire to learn more about topics related to his student community and other topics of curiosity, on which Reddit uniquely provided genuine human perspectives that P12 felt were unavailable elsewhere.

Unlike P12, P8 was not able to use Instagram to her liking via the Tilt Mobile App during the intervention, and only reverted back from the tipping point during Week 2. As a result, P8 compensated during Week 2 by "using social media a lot more" to "catch up on everything" and reported feeling a sense of "relief."

> *P8*: I had noticeable feelings of missing out on things before, and the week before, especially since a lot of the times I could either hear about it from my housemate, or see like a glimpse of it before the screen went dark. It felt even more apparent that there were things that I was missing out on. So, going into the [post-intervention] week, one of the reasons why I started using social media a lot more was to catch up on everything. And because of that sense of relief, where, oh, everything is accessible again.

Jansen & Slob describe opposing forces controlling the usability of human-powered devices, including the tension between user motivation and "added discomfort," or a physical cost to powering and operating a device [54]. According to Jansen & Slob, a user will choose to "accept or reject" the added discomfort depending on their motivation to use the product. When faced with one of my four proposed interventions, all participants were forced to reconcile their desire for social media with the added discomfort of interacting with the intervention systems. Participants eventually developed an implicit threshold for the conditions where they would choose to "accept or reject" the added discomforts. For some participants like P12, this threshold started off as a conservative boundary on his effort to operate the *Shaker*, but the threshold shifted over the course of the intervention, until it reached the *tipping point* – when P12 opted to use the *Shaker* liberally for a longer period of time to use Reddit for leisure in addition to essential information gathering. On the other hand, P8 maintained a consistent, unchanging threshold balancing motivation with added discomfort moderately throughout the intervention, but P8 encountered a *tipping point* after the intervention, where the lack of added discomforts allowed her to use Instagram in an unrestrained way.

6.3.4 Love-Hate Relationship with Social Media and Devices

Users' reported simultaneous feelings of frustration and appreciation toward the intervention systems, in a way that parallels their typical attitudes toward social media. All participants expressed appreciation for the access to news and politics, friends, jokes and memes, events, and communities enabled by their various social media, but they also remarked on how social media is sometimes a "burden" (P12) that they can get "roped into spending hours on" (P9) and is "kind of a waste of time" (P7). These antithetical perspectives capture two opposing forces that simultaneously attract users to social media and build frustration around their "subconscious" (P4, P12) use of social media.

While participants expressed negative sentiments toward the experience of operating the interventions ("that was horrible" (P10)), they simultaneously reflected with positive sentiments about the observed changes in their social media behavior.

> *P10*: I'm actually really glad that I went through this study...I feel like it decreased the amount of time I spend on Twitter and that's really impacted like my mental health.

> *P10*: I felt a lot better afterwards. I think like Twitter has the potential to like sometimes like ruin your day if you see something pretty horrendous.

On the other hand, P5 felt that her amount of time spent on Facebook only changed slightly as a result of the intervention, but the quality of time spent changed drastically and affected her mood for the rest of the day. After the intervention she reflected:

> *P5*: ...now I kind of look at notifications in the morning and then get on with my day instead of like spending more time... ... I like being able to get started feeling like I did accomplish something before lunch... I think just like even five minutes of doing doomscrolling makes me feel like, I just want to like go outside and forget that I just did that... it just doesn't make me feel satisfied... I just feel gross about it so I'm just like, *stop wasting time*, get on, just be productive. And so, I guess I don't have to feel that every morning.

Some participants even appreciated the capacity of the intervention to lower distractions in settings other than social media. P6 described a creative use of the *Crank Box* to complete a task during which she preferred to not be distracted by notifications on her mobile phone:

> *P6*: I thought of an idea when I was reading this one book, that I can use the device to look at definitions so that I won't get distracted if I look it up on my phone or look at it on my computer. [...] if I find a word I don't know, I'd get another journal, write down the word, and then afterwords when I get a big pile of words, I would get the device, and type it in it slowly, [...] then I'd just crank it, look up the word, [...] and then move onto the next word, and that's kind of like a nice break where I don't see if a notification pop up, because if it pops [on my phone] up I'm like nahh it's too much of a hassle to answer so I'll just keep going with the definitions.

In this way, embodied constraints can enable digital experiences to be more effective than low-friction digital experiences. Interventions like the *Crank Box* take away users' ability

to freely browse and traverse digital content with physical ease. However, by restricting users in this way, such interventions provide users with a greater responsibility and agency to understand and enact their own intentions for using social media. Users' relationships with the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* mirror their "love-hate" relationships with their typical social media usage. While the added physical barriers of constantly cranking, shaking, and tilting their social media devices added annoyance, users also felt appreciative of their newfound understanding and control of their social media habits.

Chapter 7

Discussion and Future Work

The four designs presented in Chapter 3 deviate from existing tools and strategies for countering excessive use of social media (discussed in Section 2.3.4). Existing techniques for digital detoxes and apps for digital wellbeing [130, 78, 118, 96, 48, 99] discourage social media use by enforcing time-bounded sessions [137, 102] and by making users feel guilty for using social media [16]. In contrast, the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* give users agency to control how they want to use social media, with physical mechanisms that provoke reflection on the value of social media in their lives.

The results of my user study revealed that applying embodied constraints to social media has potential to affect users' behavior, their social interactions, and their perception of social media. My exploration of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* presents a broader critical design space for building social media interventions that oppose traditional narratives of social media addiction (Section 2.3.3) and digital wellbeing (Section 2.3.4).

In Section 7.1, I present a set of design considerations for building social media interventions, specifically those that leverage embodied constraints and depart from traditionally digital intervention designs. Next, in Section 7.2, I present design speculations about future social media interactions that may leverage embodied constraints and other sensory, spatial, and social critical design limitations.

7.1 Design Considerations

The designs of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* respond to various design opportunities in the space of social media interventions. In Table 4, I present a summary of notable design qualities that differentiate the four designs from existing digital social media interventions.

In the subsequent sections, I define, generalize, and discuss the seven design factors that emerged from my designs: GOAL, PHYSICAL APPARATUS, DIGITAL APPARATUS, ACTIVATION THRESHOLD, CONTINUITY OF FRICTION, TRANSPARENCY, and CONTROL & OVERRIDEABILITY. I frame each design factor as a question followed by a discussion of existing

approaches and design opportunities for that factor. I propose these seven factors, summarized in Table 5, as a set of design considerations for the future design of social media interventions that may engage components of the physical world in addition to digital interactions.

Design Factor	***Crank Box***	***Cranker***	***Shaker***	***Tilter***
Goal	To bring more user awareness to their relationship with social media, by requiring them to provide constant physical input when accessing social media.			
Physical Apparatus	A physical box with a touchscreen surface and a crank attachment. Must be plugged into a power source.	An auxiliary physical device attachment (bluetooth device connected to a mechanical hand crank or accelerometer) interfacing with a desktop web browser. Must be plugged into a power source.		iOS mobile device (iPhone)
Digital Apparatus	Social media website opened in a web browser window on the digital screen surface of the interface.			
Activation Threshold	The user must locate the device, plug it in, wait for the device to power up (for the *Crank Box*) or connect the device with the web browser (for the *Cranker* and *Shaker*), and begin interacting with the device (cranking or shaking) until the screen gradually reveals the social media content.			The user must open the mobile app and tilt the phone at various positions until they find a configuration that reveals onscreen content.
Continuity of Friction	Instead of simply scrolling through their social media feed with a finger on a handheld device, the user must hold the device and constantly exert physical effort to interact with it.			
Transparency	The form of the crank attachment indicates a clear affordance – that a user may grasp the crank handle and turn it.		Shaking the device is a learned behavior that becomes clear to the user after initial use.	The target angle condition, unknown to the user, changes at frequent intervals of use.
Control & Overrideability	The design of these interventions requires constant physical input. Unlike with other interventions, the user may not perform a one-time override to access social media unhindered, unless the user turns to their other habitual devices for social media access.			

Table 4: The design qualities that distinguish the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* from existing digital social media interventions.

7.1.1 Goal

Design Question

What is the GOAL of the social media intervention? What effect(s) does the intervention aim to have on users' social media behavior?

Discussion

Some interventions aim to completely cut off user access to social media (e.g. deleting or deactivating a social media account, uninstalling a social media application). While these blocking effects may last permanently, they can also be temporary and can sometimes be reverted (e.g. reactivating a social media account, re-installing a social media application). Section 7.1.7 further discusses the "overrideability" of certain interventions.

Other interventions intentionally aim to restrict or time-bound social media access (e.g. screen time limits [137, 102], website blockers [15, 14, 85]). Such interventions rely on scheduled distraction-free "focus sessions" [15, 104], where undesirable sites like social media are blocked, and unblocked usage periods where users may freely browse such sites.

Some interventions also aim to deter and drastically reduce time spent on social media by altering platform-specific interface elements rather than by explicitly time-bounding access (e.g. social media feed eradicators [143, 44], embedded timer or visit count displays [44], social media scroll freezes or loading delays [44]), onscreen callouts annotating persuasive design techniques used by social media platforms [138]).

The broad category of publicly available social media intervention apps center around being mindful and increasing productivity by decreasing social media usage. Additionally, many interventions are opinionated on specific social media behaviors to encourage and discourage. Apart from interventions that allow scheduling restricted versus unrestricted web browsing, most interventions treat all social media sessions alike, implying that users may always benefit from escaping the social media and doing something else that is more productive.

Opportunities

With the design of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*, I identify an opportunity to create interventions that aim to make users more mindful of their social media experience in the moment, without necessarily pushing them off of social media platforms to experience mindfulness elsewhere. In this way, my four presented designs do not aim to explicitly reduce a user's social media usage, unlike most social media interventions. While the reduction of social media is an effect of the four proposed interventions, it is not the core intention, which is rather to prompt reflection on social media behaviors and patterns. As such, there is an opportunity for intervention designers to break away from the perspective that time spent on social media is typically a "waste of time" and should be discouraged. Instead, designers may build interventions that empower users to use social media productively and

gain intentional value from it. A future category of critical social media interventions may even aim to increase rather than decrease social media usage, if increased usage brings more value to users.

7.1.2 Physical Apparatus

Design Question

What is the user-facing PHYSICAL APPARATUS, or tangible physical hardware infrastructure, required to instantiate and maintain the social media experience?

Discussion

Users access social media through a variety of devices, including smartphones, laptops, tablets, smartwatches, and other conveniently available screen interfaces. Most social media intervention systems are typically software applications, browser extensions, or user-controlled device settings. However, users may intervene in their own social media patterns by changing the PHYSICAL APPARATUS they engage with to access social media. For example, a user may delete social media apps from their phone to restrict their usage to other physical screen interfaces. However, a one-time uninstall of a social media application from a device completely removes social media access from that device, but such an action can often be reversed via reinstallation.

Opportunities

The typical ease of accessing social media without extensive additional physical apparata (besides digital screens) is a cornerstone of the ubiquitous computing vision, which imagines the physical apparata for digital interactions as so inextricably integrated in our daily lives that digital interactions are seamless extensions of the physical [142]. Oppositional to the ubiquitous computing vision is a critical design opportunity to make the physical apparatus of social media salient, rather than well-embedded, in our existing systems and infrastructure.

Common strategies of uninstalling or removing digital social media infrastructure from a physical device cause a complete detachment of social media from that device. On the other hand, the *Cranker* and *Shaker* are examples of social media interventions that add physical apparata to an existing digital social media experience, entangling the digital social media space with the user's actions in their physical space.

There is another opportunity to intervene in social media experiences on a physical device by keeping the digital infrastructure of social media intact but transforming the physical container to add friction to the experience. Like the *Crank Box*, such social media interventions have the unique ability to enter a new physical object into the user's environment. Physical social media objects with unusual affordances, like the hand crank of the *Crank Box* and *Cranker*, are imbued with a latent potential to prompt reflection even when they

are not actively in use (i.e. seeing the *Crank Box* in a corner of the room may prompt a user to think about social media even when they are not using social media).

7.1.3 Digital Apparatus

Design Question

What is the DIGITAL APPARATUS, or software infrastructure, required to instantiate and maintain the social media experience?

Discussion

Most social media users access social media via a native application or website on their phone, tablet, laptop, or desktop computer. Given access to the aforementioned physical devices, the digital apparatus or infrastructure required to access social media is often minimal as long as the user has WiFi network access and software operating systems to access social media on their devices. Social media websites and applications are designed to be as frictionless as possible, with scrollable, stimulating content that makes it easier to stay in the experience than to exit the experience [140, 62, 138].

Opportunities

Social media design leverages a slot machine-like unpredictability in the type and quality of content presented to a user at every page refresh [115, 20]. There is an opportunity to leverage a similar principle by introducing unpredictability in the digital fidelity of the social media experience. Implementing intentional digital glitches, defects, and distortions (Section 7.2.3) may be a possible strategy to reduce the digital fidelity of a social media experience given certain input from a user.

The *Tilter* mobile app is an example of a transformed digital social media experience that leverages seemingly glitchy behavior to prompt physical action from a user. In particular, sharp reductions of screen brightness at all but one phone holding angle nudge the user to physically test various holding angles to find the target holding angle. In fact, participants in my user study even commented on this functionality:

> *P7*: I've downloaded the app and tested it out a bit, and the screen keeps getting dim? I was wondering if this is part of the app design or a bug?

> *P9*: For some reason the app is doing this thing where it goes dark and I can't see anything. [...] it's very hard to use [...] is that part of the study?

Another opportunity to alter the DIGITAL APPARATUS of social media draws inspiration from onscreen advertisements. Onscreen advertisements are a common way for social media companies to monetize users' attention for profit. Just as advertisements harness

users' attention for profit, intervention designers may explore designing onscreen elements or gimmicks that redirect users' attention for purposes other than profit (e.g. promoting introspection, introducing new ideas, etc.). Interventions may disrupt the otherwise smooth onscreen experience of social media to make it more difficult for users to start and continue a social media session. For example, a low fidelity social media experience may incorporate longer loading times for social media pages or deliberately mimic the frustrating user experience of low phone battery while one reads or types out an interesting post.

7.1.4 Activation Threshold

Design Question

How easy is it for a user to start a social media experience? For each session, what actions must a user take to successfully enter the social media experience?

Discussion

Typical social media browsing and engagement patterns are low-friction during the activation phase of a session (e.g. picking up a smartphone and tapping a notification, clicking a bookmarked social media page on a web browser). Often, users are in close proximity to their mobile phone, laptop, tablet, or other screen interface for social media use, so it requires minimal effort to actualize a desire to go on social media.

Some interventions add digital layers of friction to make users reconsider whether they truly want to enter social media (e.g. a prompt for the user to articulate their goal and desired time limit for a social media session, before they may access the social media site [44], or an extra onscreen button that users must click before reaching the social media app). Other interventions add physical friction to social media access (e.g. putting one's mobile phone in another room or out of reach before going to bed or working on another task).

Opportunities

While most existing interventions rely on either digital barriers or easily reversible physical inconveniences, there is an opportunity for interventions to hybridize digital and physical barriers during user activation of a social media session. The embodied facilitation approach [51] of combining digital and physical constraints has potential to prompt new user behaviors for users to better understand their relationships with social media. For some users of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*, the presence of embodied constraints deterred them from even trying to access social media during the intervention because the ACTIVATION THRESHOLD was too high. For other users, the ACTIVATION THRESHOLD was not high enough to prevent them from accessing important information (Section 6.3.3) but was too high for exploring content (Section 6.1.2).

7.1.5 Continuity of Friction

Design Question

How easy is it for a user to stay in the experience? Once the user has entered the social media experience, what must they do to continue engaging in it?

Discussion

Most social media platforms provide "bottomless bowls" [140, 138] of "infinite scroll"-type content [62] that users may scroll through with their thumb or finger. For video-based social media platforms like YouTube or Twitch livestreams, users may passively consume autoplaying content without providing any active input at all.

Some social media interventions, like the YouTube *Take a break* feature [126], add friction by automatically pausing content at certain user-specified time intervals and requiring the user to click a button to continue engaging in the experience. Screen time limits [137, 102] similarly add friction consisting of a few additional button clicks after the user exceeds a certain time limit on time-monitored apps. The continued effort of staying engaged in a social media session is minimal, even with certain digital interventions at fixed time intervals. Once a user is "in" the experience, there is little required input from the user to continue. The lack of CONTINUITY OF FRICTION enables behaviors described by others as "absentmindedly scrolling" and "doing nothing at all" [76].

Platform-specific interventions [144, 138, 109, 44] may modify social media interfaces in ways that deter use. However, such modifications add friction without providing dynamic user controls to mitigate the frictionful effects, other than overriding the intervention completely.

Opportunities

Though many existing interventions attempt to increase the ACTIVATION THRESHOLD (Section 7.1.4), or the effort needed to start a social media session, there is an opportunity for interventions to raise the threshold for continuing a social media session. I proposed four social media interventions that require users to put significant physical effort into operating the social media device. Such physical interventions may either require bursts of physical effort at time intervals, which may produce binary "active" and "inactive" states.

Social media interventions can also require continuous, sustained physical input from the user, as I demonstrated in the four presented intervention systems. Requiring constant input from the user allows for the CONTINUITY OF FRICTION added throughout a social media experience. Such intervention designs can also enable a user to dynamically control and vary the quality and fidelity of their social media experience based on the level of physical input they provide. A fruitful area for future research also includes experimenting with requiring various levels of sustained physical exertion from the user. Varying levels of

sustained exertion can be quantitatively measured and studied via the Critical Power test, which can determine the muscular physical work output and capacity from a user [54, 87].

Critical designers may further explore extreme approaches to the CONTINUITY OF FRICTION design factor, by creating social media interactions that induce pain rather than mild forms of exertion. For example, *Kit*, discussed previously in Section 2.3.4, is a belt tourniquet that interfaces with a browser extension to deliver "prick-like shocks" to users whenever they visit Facebook [99]. Gaming applications have also demonstrated the potential for building painful interactions into interfaces. The *PainStation* is an adaptation of *Pong* that inflicts varying levels of pain on players when they hit the ball to locations other than the target destination on the playing field [82]. Specifically, *PainStation* delivers a variety of heat sensations, punches, and electroshocks that last for variable amounts of time in response to users' mistakes in the game [82]. Social media interventions may similarly leverage painful feedback as an extreme design mechanism for adding friction to an experience.

7.1.6 Transparency

Design Question

How easy is it for the user to understand the intervention condition and the type of user input required to satisfy it?

Discussion

Onscreen affordances of social media platforms present users with well-defined interactions allowing them to browse, create, and share content. Elements like large clickable, animated buttons, eye-catching "unread messages" badges, and conspicuous calls to action make it clear to users how they should interact with onscreen social media content [36, 138]. Digital social media interventions offer similarly straightforward cues (e.g. screen time locks clearly indicate when a user may access social media freely and when they must manually override the intervention with the click of a button).

Opportunities

There is an opportunity to build even clearer visual signals to the user indicating how they must interact with the intervention system in order to gain access to social media. For example, building conspicuous physical controls with easily understood affordances may be a way to make the engagement conditions for an intervention even more transparent. Alternatively, instead of offering well-defined user controls (e.g. the click of a button overrides an intervention), there is an opportunity to provide cryptic digital affordances that require the user to perform actions that are not immediately apparent to the user.

Gaver et al. argue that ambiguity can be employed as a design feature; for example, designers can create strategic ambivalence in the relationship between a user and a system by adding new "incongruous functions" to "existing genres" of interaction [39]. In this sense,

all four designs described in Chapter 3 add new, unfamiliar functions to familiar social media contexts. The design of the *Tilter* additionally showcases how an unknown target angle can cause users to perform physical maneuvers in an "open-ended" way, following Gaver et al.'s perspective that "if people are to find their own meaning for activities, or to pursue them without worrying about their meaning, designs should avoid clear narratives of use" [38, 40].

Social media systems may simultaneously introduce ambiguity and provide users with hints to resolve the ambiguity. A digital social media system may act like a digital and physical multi-armed bandit (a system with multiple controls and levers) that must be controlled and manipulated in ways initially unknown to the user. In such a setup, the user may gradually discover which social media actions are desirable and which are undesirable. Just as in human-robot interaction contexts, where robots can help humans uncover hidden reward functions [23], a social media intervention interface may similarly nudge users to perform certain actions, unbeknown to the users.

7.1.7 Control & Overrideability

Design Question

How does the user operate the intervention? How easy is the intervention to override?

Discussion

Due to their digital medium, most existing social media interventions rely on user responses to onscreen popups and clickable buttons. Most such interventions are not difficult to override. For example, screen time limits [137, 102] require a simple tap of a button to override the intervention and subsequently spend time on social media, unhindered. Media studies and game design scholar Ian Bogost reflected on his experience with screen time locks as a "hopeless" effort to enact a "punitive" measure meant to "enforce boundaries" on his time [16]. Bogost describes his interaction with the Apple Screen Time feature as follows:

> *Ian Bogost*: Let me tell you what I do with it: basically nothing. I use the app until the time expires. Then I just "ignore limit." Usually for 15-minute increments—often a number of them, over time—and then sometimes for the rest of the day, when the extra tapping becomes a nuisance.
>
> This ritual might make me more mindful, but mostly by making my self-loathing more self-aware. Now, instead of tapping the Twitter icon to load the app, I tap it to load the Screen Time nag screen, which reminds me that I'm a bad person for using Twitter too much. Then I tap "ignore," ensuring the prophecy gets fulfilled.

Such one-time barriers are able to marginally raise the ACTIVATION THRESHOLD (Section 7.1.4) at the cost of causing negative feelings like guilt and "self-loathing" according to Bogost. However, such interventions fail to add CONTINUITY OF FRICTION (Section 7.1.5) to the intervention experience. This results in momentary, isolated experiences of guilt when a

user sees a screen time limit, along with prolonged, unrestricted content consumption when a user overrides the limit. Such interventions propagate the narrative that social media can only be considered a guilty pleasure rather than a fruitful experience.

Opportunities

Regulating social media experiences may be valuable, and technology can play a role in this effort. While Bogost described his experience with the Apple Screen Time feature as a "miserable failure," he still uses the feature as a "dutiful submission to a punishment" in an effort to regulate his social media usage [16]. Instead of building interventions that feel like punishments and are easy to override with the tap of a button or swipe of a screen, there is an opportunity to build interventions that prompt reflection while allowing users control to access social media for productivity, entertainment, and other valuable purposes.

One way to make interventions harder to override in the spur of the moment is to increase the ACTIVATION THRESHOLD (Section 7.1.4) for entering social media experiences. The *Crank Box*, *Cranker*, *Shaker*, and *Tilter* propose unique ways to require sustained input from the user, rather than providing a one-time switch that either unequivocally locks a user out or lets them in without restriction. The design of sustained input also has potential to prompt productive reflection on social media habits, as evidenced by the participants' increased awareness about the role of social media (Section 6.3.1).

Design Factor	Design Question
GOAL	What is the GOAL of the social media intervention? What effect(s) does the intervention aim to have on users' social media behavior?
PHYSICAL APPARATUS	What is the user-facing PHYSICAL APPARATUS, or tangible physical hardware infrastructure, required to instantiate and maintain the social media experience?
DIGITAL APPARATUS	What is the DIGITAL APPARATUS, or software infrastructure, required to instantiate and maintain the social media experience?
ACTIVATION THRESHOLD	How easy is it for a user to start a social media experience? For each session, what actions must a user take to successfully enter the social media experience?
CONTINUITY OF FRICTION	How easy is it for a user to stay in the experience? Once the user has entered the social media experience, what must they do to continue engaging in it?
TRANSPARENCY	How easy is it for the user to understand the intervention condition and the type of user input required to satisfy it?
CONTROL & OVERRIDEABILITY	How does the user operate the intervention? How easy is the intervention to override?

Table 5: A summary of design factors to consider for social media intervention design.

7.2 Design Speculations Using Embodied Constraints

In this section, I propose design speculations about social media interventions that apply a variety of embodied constraints beyond *cranking*, *shaking*, and *tilting*. Prior research by Pierce & Paulos has explored the potential for energy generation via other motions like *twisting*, *turning*, *squeezing*, *treadling*, and *pedaling* [106]. I envision speculative interfaces that involve unusual sensory interactions, social and spatial factors, and unexpected distortion of digital experiences. Such novel interactions may leverage the "vital materiality" [11], or living potential and agency, of our nonhuman technological artifacts – our screens, phones, computers, and digital devices – to affect human behavior.

7.2.1 Sensory Interfaces

I share examples of speculative sensory interactions involving breath, heat, and ingestion that may produce meaningful critical designs of social media interfaces with embodied constraints.

Breathe-to-power social media interfaces

Traditional social media interactions are equipped with real-time notifications, livestreams, and instant messaging functionality that adds an element of *liveness* [76] to the interface. Imagine a social media screen that mimics being "alive" in a human-like sense, dependent on breath for life. Consider a design where, in order to access social media, a user must first enliven the digital media using the physical apparatus of a ventilator, to breathe "life" into the interface. Patel et al. demonstrate a hands-free "blowable" user interface called BLUI, which allows users to directly control specific parts of an onscreen application by blowing on parts of the screen [101]. Blowable, or breathable interfaces may also have potential to make digital interactions more accessible, like Drew & McElravy's *sip/puff* switch for digital devices that can users can activate with minimal pressure or a quick blow of air [35, 28, 91].

Digital social media devices can harness the mechanical power of breath by requiring users to breathe onto a sensor, by using the physical form of a tube through which users must channel air at a certain pressure, or by sensing the expansion and contraction of their chest as they breathe [30, 10]. For example, a breath sensor could be attached as the auxiliary device in the modular design of the *Cranker* and *Shaker* designs presented in Chapter 3, requiring a steady stream of breath to illuminate a social media browser window on a user's laptop.

Heat-to-power social media interfaces

One of the participants in the user study, P7, mentioned that he typically his social media sessions when he noticed his phone gets "hot" as he scrolls, which serves as a reminder that he has consumed enough social media content and should put his phone away. Instead, imagine a social media device that only powers up or operates functionally when heated or

cooled to a particular temperature. For example, there is an opportunity for social media devices to employ "friction" in two senses. In a figurative sense, a social media experience could aim to make more frictionful, or difficult to instantiate and maintain. In a literal sense, a social media device could also require a user to power the device by physically heating it with sliding friction of from the user's hands, by rubbing the device.

Another speculative design for body heat-mediated social media is a device that gates access to content based on body temperature (i.e. a user may only access social media if their body temperature is adequately low, high, or moderate), or the directionality of change in body temperature (i.e. a user may only access social media as they begin to heat their body by doing a physical workout, or as they cool down). Such designs allow users flexibility on how to control their body temperature, like players of the temperature-varying "Guts Game" by Li et al. [74]. For example, users may take contrasting approaches to raise body temperature (i.e. exercising versus donning layers of blankets). Either way, a constraint on body temperature requires physical action from the user to achieve the condition required by the social media interface to allow access.

Ingest-to-power social media

The tension between the fast food consumerism and the emerging *slow food* movement – a call for mindful, fair, clean food consumption [2] – parallels the opposing ends of the social media usage spectrum, from *addiction* (Section 2.3.3) to *digital well-being* (Section 2.3.4). I envision a literal translation of social media content "consumption" that requires a user to chew, swallow, or ingest a device to enable and control social media access.

Past work has demonstrated how ingestible devices can give rise to ludic interactions, like Li et al.'s *Guts Game*, which requires players to complete challenges by varying their body temperature, measured by an ingestible sensor [74]. Ingestible sensors are capable of measuring various information about the human gut, including information about "electrolytes, enzymes, metabolites, hormones, and the microbial communities" [57]. The variety of data available from ingestible sensors may allow the design of social media experiences that are limited and enabled based on physical qualities like gut health or the pH value of food that the user consumed. In this speculative proposal, a user must physically consume or ingest a sensor and other food or liquid to enable social media content consumption.

Additionally, ingestive interactions have potential to affect users' relationships with social media outside of their direct interaction with social media. Recent work by Mueller et al. proposes "data as delight" experiences for users to eat edible products whose creation is informed by the data [1]. Prior work on data "edibilization" additionally presents an embodied form of "data communication" [139]. Such approaches to converting social media data into edible experiences may allow for users to consume or ingest edible material material in order to trigger reflection on their social media consumption. For example, consider a technology that builds edible daily reports of a user's social media usage, where the quantity of edible mass corresponds to a user's time spent on social media, or another social media

usage metric relevant to the user. The gustatory properties of the edible material may have potential to very the quality of the user experience from enjoyable to unpleasant.

7.2.2 Social and Spatial Interactions

One of the key findings reported in Chapter 6 is that users of the presented interventions generated collocated, collaborative modes of social media content consumption for support with the limiting physical embodied constraints (Section 6.2.2). The presented social media interventions also affected the users' other social dynamics (Section 6.2.1). Lupinacci also discusses the experience of "immediate connection through media" as a form of *liveness* afforded by digital communication [77]. I imagine a genre of social media interfaces that leverage collocated presence and physical spatialities to power virtual social media experiences.

Crowd-powered social media

Consider a social media interface that requires a user to be physically present with other social media users in order to unlock access to their digital social media content. A condition like this could be enforced by a mobile camera input that requires a user to connect with a social media "partner" whose face must be visible to the user's mobile camera in order for the user to visit social media. Such an interaction could be two-sided, where the user and their social media "partner" mutually enable each other to access social media as long as their cameras are positioned to detect each other's faces. Given the overt requirement for facial data collection in this proposed interaction, this critical design may engender discussions about the privacy implications of social networking interactions.

At a larger scale, there is an opportunity to harness the physical presence of crowds – clusters of individuals teeming in a single physical locality – to power virtual social media experiences. Paulos & Goodman explore how a Bluetooth-enabled mobile application and personal wearable devices can chart qualities of interactions among "familiar strangers" in a crowd [103]. Ko et al.'s Lock n' LoL application explores how a mobile application may disable notifications and block extraneous internet activity when users are physically present in the same room [63]. There is an opportunity to pursue the opposite goal of enabling social media interactions only when enough digitally connected individuals are present in a crowd.

Scavenged social media

Users of the *Crank Box*, *Cranker*, and *Shaker* expressed a friction arising from the physical distance between the device and their location when they desired a social media interaction. Specifically, users mentioned how the low portability of the devices often physically separated them from the devices, whether by a few steps in their own home (P2) or by an entire commute to work (P6). I envision social media interfaces that augment the frustration of physical travel in pursuit of social media.

For example, an interface may require a user to physically navigate to a specific social media "zone" in their neighborhood, or scavenge for social media "hotspots" scattered across a geographical terrain like Pokémon Go [5] or geocaching games [95]. Rather than searching for specific locations, a user may alternatively power a social media interface with scavenged colors, textures, sounds, and other sensory matter that they can capture via sensors interfacing with a digital screen.

A social media interface may also distribute and embed granular elements of a social medium, such as posts, across a geographical terrain so that a use must scavenge for individual pieces of content. Such social media experiences can be formulated in an augmented reality or virtual reality context, like TweetReality, an augmented reality browsing experience for Twitter [37]. Another type of social media interface may require a user to be in transit, in a moving bus or train route, to enable social media access.

7.2.3 Unusual Distortion of Interfaces

Apart from manipulating the brightness of screen interfaces, there is a range of digital distortions that social media interfaces may leverage to control the visibility and obscurity of social media content based on user input.

Foggy social media interfaces

Future work may model interactive social media experiences based on the experience of looking at a foggy mirror or looking through a foggy window. In particular, individuals are accustomed to performing a "wiping" motion, to remove fog, or condensation, that obscures their view. Similarly, social media screens may enact a digital "fogging" of their interfaces, that repeatedly shrouds the social media content with a murky, cloudy filter. The act of manipulating social media content through a distortion filter mimics the digital facial lenses offered by social media platforms like Snapchat [52]. To access social media, a user must then perform a physical removal of the filter via a wiping motion. The metaphor of wiping away fog from a mirror or window extends to the outcome of engaging in such an interaction; just as windows and mirrors reflect back a physical image of the viewer, my work demonstrates how physically constrained social media usage can inspire user reflection on their own social media behaviors and practices.

Fragile social media interfaces

The fragility of existing screen-based interfaces is evidenced by the plethora of protective casings and screen protectors that consumers buy and use for their smartphones and other devices [24]. Adding additional physical apparatus to a social media device, like the crank attachment of the *Crank Box* and *Cranker*, adds another element to the device that may break and compromise its functionality. Future critical designs for social media interfaces may deliberately include fragile components essential to the functionality of the interface, in

order to slow [45] the experience. Another way to leverage fragility in the design of social media interfaces is to require destruction and breakage of a part of the interface in order to access social media, like Pierce & Paulos's Obscura 1C Digital Camera, which requires a user to break the camera to access its captured photographs [108].

7.3 Beyond Social Media

Social media is a global phenomenon with vast political, social, environmental, and historical impacts. As policymakers, technology innovators, and global leaders search for solutions to the macroscopic, network-level issues like widespread misinformation, algorithmic bias, and consumer data privacy, my research narrows in on the scale of individual interactions with social media (Section 2.3.3, Figure 8). In particular, my work proposes a way for users to interrogate their own patterns of social media use and arrive at a clarified understanding of the value of social media in their lives.

There is an expansive opportunity to learn more about our attachments, anxieties, and curiosities around interactions with habitual digital technologies other than social media. Designers of other digital platforms and tools may consider applying my critical designs to domains outside of the social media canon (Chapter 1, Figure 1). In fact, the design considerations for building social media interventions may be extrapolated to any type of digital tool that has a nebulous purpose in a user's life that may benefit from reflection (i.e. video conferencing tools like Zoom, financial investing platforms, video game applications).

Chapter 8

Conclusion

In this thesis, I focused on how physically effortful social media experiences can provoke users to interrogate their personal behaviors and value toward social media. Based on research paradigms from *embodied interaction*, *tangible interfaces*, *critical design*, *persuasive technology*, and *slow technology*, I contribute a novel approach to designing social media interfaces that extend beyond the digital realm and require users to physically engage with devices to access social media.

I presented four critical designs of social media interventions with embodied constraints: the *Crank Box*, the *Cranker*, the *Shaker*, and the *Tilter*. These prototypes control the visibility of onscreen social media content based on how actively users perform physical gestures including *cranking*, *shaking*, and *tilting*. The four presented systems transform typical digital social media experiences into embodied experiences that raise the amount of physical effort it takes to interact with social media.

I hypothesized that adding embodied constraints like cranking, shaking, and tilting would add friction and discomfort to users' experience of social media that promotes reflective behavior instead of habitual use. I evaluated this hypothesis through a user study with twelve participants, who each used one of the four presented designs to access one of their typical social media platforms for a week-long intervention. Using a combination of quantitative data about social media usage and qualitative data from interviews and diary studies, I analyzed users' responses to the physical and interruptive qualities of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter*.

The results of my user study revealed that using the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* to access a specific social media platform caused a significant decrease in all users' time spent on that platform during intervention. The removal of these frictionful systems post-intervention caused users' low social media usage to either persist or rebound to match or exceed their pre-intervention patterns. Based on iteratively open-coded interview transcripts and diary study responses, I identified how the interventions affected user behaviors and values toward social media. Due to interacting with the interventions, users changed how and why they spent time on social media. Users demonstrated emergent social dynamics including novel collaborative, collocated ways of operating the social media intervention

systems. Interacting with the physical social media interventions also transformed users' attitudes towards social media and their understanding of their relationships with social media.

Based on the design and outcomes of the *Crank Box*, *Cranker*, *Shaker*, and *Tilter* interventions, I identified 7 categories of various design qualities that distinguish these intervention systems from typical digital social media interventions. I discussed and expanded each design quality into a generalizable design factor for building social media interventions. Accordingly, I proposed a set of 7 design considerations for the design of social media interventions, particularly those with embodied constraints.

I further presented design speculations on embodied designs for social media interventions that leverage interactions beyond *cranking*, *shaking*, and *tilting*. In particular, I speculated about a broad space of social media interventions that incorporate sensory interfaces, social presence, locative interactions, and unusual distortions of social media interfaces. Lastly, I remarked on the vast potential to apply insights uncovered by my social media intervention designs to other domains.

Building social media interventions with embodied constraints is a way to bring physicality, friction, and tension to digital social media experiences. Removing the physical ease of social media access grants users with something arguably more valuable: an exceptional responsibility and control over their social media experiences. With insight into how users value and use digital technologies like social media, users can learn to build healthier relationships with their social media, use the platforms more effectively, and increase the value social media experiences bring to their lives.

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