Media Prophylaxis: Night Modes and the Politics of Preventing Harm

Dylan Mulvin

Abstract: This article develops the term "media prophylaxis" to analyze the ways technologies are applied to challenges of calibrating one's body with its environment and as defenses against endemic, human-made harms. In recent years, self-illuminated screens (like those of computers, phones, and tablets) have been identified by scientists, journalists, and concerned individuals as particularly pernicious sources of sleep-disrupting light. By tracing the history of circadian research, the effects of light on sleep patterns, and the recent appearance of software like "f.lux," Apple's "Night Shift," and "Twilight," this article shows how media-prophylactic technologies can individualize responsibility for preventing harm while simultaneously surfacing otherwise ignored forms of chronic suffering.

Keywords: history of technology, history of science, screens, light, defaults, harm prevention, labor, infrastructure, mobile technology, circadian rhythms

In 2012 the American Medical Association (AMA) published a major report titled "Light Pollution: Adverse Health Effects of Nighttime Lighting," detailing the many health consequences and correlated problems of untimely light exposure. According to the AMA, these health effects may include, among other risks, accelerated tumor growth, reduced anticancer signals, increased rates of diabetes, a range of mood disorders, and depression.[1] Over the past thirty-plus years, untimely light exposure has taken on new prominence as a potential cause of harm through the loss and disruption of sleep. The world that the AMA portrays in its report is worth highlighting. The report begins by arguing that artificial light is a fact of contemporary human life: "Lighting the night has become a necessity in many areas of the world to enhance commerce, promote social activity, and enhance public safety."[2] Yet this fact

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Information & Culture, Vol. 53, No. 2, 2018

DOI: 10.7560/IC53203

of life, the report states, runs up against a potential conflict with human biology: "The power to artificially override the natural cycle of light and dark is a recent event and represents *a man-made self-experiment on the effects of exposure to increasingly bright light* during the night as human societies acquire technology and expand industry."[3]

This is not a new claim. For decades, artificial light has played the role of antagonist in what is perceived to be an otherwise natural relationship between people and the sun. In such an imagined relationship, humans possess a *natural and biologically compatible* relationship to the sun that is in conflict with an *artificial but socially necessary* relationship to lit and lighting technologies. To moderate this conflict, software and hardware makers have recently developed new "night modes" that promise to return humans to a more harmonious relationship with their lit environments. Unlike a hat, sunscreen, or the shade of a tree—technologies that protect humans from the rays of the sun—night modes draw on clinical research into circadian rhythms to create technological solutions to the problem of untimely light exposure.

"Media prophylaxis" is an analytic concept for describing and analyzing the arrangement and orientation of bodies and technologies according to the avoidance, prevention, and mitigation of harm from the form or content of media. Such an analysis is undertaken with the knowledge that the availability of less harmful orientations and arrangements is differentially understood and differentially distributed across populations. Media prophylactics—as the objectified form of these orientations—are the techniques, technologies, and design choices that are made on behalf of or by users to preempt the ill effects (whether imagined or concrete) of media use, participation, or environmental exposure. I argue that such techniques, technologies, and design choices can, in the right circumstances, lift the experiences of discomfort and debility that characterize somatic life into the realm of sentient fact.[4]

To approach the arrangement of people and things through prophylaxis is to understand that harm is difficult to prove, that pain and suffering wax and wane, and that no analysis can fully capture the felt, subjective reality of experiencing harm and suffering.[5] Yet just because subjective phenomena are difficult to explain and account for doesn't mean we should avoid reckoning with them. Quite the opposite: to approach mediated relationships through the lens of prophylaxis is to be concerned with how people, things, and environments are arranged and calibrated to ward off, prevent, and mitigate harm, *regardless* of its explanation or concrete cause. Moreover, the theoretical underpinning of media prophylaxis takes as a given that claims of pain and suffering are almost inevitably treated with suspicion; instead of refuting or assuaging

this suspicion, I argue that we ought to incorporate doubt as a constitutive feature of how people and things are arranged according to the perception of harm.

Dan Hassoun and James Gilmore have suggested that "*sleepiness* is a sensation that rarely abides fully by the desire to organize and routinize the everyday."[6] Likewise, this article treats chronic sleep disruption and its direct consequences (fatigue, exhaustion) and indirect consequences (possible carcinogenic risk, depression, and mood disorders) as a form of pervasive suffering that results from an irreducible conflict between working conditions, physical and physiological dispositions, and an incessant demand for more productive and cheaper labor. I want to suggest something else as well: that we are particularly bad at recognizing fatigue and exhaustion as sources of suffering. Instead, fatigue and exhaustion are treated as necessary conditions of modernity, industrialization, and the cost of social success.[7] Fatigue is treated as a shorthand for how hard we labor (at work, at home, at school) and not as a shorthand for how hard we are worked by our institutions and our environments.

Prophylactics emerge with corresponding harms and notions about the human bodies that are afflicted by or vulnerable to those harms. In other words, etiologies, diagnoses, and prophylactics develop in concert. The social production of a prophylactic is, concurrently, the production of new conceptions of human bodies: bodies before harm, after harm, and in the process of reducing or redressing harm. The prophylactic can be understood as an interface, or go-between, which operates as an interference, blockage, mitigator, or ward against complete capture by new threats. By warding off disease, prophylactics are an attempt to retain an existing order.[8] Prophylactics are one way of crystallizing, understanding, and debating the conflicts that are endemic to technological development. In this way, this article builds on the growing intersection of disability theory and the critical study of technology to understand how new ways of lighting the physical environment force us to reckon with exhaustion as a chronic and pervasive bodily condition.[9]

In this article, I undertake a history of contemporary night modes as examples of media prophylaxis. Beginning with the recent introduction of new night modes like Apple's "Night Shift" in the company's mobile iOS, alongside a growing awareness of the differential distribution of sleep and rest, I argue that night modes have recast sleep loss as a pervasive and potentially debilitating problem resulting from untimely screen use. I use this fact to launch a history of this form of harm and its attendant prophylactics. With the key discovery in 1980 that humans could disrupt their circadian rhythms using artificial light, the following three sections outline the history of circadian research underpinning night

modes. This research produced new understandings of light-induced sleep disruption and led, almost immediately, to technological solutions for controlling and mitigating light exposure. Throughout the 1980s and 1990s, artificial light research split, with some researchers attempting to manipulate light to protect the public from unwanted exposure and others working to harness the disruptive powers of light exposure as a therapeutic technology. In the early 2000s the discovery of an apparently novel light-perceiving cell in the "normal" human optical system drew on a small group of blind human test subjects and reignited concerns about artificial light and the effects of ubiquitous self-illuminated screens. This discovery repeated a well-worn research method where the exceptional bodies of people living with disabilities are used to isolate physiological functions. Prompted by this research, new concerns about the sleep-disrupting threat of untimely screen exposure led to the first software for filtering screen light appearing in the late 2000s. The paper concludes with a consideration of what night modes represent as artifacts of media and information history.

Night modes, as examples of media prophylaxis, are rich sites for understanding how nascent ideas about color, light, and perception shape and reshape screens and their aesthetics, how the responsibility for proper sleep management is individualized through screen modes, and how the objectification of potential harm in a new default setting can become the basis for future gains in recognition and repair. By treating them as a form of media prophylaxis, night modes can be understood as attempts to normatively disentangle a complex knot of untimely light, inflexible labor conditions, the convergence of work and leisure in portable screens, and the difficulty of engineering restful spaces and times. For Elaine Scarry, the only path to validating another person's suffering is for that experience to be objectified and lifted into a world of shared symbols and representations in a manner that retains its definite reference to the human body.[10] This means we must treat design itself as a form of symbolic representation and default operating conditions as a ratification of what designers believe ought to be "normal."[11] The implications for software, hardware, and interface engineering are significant. Far from mere utility, design and engineering choices are deeply ethical choices that propagate across ubiquitous devices, in heterogeneous contexts, and into the seams of everyday life.

Workin' on Our Night Modes

On March 21, 2016, Apple Inc. released a new version of its mobile operating system, iOS 9.3. The update made several tweaks to the system.

One conspicuous and much-discussed change was the incorporation of a new screen mode called "Night Shift." "Night Shift" is a new display setting that causes, by default, the screen to become more amber in color by shifting the temperature of the screen light away from the "high-intensity" bandwidths of the visible light spectrum (violets, blues) and toward the "low-intensity" bandwidths (yellows, oranges, and reds).[12] In the public event announcing the iOS update, Apple's Greg Joswiak describes how "Night Shift" works, stating, "When it's enabled, 'Night Shift' uses your iOS device's clock as well as its geolocation to know when it's sunset in your location."[13]

Apple introduced "Night Shift" as a response to growing concerns, like those expressed by the AMA, that self-illuminated screens contribute to widespread sleep disruption. These concerns were first expressed in clinical research in the 1980s, but are now increasingly repeated in popular press accounts and in the promotion of screen-based night modes like "Night Shift." Though sleep researchers have spent decades investigating the effects of artificial light at night (ALAN) on humans, mammals, and other organisms, new concerns about blue light, in particular, have gained currency beyond the scientific community. One current theory holds that exposure to artificial light in the hours leading up to a person's bedtime can severely hamper that person's ability to transition into sleep and maintain a deep sleep. As a solution to this problem, "Night Shift" and other prophylactic software applications (e.g., "Twilight" and "f.lux") claim that bodies and devices can coexist more harmoniously through automatic color and light calibration. Apple announced the update to its iOS with an appropriately salubrious offer. In the promotional copy for iOS 9.3, it announced the system as "a better experience every day. And night." In the small print copy, Apple states, "iOS 9.3 may even help you get a good night's sleep" (figures 1 and 2).[14]

"Night Shift" received widespread coverage at the time of its release and continues to be a popular topic in discussions about emergent interface design trends. In the days immediately before and after the release of iOS 9.3, coverage of the update sorted into two general categories: Apple fans and vigilant watchers of the corporation who embraced "Night Shift" as a positive gesture; and less partisan writers (e.g., newspapers, technology journalists, and bloggers) who warned against accepting the new screen mode as a cure-all solution to the many sleep- and attention-related issues associated with personal device use.[15] With such a mixed reception, we might wonder if Apple regretted its choice to emphasize "Night Shift" in the release of iOS 9.3. Our doubts could be put to rest, however, with Apple's next, much more significant overhaul of its iOS, version 10, which it released on September 13, 2016. In

A better experience
every day. And night.

This latest iOS release adds numerous innovations to the world's most advanced mobile operating system. There are improvements to a wide range of apps, along with great new additions to CarPlay. iOS 9.3 may even help you get a good night's sleep. And you'll find a preview of new features that will make using iPad in schools easier and better for students and admins.

Figure 1. Promotional copy for iOS 9.3: "A better experience every day. And night. This latest iOS release adds numerous innovations to the world's most advanced mobile operating system. There are improvements to a wide range of apps, along with great new additions to CarPlay. iOS 9.3 may even help you get a good night's sleep."

the new Control Center (figures 3 and 4), "Night Shift" grew in size and prominence, transforming from a small icon to occupying the largest portion of the menu: one button, square with rounded edges, stretched across the width of the Control Center, announcing its purpose: "Night Shift: Off Until 22:00."[16] The prominent placement of "Night Shift" reaffirmed its importance and its active entrenchment in Apple's device interface.[17]

Scientific and clinical research on how artificial light might disrupt sleep had historically focused on the implications for shift workers, who, since the 1970s, had been identified as the population most vulnerable to untimely light exposure.[18] In 1977 Randall Dunham wrote in the *Academy of Management Review* that there are both twenty-four-hour biological and social rhythms and that shift workers were out of phase with both, becoming "the deviant within the society."[19] Dunham made this comment before any relationship between artificial light exposure and sleep disruption had been established in the scientific literature. Today there are very few consensus avenues through which critics, activists, and concerned users can vocalize and lodge their complaints about

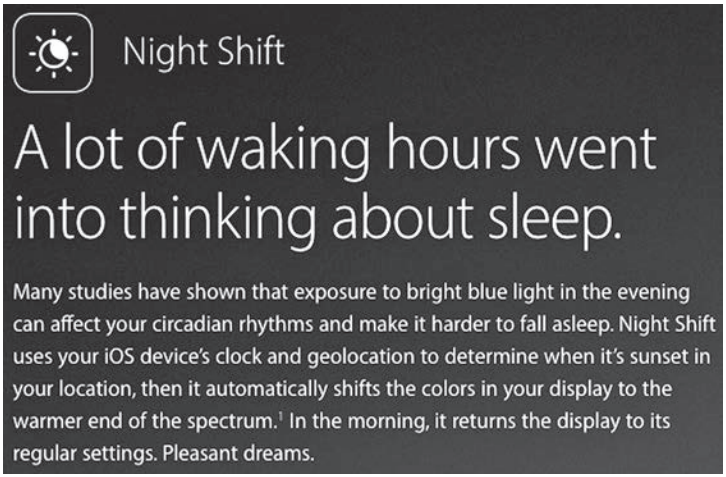

Figure 2. Promotional copy for iOS 9.3: "A lot of waking hours went into thinking about sleep. Many studies have shown that exposure to bright blue light in the evening can affect your circadian rhythms and make it harder to fall asleep. Night Shift uses your iOS device's clock and geolocation to determine when it's sunset in your location, then it automatically shifts the colors in your display to the warmer end of the spectrum. In the morning, it returns the display to its regular settings. Pleasant dreams."

endemic fatigue.[20] As Dunham's statement indicates, the people most at risk of light-based sleep disruption—shift workers—are cast as "deviants" instead of casualties, victims, or survivors of an unnecessary distribution of labor. However, in recent years, light pollution, the ubiquitous presence of illuminated screens, and the creep of work into every crevice of the day have all converged to make sleep loss into a problem suddenly worthy of a solution.[21] Popular press and scientific journals regularly publish articles on the risks of untimely light exposure, the need to practice proper "sleep hygiene," and the dangers of nighttime screen use. In 2016 the entrepreneur Ariana Huffington left her position running the *Huffington Post* to concentrate on a wellness start-up with a focus on sleep. Huffington also published a book, *The Sleep Revolution: Transforming Your Life, One Night at a Time*. Companies such as Procter & Gamble and the Goldman Sachs Group have also embraced a focus on sleep and rest by providing sleep hygiene courses to some employees, changing office

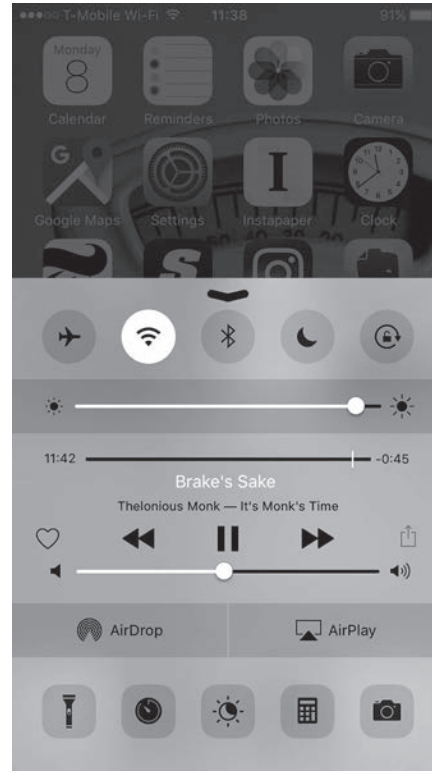

Figure 3. iOS 9.3 Control Center. "Night Shift" is in the center of the bottom row of buttons.

lighting schemes, and accepting "chrono-diversity" as an important aspect of maintaining high productivity.[22] In April 2017 the *New York Times* (a key venue, as we will see, for publishing provisional ideas about sleep management) ran a highly publicized feature in the Fashion & Style section titled "Sleep Is the New Status Symbol." An accompanying website instructed readers on "how to get a good night's sleep."[23]

To punctuate this trend, the 2017 Nobel Prize in Physiology or Medicine was awarded to three scientists (Jeffrey C. Hall, Michael Rosbash, and Michael W. Young) who isolated in fruit flies a gene that appears to regulate circadian rhythms. In their summary of the scientists' work, the Nobel committee wrote, "Their discoveries explain how plants, animals and humans adapt their biological rhythm so that it is synchronized with the Earth's revolutions."[24] While this was an award that honored basic science, the practical implications were presented as obvious. The committee concluded its summary with a now-familiar argument: "Our wellbeing is affected when there is a temporary mismatch between our external

Figure 4. iOS 10 Control Center. "Night Shift" occupies an entire row.

environment and this internal biological clock."[25] Here in the press release of the Nobel Prize are the stakes, however implicit, of light prophylaxis: a fundamental and biologically hardwired relationship of human beings to the sun is under constant assault from "external environments" that threaten to disrupt that relationship and with it our well-being.

The regular and vociferous publicity surrounding sleep hygiene shows an active redistribution of control and responsibility for rest: global and national health organizations are working to pathologize a range of diseases correlated with (if not attributable to) chronic sleep disruption at the same time as investment banks and corporate leaders are embracing chronodiversity for their highest-ranking employees and sleep is reconstrued as a status symbol; more American workers than ever labor outside of peak daylight hours; gains in so-called worktime flexibility have disproportionately benefited racially classed "white" workers and managers, while workers with less than a high school diploma are the least likely to have a flexible working schedule.[26] In other words, while there

is a greater emphasis placed on worktime "flexibility" and heightened awareness about the health consequences of sleep disruption, there is a greater inequality over who has control over the timing and quality of sleep. Rest, sleep, and darkness are scarce resources to which the already-privileged can gain easier access. Artificial light is far from the only or the greatest contributing factor to sleep loss and chronic fatigue. Yet the convergence of light, the pervasive presence of screens, and recent discoveries in optics and circadian physiology have, together, surfaced the inextricable relationship of labor, light, and sleep.

The unequal distribution of rest and darkness does not appear in the marketing of night modes or their interfaces. Instead, night modes individualize control over the lit environment through a content-agnostic approach to transforming the lightscape. Many prophylactics position bodies against perceived harms through the mechanisms of filtering and blocking—though *what* gets filtered or blocked and *at what register* varies widely.[27] We might sort kinds of media prophylactics according to their relationship to content and form. Some kinds of media prophylactics are *content agnostic*: for instance, ear plugs, air purifiers, and night modes are all designed to filter wanted and unwanted phenomena at the level of form. Though ear plugs are designed with some uses in mind (e.g., blocking the sound of snoring, industrial noise, neighbors, or coworkers), and they might, say, filter sonic phenomena between specific decibel thresholds, they do not discriminate against particular words or musical notes. Other prophylactics are, by design, *content partisan*: for instance, safe search algorithms, the "V Chip," the use of commercial content moderators in platform governance, and certain kinds of noise regulations, such as those that limit music or construction at certain hours.[28] Ear plugs and safe search algorithms may seem like an odd pairing, but they share a prophylactic logic for filtering media that plays out through vastly different tactics.

Since night modes are content agnostic, they do not yet discriminate against particular uses of light; instead, they operate by filtering targeted light bandwidths because of the apparent biological implications of untimely exposure. However, any division between form and content is always pragmatic. By framing screen-based night modes as a formal intervention, hardware and software manufacturers shift responsibility for the management of unwanted light exposure to users while simultaneously remaining nonpartisan about the uses of screens. By remaining nonpartisan, light-prophylactic technologies assert a neutral position toward the reasons that people end up looking at their phones in untimely ways (e.g., before bed and in the middle of the night). Light prophylaxis

suggests that a screen user can sever the harmful *form* of this problem (bright blue light) from the source of the demand (work, family, and social cohesion) with a nuanced understanding of the right screen color for the right time of day.

If night modes appear as a necessary response to a growing public health problem—the intrusion and pollution of space by artificial light—then they also acknowledge the world-making role of technological standards, infrastructures, and design choices. When a health scare or moral panic emerges related to consumer objects (e.g., guns, slot machines, soft drinks, seatbelts), manufacturers, users, and governments engage in a debate over the *locus* of harm. As Natasha Dow Schüll puts it, researchers, politicians, clinicians, and users all suggest their own answers to a common question: "Are the problems in the product, the user, or their interaction?"[29] The obvious answer is "Yes." Or, more accurately, products, users, and interactions are not separable. Yet, for the purposes of assigning responsibility, the locus of the problem needs to be determined by a competitive set of stakeholders. This is also the case with light prophylaxis: clinical researchers, medical officials, news outlets, and private technology operators have all contributed partial responses to the question: Is the problem of light-induced sleep disruption in the light, the user, or the relationship of people to their lights?

Apple's "Night Shift" is a vociferous contribution to this debate that argues that while the problem may be "in" screen light, the solution is in the user, who, armed with the equipment and promise of light prophylaxis, is responsible for judiciously transforming their screen into a more healthful artifact—regardless of the content. Light prophylaxis results from a complex history of light, labor, and sleep. "Night Shift," as the latest episode in this history, is exemplary of the ways that technological design exposes endemic ethical dilemmas born from the harmful and painful effects of technological use, labor, and bodily incorporation. The apparent outcome of a renewed focus on screen light is the increasing likelihood that the color temperature of our devices will shift, by default, to calibrate our bodies and their biological rhythms with our personal and professional spaces. If "Night Shift" acknowledges the disrupting effects of screen light on bodies, it simultaneously proffers that a soothing solution to these effects is accessible through *better forms* of screen light. Through the history of research into the health effects of light and the domestication of health concerns and technological solutions, we can better understand how "Night Shift" and similar attempts to mitigate light at the level of interfaces materialize novel understandings of harm related to technology use.

The Problem of Artificial Light in the Early 1980s

In recent years, scholars in science and technology studies, disability studies, and the critical and historical study of design (and allied fields) have investigated how the threat and awareness of harm and injury are incorporated into the crafting of technologies, infrastructures, and defaults so as to be more accommodating of human bodily variety and less harmful to more populations.[30] Night modes that are designed to reduce the perceived harms of screen light build on a longer history of so-called universal design practices.[31] Universal design, as a value, emerged from a postwar expectation—what Bess Williamson calls a "right to design"—that buildings, technologies, and material culture ought to function for a broader range of bodies.[32] Though organized protests by disability activists led to new building design regulations, consumer technologies were not required to meet the same accessibility standards. Still, some designers took up the cause of universal design in the 1970s as a "creative challenge and a source of innovation."[33] As Williamson writes, "Departing from conventional approaches to designing for the most common physical types, they considered the extremes of the human body—the impaired bodies of older people and people with disabilities—as a starting point for new designs."[34] Universal design was—idealistically—an attempt to craft new standards and default operating conditions that weren't based on the expected universality of a single human body but instead on the value of accessibility, broadly construed.[35] Early research in the effects of light on human biological rhythms similarly led to an interest in the ways design responds to the accommodation of bodily difference and environmental harm.

One origin story for the emergence of light prophylaxis is the 1980 publication of research by Alfred Lewy and his collaborators, which showed that humans, like other mammals, use light to cue themselves for sleep and wakefulness—a crucial circadian rhythm that governs the length of a person's day.[36] This process is called "circadian photoentrainment." Light serves as an external stimulus (or zeitgeber, in the parlance of circadian science) that resets the period of the internal clock.[37] The confirmation that humans calibrate their circadian rhythms through photoentrainment implied that human sleep was also susceptible to disruption by untimely exposure to bright light, whether "artificial" or "natural."[38] The basis for Lewy's research came from several previous findings, including the isolation of melatonin (a pineal hormone that, among other functions, signals sleepiness) by Aaron Lerner; Patricia DeCoursey's 1960 work showing that light could alter the sleep and wakefulness rhythms of flying squirrels otherwise kept in

darkness; and the Andechs Bunker studies of Rütger Wever and Jürgen Aschoff, who isolated hundreds of humans without time cues for weeks at a time in an attempt to discover a "natural" circadian rhythm.[39] In the twenty years following DeCoursey's discovery, no similar mechanism was identified in humans. Instead, researchers used evolutionary arguments to explain why humans were apparently immune to the effects of photoentrainment. Curt Richter, working out of the Johns Hopkins School of Medicine, wrote a widely cited article arguing that the artificial light of fire had, in fact, exerted a determining impact on human evolution by allowing humans to break an otherwise "natural" onset of sleepiness with the arrival of dusk.[40] Richter's now-debunked theory nonetheless set an important precedent that reappears in contemporary discourses around light prophylaxis: that the use of artificial light was a resource that opened up more hours of the day to being productive (hunting, being vigilant, procreating, etc.), but only if it was used sensibly.

The early 1980s therefore mark a moment in which the very categories of natural and artificial light were being worked out through clinical research and associated suppositions about human evolution, behavior, and lived environments. If artificial light is any light that is not received directly from the sun, then it comprises an incredibly diverse set of technologies, including everything from fire, candles, gaslight, incandescent lightbulbs, neon, cathode-ray tubes, LED screens, and LCD monitors. The only feature that holds together these technologies is their negative relationship to a concept of natural light. Moreover, the management of light, whether natural or artificial, has always entailed concerns about the quality, brightness, and mitigation of its effects. Just as the category of "artificial light" includes everything from fire to a car dashboard, and the category of light prophylaxis includes everything from hats, veils, sunglasses, and sitting under a tree, it is far from useful to delineate which of these technologies are more or less "natural"; instead, we should attempt to understand mitigation and prophylaxis as economical responses to the desire for or resistance to light exposure.

If we accept, then, that 1980s era research into photoentrainment prioritized a connection between light and time that manifests in biological rhythms, another way of thinking about the categories of "natural" and "artificial" is to consider whether there is a natural or artificial time to be awake. Researchers in the late twentieth century were asking, in effect, what a natural wakefulness rhythm is and which rhythms are established merely through social context. One obvious answer is that it is impossible to determine a human's natural relationship to light. What may be possible is understanding how humans have responded, with uneven efficacy, to the forms of consensual and involuntary photoentrainment that are

endemic to lit environments at home, at work, and in public. If we imagine that most people have some relationship to light generated from a place other than the sun, then we might ask how the power to manage that exposure is unequally distributed. To put it simply, some people have more darkness at night than others. What researchers in the 1980s were discovering was not only a biological connection between light and sleep but the health consequences of an uneven distribution of darkness.

Light Prophylaxis Goes Electric: Commercial Adaptation and Publicizing a New Harm

True to the intertwined development of harms and their prophylactics, Alfred Lewy's discovery of light-induced circadian disruption quickly instigated efforts to manage and reduce unwanted light exposure. Following the discovery of human circadian photoentrainment in the early 1980s, two important stages marked how that knowledge was understood and applied. First, through mainstream news sources, photoentrainment became a matter of public concern in the late 1980s; second, many people and organizations sought to capitalize on the potential threats and benefits of photoentrainment by creating technologies that either mitigated the effects of exposure or exploited artificial light's potential to reset one's own biological rhythms. In 1987 Charmane Eastman stated that Lewy's discoveries of light-based sleep disruption had "captured the interest of the media, and has led the public to expect instantaneous, permanent cures to modern man's circadian rhythm problems."[41] Already by the mid-1980s, researchers who foresaw the implications of photoentrainment for night- and alternative-shift workers understood their role as scientific emissaries to a concerned public.

Between 1988 and 1991, newspapers in Canada and the United States ran hundreds of stories publicizing the claim that artificial light could disrupt sleep patterns. Further press coverage showed how this research was leading to both prophylactic efforts and therapeutic technologies. The mainstreaming of the theory of human photoentrainment is encapsulated in two prominent articles that ran in the *New York Times* between June 1989 and April 1990. A front-cover article from June 16, 1989, titled "Recent Findings on Light Could Be a Boon to Sleep" detailed how researchers (most of whom were based at Harvard Medical School) had "uniform success" in forty-five attempts to alter the biological clocks of men between the ages of eighteen and twenty-four.[42] The article ends with a bulleted list of "therapeutic possibilities" that include "insomnia and other sleep disturbances," "sleep disruptions from working late or odd shifts," and "jet lag."

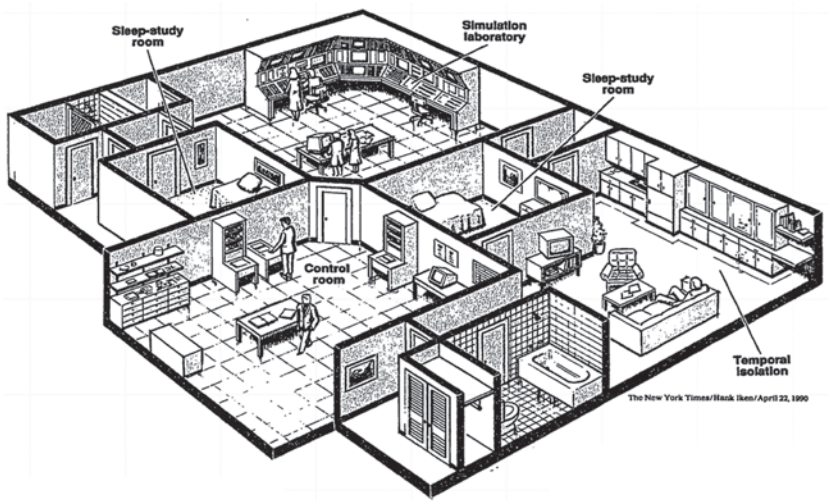

Figure 5. Diagram depicting the simulated control room at the Institute for Circadian Physiology in Boston, *New York Times*, April 22, 1990.

On April 22, 1990, the *Times* continued its coverage of changes to sleep science with a special exposé titled "Probing the Cycle of Sleeping and Waking." The exposé explored how a new consortium of insurance companies, university researchers, and a "host of utilities, oil companies and chemical refineries" was coordinating research at a Boston-based nonprofit called the Institute for Circadian Physiology. A diagram of a mock power plant control room showed how these researchers created a simulated environment for testing new the intentional manipulation of sleep and wakefulness (figure 5). As was typical of the coverage of photoentrainment from this time, the objectives of this research were always pitched as beneficial to both workers and their employers. The article's most prominent pull-quote, running directly under the diagram, proclaimed simply, "Circadian research may make life on the night shift easier." We also learn in this article that a for-profit consulting firm, Circadian Technologies Inc., had already worked with more than a hundred Fortune 500 companies.

From an early point, the benefits of a growing understanding of circadian physiology were understood by both researchers and their corporate sponsors as a way of both maximizing worker productivity and increasing comfort in the lives of those now-more-productive workers.[43] These twin motivations were captured in a quote from David Hayward, a manager of an electrical generation and transmission control facility

in Westborough, Massachusetts. Hayward states: "People who work shifts have special problems. . . . They have social problems and physical problems. If you have a better understanding of why these things occur, you can do something about it, and you're going to have better workers."[44] It is never suggested that the search for greater productivity might itself be a source of friction between people and their environments. Instead, like Apple's promotional copy for "Night Shift," a better night's sleep (with all the symbolic potency of that statement) and a more rested worker become one and the same.

If the press coverage surrounding photoentrainment indicates how new clinical science was becoming more public, then the transfer of this knowledge to technological applications conveys the limits of novel discoveries. By the late 1980s several patents had already adapted the new understanding of circadian rhythms, light, and sleep disruption into both prophylactic and therapeutic technologies.[45] The same Harvard researchers profiled in the *New York Times* patented the application of this research for resetting and manipulating circadian rhythms. In 1987 they filed a patent for a technique of "assessment and modification of circadian phase and amplitude."[46] Another patent for the Bright Light Mask was filed by Roger J. Cole in 1987 and appears to be the first example of the application of new circadian discoveries to a technology made by a person from outside the research community (figure 6). The Bright Light Mask, which resembles a contemporary virtual reality headset, had as its primary objective "to provide a light weight and portable

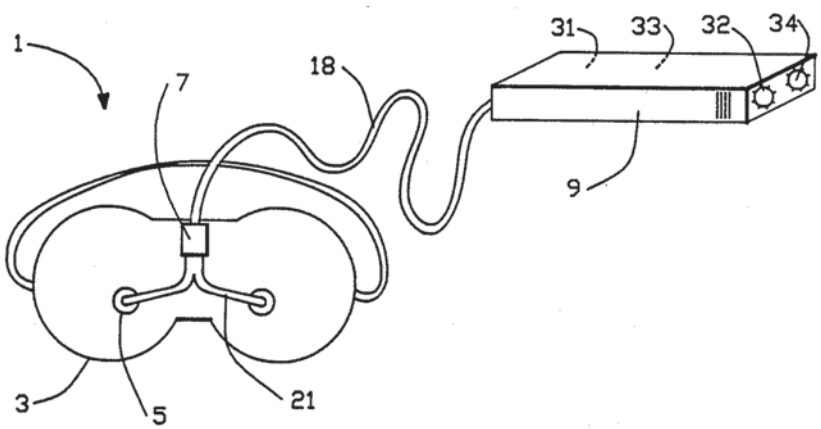

Figure 6. Bright Light Mask diagram from Roger J. Cole's patent. The mask is on the left, and the controller on the right contains a means of varying the intensity and setting a timer.

bright light source capable of generating a light intensity bright enough to modify human biological rhythms."[47] In other words, a person might pack a Bright Light Mask in their luggage to handily blast their eyes with light in order to, say, reset their circadian rhythms while battling jet lag.[48] The swift appropriation of circadian science in patentable applications is one manner in which novel understandings of harm create correspondent prophylactic and therapeutic techniques for harnessing that knowledge. What these early patents share is a reliance on the very limited and provisional understanding of photoentrainment from this period. Over the next twenty years, the threshold reported for the amount and kind of light capable of disrupting a circadian rhythm changed considerably. Whereas in the late 1980s a very bright light was believed necessary disrupt a person's circadian rhythms, by the early 2000s *any screen* was now a potential antagonist.

Circadian Rhythms and Blues: Light Prophylaxis in the Twenty-First Century

In 2001 George Brainard and his collaborators suggested that they had evidence of a previously unidentified optical mechanism that regulated melatonin suppression.[49] What Brainard called the Novel Circadian Photoreceptor was identified by Farhan Zaidi and others in 2007 as "intrinsically photosensitive retinal ganglion cells" (ipRGCs).[50] These cells, located at the back of the human eye, monitor changes in light and send signals to the nervous system that regulate many physiological processes, including the onset of sleepiness. Though relatively little is known about these cells, the early clinical science demonstrated that they are activated by exposure to high-energy wavelengths of light, or what most people see as blue. In plain English, researchers now believe that a part of the human eye (a previously unknown cell type) can hamper one's ability to fall asleep if it is exposed to enough blue light. There is much to be said about this discovery and the way it has developed in the years since, but I want to highlight two salient features of the discovery: first, the identification of ipRGCs came from research that was conducted on blind persons lacking rods and cones; which meant that, second, these light-detecting cells exist and appear to operate separately from the image-forming parts of the eye. By examining these features together, we can understand how a novel media-prophylactic technique—the orange-tinted screen of "Night Shift" and other similar technologies—emerged in the late 2000s and early 2010s.

The identification of ipRGCs was possible because there are humans with eyes who lack rods and cones yet still possess other optical cells and

nerves.[51] It was already known that people completely lacking eyes were liable to "free run"—people without eyes cannot entrain their circadian sleep rhythms using light stimuli. In other words, the physiological understanding of the relationship between light and sleep has long been established through blind people as test subjects. Zaidi's group showed that people lacking rods and cones whose eyes were otherwise intact were still able to set their circadian rhythms using light stimuli. Where people with all three photoreceptor cells might present more confounding variables than those with "only" one kind of cell, a class of blind person could serve as a control group for isolating a novel mechanism.[52]

The history of technology is characterized by a well-established irony: while new communication technologies and infrastructures are often created and honed through tests using users living with disabilities, impairments, or unexpected bodily functions, those very same users must regularly demand basic accommodations to actually use these pieces of technology.[53] This is also the case with night modes. When Apple writes, in its promotional copy, that "many studies have shown that exposure to bright blue light in the evening can affect your circadian rhythms," it is referring to studies conducted on a minuscule subset of the blind population who served as test subjects in isolating previously undiscovered facets of human eyes. The history of circadian research is marked at key moments by research into normal and deviant behavior that draws on insights developed through the bodies and behaviors of "normal" and "exceptional" humans.

Disciplines across the sciences and humanities frequently rely on disabilities, impairments, and prostheses as symbolic tools, as grounds for philosophical quandaries, and as test cases.[54] And because scientists and researchers often rely on users with disabilities to test theories, cultural historians recapitulate these relationships in their accounts of technological history. As a result, as David Mitchell and Sharon Snyder write, "disability underwrites the cultural study of technology writ large."[55] We see this process unfold in the ways light-based sleep disruption has unfolded in scientific research and its reception. *New Scientist* reported the discovery of ipRGCs in an article titled "Blind People 'See' Sunrise and Sunset"; the American Association for the Advancement of Science's blog reported, "Blind humans lacking rods and cones retain normal responses to nonvisual effects of light"; and *Nature* has described the discovery of the new cells as "seeing without seeing."[56] These articles, like Zaidi's research, simultaneously embraced an unconventional understanding of vision while fully embracing an instrumentalized understanding of people living with one form of blindness. To say that people without rods and cones who also possess ipRGCs also *see* because they

are using light to set circadian rhythms is an inclusive and expansive understanding of vision. Yet, these proclamations are based on a tiny sample of people, a flattening of the different forms of blindness, and the assumption that there are "normal" responses to light, both visual and nonvisual. It is taken as routine that exceptional human bodies can be used to form assumptions and make new technologies for other human bodies that are not exceptional in the same ways. Vision, in other words, is always differential and never fully allied with the production of images. Nonetheless, for many people, light structures a relationship to space and time that surpasses its function as an image-forming medium. It is precisely this function—the ways that light enters the body and patterns it to the lived environment—that compelled the production of new night modes as prophylactic filters.

The instrumental use of blindness in circadian research produced a finer differentiation between the optical mechanisms involved in sleep disruption. This had cascading results. With new mechanisms came corresponding distinctions in the functions of light (light as image versus light as nonimage stimulus), kind of light (disruptive versus nondisruptive), and people (those who experience light as form and content versus those who only experience form). These sets of distinctions established the context in which night modes appeared as the newest form of media prophylaxis used to fend off sleep loss. If research scientists had reduced the focus of light-based circadian disruption to a narrow set of light bandwidths, a suitable prophylactic technique would target those bandwidths. But since all LED-backed screen technologies use high-intensity blue light to form images, the range of antagonistic actors was immense and had increased by many orders of magnitude since the discovery of light-based melatonin suppression in the 1980s. The contemporary set of media prophylactics for combatting untimely light exposure therefore had to parse a new problem: filtering light at the right time, from devices that are everywhere, in ways that fit existing patterns of behavior and expectations for the aesthetic and luminous qualities of screens.

In 2009 the husband-and-wife team Lorna and Michael Herf released f.lux, software that users install on their computers to automatically adjust the color temperature of the monitor to blend with the ambient color temperature of the room. According to an account the Herfs gave to *Scientific American*, they "simply intended to harmonize the lighting scheme in their home" but also soon discovered that f.lux "might offer some health benefits as well."[57] The Herfs speak explicitly about mimicking nature and the fact that computer screens appear to "spoil" the existing ambience of interior architecture.[58] From the profile in *Scientific American*:

> The Herfs' goal was to mimic natural shifts in ambient light as closely as possible, transitioning from the bright, bluish-white light characteristic of morning and afternoon sunshine to a dim, orange glow in the evening.
>
> At first, they simply intended to *harmonize* the lighting scheme in their home. But they soon began to suspect that their new app, dubbed f.lux, might offer some *health benefits* as well.[59]

On the website for f.lux, the Herfs position the software as a public service and include a special section containing resources for people who have trouble sleeping, including a report detailing the dangers of reading on a tablet versus reading a paper book, details of the couple's "f.luxometer" for measuring color calibration, and a bevy of research on circadian science from the Brigham and Women's Hospital.[60] These resources are an attempt to shore up f.lux's credentials as a legitimate prophylactic technique and to distinguish it from other pseudoscientific applications of photoentrainment research.

When f.lux was introduced it immediately recapitulated the fears of artificial light that accompanied the circadian research of the 1980s, posing a distinction between a prelapsarian natural order and postlapsarian order dominated by an intrusive artificial lighting infrastructure. This is not just a view propagated by software evangelists, it is an empirically demonstrated phenomenon that undergirds scientific research. A recent article in *Current Biology* begins with the premise that artificial light has fundamentally disrupted a natural relationship to light: "The electric light is one of the most important human inventions. Sleep and other daily rhythms in physiology and behavior, however, evolved in the natural light-dark cycle, and electrical lighting is thought to have disrupted these rhythms."[61] Debra Skene, a chronobiologist at the University of Surrey in England, ties the entire history of light-based sleep disruption and prophylaxis together: "Before we had all this technology, before electricity and artificial lighting, we would be awake in daylight, *have a little bit of fire* in the evening, and then sleep."[62] The picture that Skene paints is thoroughly moralistic, implying not only that an imagined earlier state of humanity was unperturbed by contemporary lighting technologies but that these humans were judicious about their use of their own artificial light. No one imagines cave dwellers binge-watching fire or leaving the torch on all night to stare, glassy-eyed, at a hunting manifest. Instead, contemporary screen technologies are figured as engineered in ways that enervate humans in particularly malignant ways; and humans are figured as especially susceptible to the attraction of these harmful actors.

The discovery of ipRGCs isolated a small range of bandwidths of light as primarily responsible for the suppression of melatonin and an associated disruption in circadian rhythms. By focusing on a narrow band of the visible light spectrum, the discovery shifted the focus from shift workers and frequent flyers to all users of self-illuminated screens. This was only possible if we understand this discovery as the continuation of a process that began in the 1980s, with its separation of natural and artificial light and an accompanying separation of the "form" and "content" of light. The idea that light operates on people through their eyes in ways that are not experienced as vision has immense implications for how we think about perception, optics, and the physiological effects of engineering and design. As if trying to fulfill Marshall McLuhan's dictum that electric light is "pure information" and a "medium without a message,"[63] the separation of "light as image" and "light as invisible physiological disruption" also transformed the prophylactic approach to mitigating this effect. By 2001 light was newly imagined as even more thoroughly infrastructural, as it was now understood to also operate below the threshold of perception.

It is in this context that we return full circle to Apple's "Night Shift," the first attempt by a major manufacturer to incorporate light prophylaxis into the default operating conditions of its devices. It's here that we can finally note the serendipity or naive coincidence that Apple named its screen mode after the very people who were originally imagined to be most at risk of sleep disruption: night shift workers. The name further ignores the ways that changing the color of screen light does nothing to change the demands on people's labor that may dominate their time and their sleep. Instead, "Night Shift," f.lux, and similar prophylactic techniques perform their filtering operations at the level of form and remain agnostic about the reasons that some people might not be able to afford darkness, namely, that the content of their light requires them to look at a screen.

Conclusion

In theory, night modes smooth over the differences in working times and chronotypes (a person's proclivities to fall asleep at certain times and for varying lengths of time). When Apple added "Night Shift" to its operating system, it represented the hardwiring of clinically identified harms into the iconic architecture of a device interface. I have used harm and its materialization in interfaces to surface implicit understandings of the social, physical, and emotional costs of technology. Media interfaces increasingly take on the responsibility for managing, mediating, and

mitigating the effects of such harms and, more generally, the conflicts of work, leisure, and sleep.

When a technology is said to cause harm, there are some conventional ways that we imagine people achieve remediation and redress. In a typical scenario, a problem is identified by an affected group and a manufacturer or firm resists accepting responsibility; eventually, people organize and agitate; if the agitation achieves some success, it might mean that a lawsuit, new regulation, or boycott leads to the problem being addressed (even just temporarily); and the social relationships that preexisted the agitation are remade. Despite prominent examples like the Americans with Disabilities Act and the Architectural Buildings Act, in the United States, a less stringent American regulatory framework (relative to other jurisdictions) has often necessitated that harmful design choices be redressed through lawsuits.[64] As the histories of both disability accommodation and liability laws show, design choices that are explicitly made to mitigate and prevent pain, suffering, and harm are often responses to coordinated acts of agitation, organization, and legal action.[65] As Lochlann Jain has argued in the American context, "The law does far more than recognize, measure, and compensate injuries. It does the political and social work of determining what will count as an injury and, ultimately, how it will be distributed through product designs."[66] This may also be the case with "Night Shift" and similar efforts, if Apple and like-minded designers, engineers, and manufacturers are preemptively acting to stave off lawsuits. We could imagine, for instance, that smartphones and default display colors are being redesigned to complement a legal system that rewards a verifiable identification of negligence.[67] However, barring some surprising revelation, a full and frank explanation for "Night Shift" is likely not coming.

I want to suggest two conclusions to this article. The first is what we might say night modes tell us about an emergent prophylactic relationship between screens and people. The second conclusion is what media prophylaxis, as a conceptual framework, can do for our understanding of how bodies and technologies are organized according to both novel and long-standing imperatives to prevent and mitigate harm.

By understanding the history of night modes as a recent form of prophylaxis, we see that they offer a solution that individualizes and atomizes the responsibility for controlling one's own exposure to light. By transferring the duty of care to individual and away from institutions, device manufacturers can tacitly protect themselves from accusations of negligence through the selection and propagation of new default settings. Second, night modes are informed by a turn toward design ethics like Behavioral Design and the idea that people ought to be "nudged"

for the social good.[68] The fact that light prophylaxis operates at the level of form instead of content and the fact that such efforts target individuals instead of collectivities as the sites of remediation and responsibility serve a political purpose; once the solution to disrupted sleep becomes a question of judiciousness, education, and self-care, it displaces the role of labor, presence creep, and the inexorable demands on attention that pull people and their devices together.[69] By shifting and atomizing responsibility in a device interface, night modes leave only the individual user as accountable for the management of their own pain and discomfort.

Finally, building on the preceding analysis, what can media prophylaxis tell us about the organization of people and technologies? I argue that a focus on the prophylactic arrangement of people and technologies provides new understandings of harm and suffering that can provide some potential grounds for possible redress. Following Scarry, a focus on media prophylactics *can* serve as the objectified representation of suffering, which *could* become a platform for future recognition of harm. Night modes join contemporary conceptions about the source of exhaustion with a history of investigating the unequal distribution of light at night, the unequal distribution of working times, and the unequal distribution of worktime flexibility. By turning our attention to both emergent and well-entrenched practices of media prophylaxis, we can understand apparent design fixes as responses to agitation *and* as the materialization of harm; in turn, this recognition can become the scaffolding for further gains in representation and recognition.

A major structuring force in the world is the organization of people, through technology, against the perceived threat of harms. As such, an analysis of prophylactic techniques is not *only* a relational approach to looking at technology. Media prophylaxis is a way of understanding a fundamental template for relationships between people and things that conditions somatic life. If we think about media as social structures of communication and prophylactics as methods developed to prevent harm, then media prophylaxis is the intersection of the two: a term designating the social structures of communication that distribute people and things according to the prevention of harm.[70] At a moment when light prophylaxis appears as a necessary response to a growing public health problem—untimely light intrusions—there is heightened awareness and acknowledgment of the world-making role of technological standards and infrastructures. Examining how techniques of media prophylaxis emerge, solidify, and become common sense is one way to understand the ways technologies are posed as solutions to the need to constantly calibrate our bodies to our environments.

Notes

1. American Medical Association (AMA), "Light Pollution: Adverse Health Effects of Nighttime Lighting," *Reports of the Council on Science and Public Health* (2012): 265–79. There is no conclusive evidence that supports many of these claims. Nonetheless, the diversity of potential ill health effects has been key in creating fear and awareness about untimely light exposure since the late 1980s.

2. Ibid., 265.

3. Ibid., 266, emphasis added.

4. For a discussion of debility and sentience, see Julie Livingston, *Debility and the Moral Imagination in Botswana* (Bloomington: University of Indiana Press, 2009).

5. This formulation draws on Tobin Siebers's work in *Disability Theory* (Ann Arbor: University of Michigan Press, 2008) to reconsider the subjective experience of pain and suffering as phenomena that surpass medical and legal definitions of harm. Disability theory has helped us to understand the ways that disability has been understood and mobilized as, at times, a medical diagnosis and category used to control populations; a socially produced and contextually specific relationship of people and environments; and as a minority and cultural identity that intersects with other forms of cultural and minority identity. We might also consider disability as a name for specific ways of being and interacting with the world that often exhaust the limited flexibility of normative design choices.

6. Dan Hassoun and James N. Gilmore, "Drowsing: Toward a Concept of Sleepy Screen Engagement," *Communication and Critical/Cultural Studies* 14, no. 2 (2017): 103.

7. Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley: University of California Press, 1992).

8. Mary Douglas, *Purity and Danger: An Analysis of Concepts of Pollution and Taboo* (London: Routledge, 1966).

9. I am building directly on Julie Livingston's theorizing of "debility" as "the impairment, lack, or loss of certain bodily abilities." Livingston writes, "Certain bodily states pose problems. Debility is one such state because it troubles, mobilizes, and intensifies social relations." *Debility*, 2, 3.

10. Elaine Scarry, *The Body in Pain: The Making and Unmaking of the World* (New York: Oxford University Press, 1985).

11. Defaults are often talked about as powerful mechanisms for creating desired behavior without coercion (what Shah and Sandvig call "de facto regulation") and as the crystallizations of implicit assumptions. In this way, they function very similarly to how scholars theorize norms and design standards that assume a universal human subject who is almost always imagined to be an able-bodied heterosexual cisgender white man of medium stature. For more discussion of defaults, see Rajiv Shah and Christian Sandvig, "Software Defaults as De Facto Regulation: The Case of the Wireless Internet," *Information, Communication & Society* 11, no. 1 (2008): 25–46; Lawrence Lessig, *Code: Version 2.0* (New York: Basic Books, 2006); Tarleton Gillespie, *Wired Shut: Copyright and the Shape of Digital Culture* (Cambridge, MA: MIT Press, 2007); Helen Nissenbaum, *Privacy in Context: Technology, Policy, and the Integrity of Social Life* (Stanford, CA: Stanford University Press, 2009).

12. "Intensity" here refers to the differences in wavelength frequencies in the visible light spectrum (itself just a tiny slice of the electromagnetic spectrum). "High-intensity" light has a high frequency of waves (like a choppy ocean),

while "low-intensity" light has a lower frequency. These properties of light waves, in combination with human perceptual apparatuses, are what make different things appear different colors.

13. Joswiak is an executive at Apple responsible for iOS, iPhone, and iPad product marketing. The whole address is available at https://www.youtube.com/watch?v=0wIiDnjz4X4.

14. Apple website, http://www.apple.com/ios/updates/, accessed August 5, 2016.

15. For an example of the positive reception, see "Why Apple's Night Shift in iOS 9.3 Will Help You Get a Better Night's Sleep," *AppleInsider*, March 22, 2016, http://appleinsider.com/articles/16/03/22/why-apples-night-shift-in-ios-93-will-help-you-get-a-better-nights-sleep. For a more tepid reception, see Benny Evangelista, "Apple's Blue Light Special Can Help Sleep, but Not a Panacea," *San Francisco Chronicle*, March 24, 2016, http://www.sfchronicle.com/business/article/Apple-s-blue-light-special-can-help-sleep-but-7044772.php; and Katherine Hobson, "Apple's New Night Mode Doesn't Mean You Should Take Your Tablet to Bed," FiveThirtyEight.com, March 30, 2016, http://fivethirtyeight.com/features/apples-new-night-mode-doesnt-mean-you-should-take-your-tablet-to-bed/.

16. The Control Center is, by default, the only part of the phone that is accessible without a passcode or use of fingerprint identification.

17. Beginning with the Mac OS operating system version 10.12.4 (released in March 2017), "Night Shift" is now included on desktop and laptop devices, promising a continuity of luminosity and color temperature between devices if one uses multiple up-to-date Apple products.

18. The World Health Organization's International Agency for Research on Cancer (IARC) published a 2010 report that specifically looked at the carcinogenic risks to humans who perform shift work, with an investigation on the risks of artificial light exposure and pollution. See *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 98, Painting, Firefighting, and Shiftwork* (2010).

19. Randall Dunham, "Shift Work: A Review and Theoretical Analysis," *Academy of Management Review* 4 (1977): 628.

20. Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty* (Durham, NC: Duke University Press, 2006).

21. Melissa Gregg, *Work's Intimacy* (Cambridge: Polity, 2011).

22. Lauren Weber, "Go Ahead, Hit the Snooze Button," *Wall Street Journal*, January 23, 2013.

23. Penelope Green, "Sleep Is the New Status Symbol," *New York Times*, April 8, 2017, https://www.nytimes.com/2017/04/08/fashion/sleep-tips-and-tools.html; Penelope Green, "How to Get a Good Night's Sleep," *New York Times*, April 8, 2017, https://www.nytimes.com/interactive/2017/04/08/style/how-to-get-a-good-nights-sleep.html.

24. "The Nobel Prize in Physiology or Medicine 2017," https://www.nobelprize.org/nobel_prizes/medicine/laureates/2017/press.html.

25. Ibid.

26. Terence M. McMenamin, "A Time to Work: Recent Trends in Shift Work and Flexible Schedules," *Monthly Labor Review—Department of Labor Statistics* (2007).

27. See Andrea Millwood Hargrave and Sonia Livingstone, *Harm and Offence in Media Content: A Review of the Evidence* (Bristol, UK: Intellect, 2009).

28. Agnosticism and partisanship may not always be clear and may shift over time. For instance, one piece of light-shifting software, f.lux, offers a "Movie mode" that temporarily shifts a screen's colors to accommodate the time it takes

to watch a film. Similarly, noise-canceling headphones are a difficult case. While they are engineered to filter out *all* noise that could interfere with the perception of what is streaming out of the headphones—and in this way are agnostic about what they block—they also presuppose a separation of signal and noise that is automatically partisan. See Mack Hagood, "Quiet Comfort: Noise, Otherness, and the Mobile Production of Personal Space," *American Quarterly* 63, no. 4 (2011).

For more discussion of filtering, blocking, and content partisanship, see Gillespie, *Wired Shut*; Lillian Radovac, "The 'War on Noise': Sound and Space in La Guardia's New York," *American Quarterly* 63, no. 3 (2011); Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900–1933* (Cambridge, MA: MIT Press, 2002); Jeremy Packer and Kathleen F. Oswald, "From Windscreen to Widescreen: Screening Technologies and Mobile Communication," *Communication Review* 13 (2010).

29. Natasha Dow Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton, NJ: Princeton University Press, 2012), 16.

30. In this article, I am particularly indebted to the work of Mack Hagood, Aimi Hamraie, Lochlann Jain, Mara Mills, Michelle Murphy, Natasha Dow Schüll, Jonathan Sterne, and Bess Williamson, who have all analyzed the ways that technologies and built environments surface normative understandings and structured relationships of human perception, behavior, and experience.

31. Though the field of ergonomics is often associated with the notion that our workplaces ought to be safe and comfortable, it originally emerged from the demand for greater worker efficiency and standardized materials: ergonomic design choices were those that could satisfy both demands. The study of both human factors engineering and ergonomics developed from a demand to produce clothing and military equipment (e.g., cockpits, weapons, uniforms) for a "common" body type. As tools of standardization, these new sciences were not primarily concerned with reducing an individual's own personal frictions with his technology but with reducing the overall friction of supplying a military or workforce with usable materials. See David Meister, *The History of Human Factors and Ergonomics* (Mahwah, NJ: Lawrence Erlbaum Associates, 1999).

32. Bess Williamson, "Getting a Grip: Disability in American Industrial Design of the Late Twentieth Century," *Winterthur Portfolio* 46, no. 4 (2012); Meister, *The History*; Aimi Hamraie, "Designing Collective Access: A Feminist Disability Theory of Universal Design," *Disability Studies Quarterly* 33, no. 4 (2013); Edward Steinfeld and Jordana Maisel, *Universal Design: Creating Inclusive Environments* (Hoboken, NJ: John Wiley and Sons, 2012).

33. Williamson, "Getting a Grip," 213.

34. Ibid.

35. Elizabeth Ellcessor, *Restricted Access: Media, Disability, and the Politics of Participation* (New York: New York University Press, 2016).

36. Alfred Lewy et al., "Light Suppresses Melatonin Secretion in Humans," *Science* 210, no. 4,475 (1980): 1267–69.

37. The English word "circadian" refers to anything that recurs daily. The Latin roots of the word translate roughly as "about a day": *circa*, "around"; *dies*, "day."

38. To say that all humans respond to light in predictable ways is false. Most humans use light to cue sleep and wakefulness. People without eyes or with a completely severed optical nerve are not susceptible to the same effects of light.

39. Aaron B. Lerner et al., "Isolation of Melatonin, the Pineal Gland Factor That Lightens Melanocytes," *Journal of the American Chemical Society* 80, no. 10

(1958): 2587; Patricia J. DeCoursey, "Daily Light Sensitivity Rhythm in a Rodent," *Science* 131, no. 3,392 (1960); Michael Globig, "A World without Day or Night," *Max Planck Research* 2 (2007): 60–61.

40. Curt Richter, "Discovery of Fire by Man: Its Effects on His 24-Hour Clock and Intellectual and Cultural Evolution," *Johns Hopkins Medical Journal* 141, no. 2 (1977): 47–61.

41. Charmane Eastman, "Circadian Rhythms and Bright Light: Recommendations for Shift Work," *Work & Stress* 4, no. 3 (1987): 245–60.

42. Women are usually excluded from sleep studies of this kind. The reasoning is that the hormones associated with menstruation have an unpredictable effect on sleep patterning. This kind of reification (using a biological process experienced by some people to exclude a person of a particular gender identification) highlights some of the obvious shortcomings of circadian research, whose practitioners nonetheless claim universal application for their results.

43. Eastman, "Circadian Rhythms."

44. Edmund Andrews, "Probing the Cycle of Sleeping and Waking," *New York Times*, April 22, 1990.

45. A related but not identical trend was emerging in the marketing of special eyeglasses and computer monitors that promised to reduce eye strain. While competing research on green- and amber-colored monochrome computer monitors suggested that one was worse for human eyes than the other, new glasses like Blu Blockers promised to both protect your eyes "and at the same time improve your vision with the most incredible breakthrough in sun glasses since they were first introduced." The marketing of Blu Blockers by their creator, Joseph Sugarman—a notorious pitch man who was sanctioned by the Federal Trade Commission for a thirty-minute infomercial that masqueraded as a public service announcement—unwittingly foreshadowed the twenty-first-century turn to blocking blue bandwidths as a key development in light-prophylactic technology. Blue-blocking glasses are now considered as a possible prophylactic against light-based sleep disruption. In the 1980s, however, Blu Blockers had to settle for other pseudoscientific claims. Quote from a Blu Blocker advertisement in *Field & Stream*, February 1987, 1.

46. Charles Czeisler, Assessment and Modification of a Subject's Endogenous Circadian Cycle, U.S. Patent 5,163,426, filed June 26, 1987, and issued November 17, 1992.

47. Roger J. Cole, Bright Light Mask, U.S. Patent 4,858,609, filed December 4, 1987, and issued August 22, 1989.

48. This is similar to the use of bright and full-spectrum lights used by populations who receive low amounts of sun (say, people who live in regions closer to the poles).

49. George Brainard et al., "Action Spectrum for Melatonin Regulation in Humans: Evidence for a Novel Circadian Photoreceptor," *Journal of Neuroscience* 21, no. 16 (2001): 6405–12.

50. Farhan Zaidi et al., "Short-Wavelength Light Sensitivity of Circadian, Pupillary, and Visual Awareness in Humans Lacking an Outer Retina," *Current Biology* 17, no. 24 (2007): 2122–28.

51. This description applies to less than 5 percent of the total population of people living with blindness.

52. Zaidi's group were not the first to rely on the blind for their research into circadian rhythms. Even in Lewy's landmark study on melatonin suppression, he gestures to deeper connections between light and circadian rhythms

by noting that "infertility is more common in blind women" ("Light Suppresses Melatonin," 1268).

53. Jonathan Sterne, *MP3: The Meaning of a Format* (Durham, NC: Duke University Press, 2012); Mara Mills, *On the Phone: Deafness and Communication Engineering* (forthcoming, Duke University Press).

54. Georgina Kleege, "Blindness and Visual Culture: An Eyewitness Account," *Journal of Visual Culture* 4 (2005); Mara Mills and Jonathan Sterne, "Afterword II: Dismediation: Three Proposals, Six Tactics," in *Disability Media Studies* (New York: New York University Press, 2017).

55. David Mitchell and Sharon Snyder, *The Body and Physical Difference: Discourses of Disability* (Ann Arbor: University of Michigan Press, 1997), 8.

56. Andy Coghlan, *New Scientist*, https://www.newscientist.com/article/mg19626354.100-blind-people-see-sunrise-and-sunset/; "Cell Press," https://www.eurekalert.org/pub_releases/2007-12/cp-bhl121307.php; Corie Lock, *Nature*, http://www.nature.com/news/2011/110119/full/469284a.html.

57. Ferris Jabr, "Blue LEDs Light Up Your Brain," *Scientific American*, November 1, 2016, https://www.scientificamerican.com/article/blue-leds-light-up-your-brain/.

58. Ibid.

59. Ibid., emphasis added.

60. f.lux, https://justgetflux.com/research.html, accessed August 5, 2016.

61. Kenneth Wright et al., "Entrainment of the Human Circadian Clock to the Natural Light-Dark Cycle," *Current Biology* 23, no. 16 (2013): 1554.

62. Jabr, "Blue LEDs," emphasis added.

63. Marshall McLuhan, *Understanding Media: The Extensions of Man* (London: Routledge, 1964), 8.

64. Sarah S. Lochlann Jain, *Injury: The Politics of Product Design and Safety Law in the United States* (Princeton, NJ: Princeton University Press, 2006); Ellcessor, *Restricted Access*.

65. Jain, *Injury*.

66. Ibid., 2.

67. Ibid.; John C. P. Goldberg and Benjamin C. Zipursky, "The Restatement (Third) and the Place of Duty in Negligence Law," *Vanderbilt Law Review*, 2001.

68. See, for instance, the work of B. J. Fogg at Stanford University, who describes Behavioral Design as "connecting people to nature" (http://bjfogg.org/nature/); see also Fogg, "Creating Persuasive Technologies: An Eight-Step Design Process," *Proceedings of the 4th International Conference on Persuasive Technology* (2009), https://dl.acm.org/citation.cfm?id=1542005; Richard Thaler and Cass Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness*, 2nd ed. (New York: Penguin, 2009).

69. Gregg, *Work's Intimacy*.

70. Lisa Gitelman, *Always Already New* (Cambridge, MA: MIT Press, 2006).