Toward a Design Theory of Sleepy Games

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Abstract
For many, healthy sleep is either not a priority or not a possibility, a deficit which has far-reaching consequences. We explore the potential for "sleepy games" as a genre of transformational games with embedded content, relevant in both the digital and physical design space. We present design challenges unique to sleepy games, synthesized through an iterative design process. *Lights Out*, one of nine sleepy games created, provides an example of our insights in context.

Author Keywords
Game design; transformational games; sleep; games for health.

CCS Concepts
•Human-centered computing → Human computer interaction (HCI);

Introduction
A good night of sleep has an enormous impact on quality of life. Healthy sleep influences everything from learning outcomes [25]; to risk for Alzheimer's, heart disease, and cancer [24]; to mortality [12]. Sleep allows us to function properly, think clearly, play joyfully, and work effectively. However, in the United States, more than 30 percent of adults [10] and 70 percent of adolescents [9] are sleep

deprived. The pace and pressures of contemporary culture push for increasing productivity within the 24 hour day. Smartphones are ubiquitous and, if not actually in bed, typically within arm's reach. Not only that, many jobs demand sleep patterns which are out of sync with the body's circadian rhythms, such as 36 hour shifts for nurses and time incentives for truck drivers. All of these factors push people to sacrifice both sleep quantity and quality.

In the face of these strong cultural pressures, how can technology effectively support healthy sleep? Existing efforts focus on educating users, visualizing users' sleep data, encouraging mindfulness, and helping with sleep timing. These approaches all handle sleep problems *explicitly*, which may induce avoidance or reactance [19]. In this paper, we explore a subtler approach to supporting healthy sleep. Transformational games [7] with *embedded* content [19] can help users improve their sleep while circumventing their psychological defenses.

As of now, little is known about how to create effective "sleepy games," our term for games that support healthy sleep using embedded design techniques. We explore this area using a *research through design* approach [26]. Nine different game design teams developed playable game prototypes over the course of eight months. These prototypes were based on literature reviews, interviews with stakeholders, and the transformational game framework [7]. The prototypes were then iterated upon for playability and relevance. In this paper, we look across the nine games to identify principles for sleepy game design, so that other designers can begin to work productively in this relatively unexplored space.

Literature Review

Obstacles to Healthy Sleep

Although sleeping habits may seem natural, in reality, it is not easy to obtain and maintain healthy sleep. For adults, adequate sleep means at least seven hours of restorative and comfortable rest, and children need more than ten [15]. There are multiple kinds of barriers that prevent people from getting the sleep they need.

First, some jobs make it hard to follow a regular work-sleep schedule. When a person's work schedule and biological clock are out of sync, the schedule may force them to work while the body tells people to sleep, and vice versa [11]. For example, nurses and doctors often work during the night, and have to interrupt their sleep for patients and emergencies. This prevents them from forming a regular sleep-wake cycle [11]. Some shift workers "bank" their sleep to make up their sleep lost. However, even one night of total sleep deprivation can decrease cognitive functioning and impair memory [14].

Second, sleep disorders often stand in the way of getting healthy sleep. Common disorders include insomnia, sleep apnea, restless leg syndrome, and narcolepsy. These disorders are related to genetic, medical, and psychological factors [3].

Third, lifestyle norms make it hard for people to be prepared for healthy sleep. A recent survey found that ninety percent of Americans used some type of electronics within an hour of bedtime, at least a few nights per week [6]. Additionally, for people who travel frequently, jet lag disrupts a regular sleep cycle [23].

Finally, people may have misconceptions about sleep that prevent them from taking related corrective measures. For instance, some people think that snoring does not interfere

Category	Condition
household	live alone share a bed have children
pain	chronic illness physical pain
mood	anxiety depression
schedule	night shifts swing shifts on-call
breathing	CPAP ventilator
sleep away	live at college business travel hospital stays

Table 1: User groups with barriers to healthy sleep.

with sleep; others believe insomnia means difficulty falling asleep and do not consider staying asleep as a problem to be addressed [22].

Existing Technologies for Healthy Sleep
Existing technological approaches to support sleep fall into four major categories: explicit instruction, data visualization, timing support, and improving mindfulness.

Explicit instruction. These technologies educate users about their sleep environment, sleep routine and daytime activities. For example, *Perfect Bedroom* [20] conveys information through an educational game, while *SleepCoacher* gives personalized recommendations [8].

Data visualization. Sleep analytics, such as visualization of sleep patterns, leverages the capabilities of sensors on mobile phone to classify behaviors into asleep/awake with relatively high accuracy [21]. These data are then used to model sleep quality and duration, and reflect this information back to the user.

Timing support. One of the main contributing factors for healthy sleep is timing, including regular sleep schedules and timing for inducing sleep or waking. *iPhone Bedtime* [17] helps users develop and retain a sleep schedule. Similar applications attempt to synchronize users' sleep schedule with their natural rhythm, such as the Philips Wake-up Light [1].

Improving mindfulness. Mindfulness can improve sleep quality [4]. While the above three approaches rely on *explicit* support for healthy sleep, mindfulness technologies facilitate healthy sleep *indirectly*. For example, *Headspace* helps users practice meditation [18], while *emWave* guides the user to reduce stress through patterned breathing exercises [4].

Game Design Approaches
Games are an existing approach within human-computer interaction to solve complex behavior change problems. There is an existing operative games paradigm of game research which leverages knowledge gained through gameplay to exert control upon the world [5]. Our approach was inspired by the Transformational Game Framework [7], which supports building connections between a problem to be addressed and game design practice. The framework comprises of a set of exploratory questions, and prompts the game development team to consider aspects of the transformation, such as high-level purpose, audience, context and barriers. Additionally, we build on the Embedded Design approach, which argues that subtler approaches to transformation can have a greater psychological impact than more explicit ones [19]. Finally, in understanding how to describe this design space, we were inspired by "cozy games." These games incorporate safety, ambience, and abundance; they eschew time pressure or individual responsibility, as described in the Cozy Games Manifesto [16]. We use this work as an example of how to define a space for a different kind of play.

Methods
In this work, we used a research through design approach [26]. Over the course of eight months, nine game design teams created sleepy game prototypes. Each interdisciplinary team was composed of three or four students, ranging from undergraduate to PhD students, all of whom had at least some game design training. Student backgrounds included art, computer science, design, psychology, human-computer interaction, educational technology and applied learning sciences. Teams spent between four and fourteen weeks developing their games.

Each team selected a user group that had barriers to healthy

Figure 1: *Lights Out* prototype.

Figure 2: *Lights Out* sensory components.

Figure 3: *Lights Out* cards.

sleep from a list developed in collaboration with sleep experts (see Table 1). Teams used a range of research methods, including literature reviews and interviews with stakeholders, to develop a sense of the problem space. This material was used to flesh out a transformational approach for each game [7]. Teams used an iterative design process to create their games, beginning with rough game sketches and developing them into physical prototypes.

The team collected a set of design artifacts from this process, including designers' descriptions of the problem space, documentation of their design process, and multiple iterations of each game. This material was analyzed using methods drawn from [13], to bring out common design challenges faced by different groups.

Sample Game

Due to the constraints of the short paper format, we present an example game, *Lights Out*, which in our team's analyses illuminated all seven design challenges (agency and control, intervention timing, social embeddedness, multisensory experience, arousal, vulnerability, and identity and values). *Lights Out* is a tactile game designed to promote healthy sleep for a family with a child (or children) aged 3-5. By making the child's bedtime routine more efficient and dependable, the nightly routine for adult(s) in the household can begin earlier, such that everyone is able to get to bed sooner.

The modular smart lights are paired with routine cards, affixed in the physical location where the task occurs (bedroom, bathroom); and the game begins with all the game lights on. As the child completes a task, they tap the corresponding light to turn it off. The routine has been completed when the child is in bed, and the only light remaining is by the bed. At this stage, a paper "dream ticket" is released, onto which the adult can write or draw whatever the child has requested to dream about. The child keeps the dream ticket under their pillow. The child can either keep the final light on as a night light, or turn it out.

Lights Out situates bedtime as one part of a larger timeline. The game enables a family to decide together upon a bedtime routine for the child during a time of the day or week other than bedtime, and keep it consistent for many days or weeks at a time. This efficiency does not translate to sacrificing quality family time; however, meaningful interactions are promoted through gameplay, such as talking about what the child hopes to dream about. *Lights Out* also addresses the socially embedded societal pressures or value conflicts that the adult may feel around bedtime expectations and developmentally appropriate practice for their child. The physical components of the game are designed to embody the aesthetic and sensory qualities of sleepy games.

Design Challenges

Our team identified seven challenges that sleepy games must address: agency and control, intervention timing, social embeddedness, multisensory experience, physiological and mental arousal, vulnerability, and identity and values. In this paper, we briefly describe these seven areas. In future work, we will expand our analysis, describe additional games, and provide additional insights from playtesting.

Agency and Control

One challenge in designing sleepy games is that sleep seems inherently at odds with 'doing' something in order to get more of it. Sleeping people cannot act volitionally. Similarly, direct methods to aid in sleep, such as counting sheep, do not reliably work, and may induce reactance in the user. A sleepy game approach addresses this issue through embedded design, as discussed above [19]. Sleepy

games do not directly tell the player to sleep - a task which they cannot reliably accomplish even if they wanted to. Instead, they embed the desired sleep transformation into a secondary physical or mental transformation that *can* be accomplished, and that is more subtle than an explicit directive to sleep. As we will see below, the barriers stopping players from achieving healthy sleep are usually linked to other parts of their lives. By addressing these barriers rather than addressing sleep directly, players can indirectly control their sleeping life.

Intervention Timing

A common assumption about transformational games is that they are played at the time of the transformation. However, sleep is often mediated by behaviors that happen at non-sleeping times of day. For example, caffeine intake during the day can affect sleep. One interviewee commented that given their two children, "for us, bedtime starts at lunch." Additionally, sleep can be affected by long-term changes, such as seasonal affective disorder. A sleepy game approach recognizes that gameplay can affect sleep at many times of day - for example, at lunchtime - and on many timescales. Sleepy games therefore need to consider replayability over one-shot fun, sustained engagement over instant transformation, and relevance to the user's larger life context rather than only when players are trying to sleep.

Social Embeddedness

Sleep may on the surface appear to be a solitary activity: no one else can sleep on your behalf. However, the decisions that people make about sleep are highly embedded in their social context. For example, players may share a bed or a room with another person. They may be responsible for another person's sleep schedule, such as primary caregivers for children. They may experience social pressures that affect their sleep choices, such as an invitation from one's manager to have a cup of coffee late in the day, or a night shift worker's desire to stay awake to spend time with their family. Sleepy games directly address the social component of sleep. Sleepy games may be multi-player, involving a number of different stakeholders. Sleepy games are also mindful about how they affect the sleep of non-players. Finally, sleepy games embrace the opportunity games offer, of creating new social norms for the playful context. By understanding existing norms that can introduce barriers to sleep, sleepy games can create counter-norms that reduce those barriers.

Multisensory Experience

Sleep is a highly embodied experience and can be affected by all five of the senses. Good sleep hygiene involves creating an environment conducive to sleep. Sleepy games consider the body as a core element of the design. For example, a sleepy game design process considers not only the game rules, and what the player says or does, but also what the player hears, smells, touches, sees, and even tastes. These choices may be manifest in the game materials, or in the environment in which the game is played. For example, a sleepy game designed to be played in bed would take into account the player's physical position (lying down), the appropriate level of lighting in the room (low), and the materiality of game pieces (no screen, calming to the touch).

Physiological and Mental Arousal

A major challenge to falling asleep is high physiological or mental arousal. A racing heart or a racing mind can make it hard to relax. However, arousal levels are not instantaneous phenomena. Having an optimal level of arousal for sleep at bedtime may mean *increasing* arousal earlier in the day, or addressing long-term sources of high arousal such as anxiety. Sleepy games recognize that sleep-related experiences do not always need to be relaxing. For example, sleepy

games can address high mental arousal by matching it with games that require high cognitive load. By distracting players from their racing thoughts, the overall goal of healthy sleep can be supported.

Vulnerability
Sleep is our most vulnerable state; a perception of danger and uncertainty is built-in. For example, when sleeping in an unfamiliar environment, people experience partial arousal all night, and do not sleep deeply [2]. Sleepy games embrace play as a way of directly addressing vulnerability. They tackle sensitive and intimate topics surrounding sleep, such as bedtime routines, sleep attitudes, and sleep-related issues (e.g. depression or chronic pain). They use playfulness and embedded design techniques to transform behaviors that are often protected by players' defensive tendencies, and to help players embrace being vulnerable rather than avoid it.

Identity and Values
Sleep habits and preferences are interconnected with identities and values. For example, parents are typically busy, but also see bedtime as an important time to reconnect with their children. They therefore want a bedtime routine that is both meaningful and efficient. Sleepy games recognize these value conflicts, and are designed to address players' value and identity needs. Instead of telling parents to put their children to sleep early, for example, a sleepy game approach would increase the efficiency of the bedtime routine, help parents and children playfully connect, and let parents feel like good parents while playing.

Conclusion and Future Work
In this paper, we have explored a design approach we call "sleepy games." Sleepy games address problems of healthy sleep using embedded design techniques. Over eight months, we created and iterated upon nine sleepy game prototypes. From analysis of our design artifacts and documentation, we identified seven cross-cutting challenges of designing games for sleep, and articulated the sleepy games approach to addressing each one.

In future work, we will expand on the sleepy game design approach. A full paper is forthcoming in which we will demonstrate how games from our dataset addressed each of these challenges. We will include descriptions of key game mechanics, user insights, and playtest findings. Additionally, we will share the design tools we have developed for addressing these issues, such as time mapping techniques for sleep-relevant events. We look forward to sharing this work with the transformational game design community.

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