

From Self-Tracking to Sleep-Hacking: Online Collaboration on Changing Sleep

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With growing interest in how technology can make sense of our body and bodily experiences, this work looks at how these experiences are communicated through and with the help of technology. We present the ways in which knowledge about sleep, and how to manipulate it, is collectively shared online. This paper documents the sleep-change practices of four groups of 'Sleep Hackers' including Nurses, Polyphasic Sleeper, Over-sleepers, and Biohackers.

Our thematic analysis uses 1002 posts taken from public forums discussing sleep change. This work reveals the different ways individuals share their experiences and build communal knowledge on how to 'hack' their sleep – from using drugs, external stimulation, isolation, and polyphasic sleeping practices where segmented sleep schedules are shared between peers. We describe how communal discussions around the body and sleep can inform the development of body sensing technology. We discuss the opportunities and implications for designing for bodily agency over sleep changes both in relation to collaboratively developed understandings of the body and social context of the user. We also discuss notions of slowly changing bodily processes and sensory manipulation in relation to how they can build on the exploration of soma-technology.

CCS Concepts: • **Human-centered computing** → **Empirical studies in collaborative and social computing**; *Empirical studies in HCI*.

Additional Key Words and Phrases: Sleep; Bio-hacking; Forum study; Sleep behavior

ACM Reference Format:

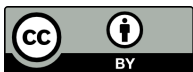
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1 INTRODUCTION

The advent of a host of new consumer-grade bio-sensors [74], alongside different wearable technologies, has renewed a focus on the body as a site for technology use. New research around Somaesthetics [32] and approaches to the intersection of health and technology, alongside a longstanding interest in embodiment in HCI, CSCW and related fields, has inspired new thinking about how technology can interact with and even be part of our bodily processes. These developments connect with CSCW's longstanding interest in how communities and health interact.

In this paper, we explore one such bodily process – sleep – and how communities work to explore and manage short and long-term changes to sleep practice. Sleep is an interesting case in that it is partially under our conscious control but also affected by longer-term patterns of activity and slow bodily processes. Moreover, as with many body processes, sleep practice is widely discussed in

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online health communities. Forums provide a site where people can share personal experiences and collaboratively support and understand problems with their bodies. This paper analyses the online postings of so-called ‘sleep hackers’ – users who are actively attempting to manipulate their sleep patterns. Sleep hackers include **shift workers**, such as nurses who need to change their sleep patterns for work, **polyphasic sleepers**, who seek to escape from the normal ‘8 hours at night’ pattern, **biohackers**, who aim to influence their sleep through controlling biological processes, and **over-sleepers** who struggle to regulate when they sleep and for how long. Through iterative coding of Reddit posts, we explore *what*, *why* and *how* communities actively discuss sleep change practices, alongside reflecting on the actual practices of fitting non-normative sleep into everyday life. These findings let us explore how bodily processes are socially conceptualised and managed in online health forums and how sleep is not something that is simply ‘produced’ by our body, but can be actively hacked through online collaboration. That is to say, how online forums support the social production of our taken-for-granted bodily processes.

We structure our findings into three parts. First, through the discussions of these online forums, we document how sleep as a bodily process is described neither as an act of will where the time and duration of sleep can be chosen nor as something untouchable or beyond conscious control, but rather something that can be manipulated to the will of the sleeper. Secondly, we document how users share their goals in changing their sleep: Focusing on being awake and at times aiming to minimise hours asleep. Thirdly, we discuss the challenge of fitting sleep into life. Engaging with sleep can be complex, weighing long-term body adaptation against maintaining social commitments and social life more broadly.

In conclusion, this work contributes to CSCW by documenting how bodily processes can be part of an active health community, with the body as an active object of manipulation, but also the many practices and challenges of sleeping non-normatively. Through this, the paper revisits discussions of bodily processes and experiences in technology and explores how we might rethink the user as both a more active and community-involved agent in these processes but also as one that is subject to social and economic conditions not entirely of their own making. This presents an interesting opportunity for future design: one where the bodily agency is cared for through collaborative exploration, social setting, long-term changes and felt experiences.

2 BACKGROUND

In this section, we discuss the previous CSCW work on online communities, introduce how sleep science approaches sleep and the cultural and social setting of the sleeper, and then turn to the growing corpus of technology research on sleep technology, and bodily interaction.

2.1 Online communities

CSCW has long used online communities as a probe to understand behaviour and community structures [54, 61, 75], but also more broadly to investigate users motivations for their participation in online forums and communities [42] or wider inter-community dynamics, such as group conflict [22]. Forum postings and user participation in online communities also constitute a rich form of data that frequently informs research and design [27, 34, 37, 62]. Researchers have analysed online posts to look at diverse user groups, from middle-school aged summer camp attendees [62], through those trying to become pregnant [38] to sign language users [14] and user experience designers [40].

In particular, online health communities have been a particular site of continuous research. These are places where people can share personal experience and knowledge between peers around specific health conditions such as managing HIV [11], addiction recovery [51], social feedback in weight loss communities [18], and men experiencing fertility issues [63]. Support through online

forums provides users with alternative and anonymous way to get support when expert help is costly [53, 56, 92] – where members exchange informational support [85]. Recent work has also explored issues such as the discussion of mental health across different health communities in different cultural settings [64]. One framework utilised to understand the process in which members find and understand health informatics is through the lens of community ‘sensemaking’ [54]. This puts an emphasis on how individuals create frameworks that inform their decisions [70]. Sensemaking has further been understood in collaborative settings as ‘collective’ or ‘collaborative’ sensemaking [54]. This refers to the process where members actively pursue common goals or work together to make sense of new information. This can take shape through generating shared vocabularies [79] or through establishing artefacts. Meaning-making in online health forums is also at times done through a search of how to create structure in relation to the disruption of normalcy – a search for a ‘new normal’ [63].

In the case of Reddit, where anonymity is a norm [38] and posting is free, this supports communities built around inquiry into health and the users’ bodies. In particular, there are communities on Reddit dedicated to both ‘hack’ life and one’s body, such as food hacks¹, or cold water training², and to ‘track’ through leveraging self-tracking data [38]. Of interest for our research here, Reddit contains a number of forums which engage with sleep, and in particular the management (and manipulation) of sleep in different ways.

2.2 Understanding Sleep

Medical sleep research has explored the many different physiological and psychological processes of sleep, alongside the social processes that regulate individuals’ sleep needs and sleep practices. While there is much debate in sleep research and many open research questions, there is consensus that sleep is a sequence of phases of Rapid Eye Movement (REM) and Non-Rapid Eye Movement (NREM) sleep. NREM can further be broken down into segments that include deep sleep [15]. Sleep quality is often evaluated by estimating the lengths of these sleep phases through a combination of sensors. The gold standard of sleep sensing is polysomnography – combinatory tracking that includes EEG for brain activity, EOG for eye movements, EMG for muscle movements, ECG for heart rate, breathing detection, body position, rib movement, and sounds [74]. These sensors have been simplified in the form of commercial sleep tracking systems that rely on cheaper and less invasive sensors such as accelerometers and microphones for sleep stage detection and PPG for tracking heart rate and respiration [6].

Sleep is regulated by two processes: homeostatic pressure and the circadian rhythm. Homeostatic pressure is built up during awake hours, and released by sleeping. If the pressure that is built up during the day is higher than the amount released through sleep it is carried over as a *sleep debt*. The circadian rhythm follows a ~24h cycle and influences sleep drive, but also the oscillation of the body temperature and alertness throughout the day [13]. To entrain stability, circadian rhythms need to be synchronized each day. This is achieved through a combination of both environmental clues, such as light [10], and social factors [89]. Misalignment between these processes and one’s schedule, such as in the case of insomnia, can be a result of many different factors including stress or issues with the sleep environment. Problems with sleep are often treated either through recommending sleep hygiene or prescribing medication. These processes are influential in the waxing and waning alertness of individuals over the course of the day, but also in the success and length of attempts to go to sleep.

¹<https://www.reddit.com/r/foodhacks/>

²<https://www.reddit.com/r/BecomingTheIceman/>

While physiological processes are of course key, sleep cannot be isolated from the cultural and social factors which influence the goals, environment, availability, and pervading attitudes towards it. When we sleep, and when it is socially acceptable for us to sleep, is heavily influenced by the culture in which we find ourselves. As culture changes, so do sleep. Indeed, in many cultures sleep is at times bi-phasic [86]: divided into two segments of sleep separated by an hour or more of time spent awake during the night. Segmented sleep is more often built from naps, such as in the widespread use of nap and siestas [59]. Naps during workdays have been both of social and political significance, such as the right to *xiu xi* (short rests) in Mao's constitution in China [29], the disappearing siesta in Spain [29], or the culturally acceptable *inemuri* (short naps) in Japan [80]. Taking napping further, *polyphasic sleepers* [72] discuss attempts to split all sleep into a series of short naps throughout the day.

Other cultures view sleep as a necessary but unwelcome 'dead time' [57], a view that has persisted since well before our industrial society³, and revolves around the idea that those who are important or highly productive achieve this by sacrificing their sleep [87]. Yet much of our modern life relies heavily on night workers in roles central to society such as blue light personnel, delivery workers or transport personnel, with resultant non-normative sleep schedules. Even for those in 9-5 employment, there are indications that expectations of availability in the modern workforce encroach on time for sleep [68].

2.3 The social body and technology

Sleep is an essential and integral bodily process, and as such, it has become an ever more popular site for the application of technology to understand, expose, and manipulate our bodily experiences. There is a growing corpus of work investigating bodily properties through the use of technology [30]. One such example is the emergence of somaesthetics in HCI, a theory proposed by Shusterman stating that the body, (or as it is called: the Soma) is central to all experiences of life [78].

Somaesthetics combines theory, pragmatism and praxis towards cultivating a greater appreciation of our senses and thereby enriching our engagement with the world around us [77]. This lens has implications in design [32] and has led to increasing work using autobiographical methods that encourage the use of a designer's first-person experience to engage through the body with design materials, which can include the body itself, as a way to ground design in how the technologies can be experienced by others. As a result of this self-reflection in design, a reoccurring theme can be seen in a lot of soma design technologies where they are in turn designed to encourage users to reflect on their experiences. We see this being used in design processes in work around woman's health [83], drones [26], and touch interactions [76]. Understanding sleep through a qualitative lens has also been approached with self-reflection through autoethnography [48] or through the use of games [68].

A contrasting approach to understanding the body is through self-study and quantifying aspects of everyday life [50]. This is often done with bio-trackers for menstrual tracking [25], fitness tracking [90], food tracking [49] and tracking for sleep as outlined above [71], and for those items more difficult to technologically count, activities such as bullet journaling are often employed [4].

The view of the body as a quantifiable object or somaesthetic appreciation differs in practice, where one evaluates the body and the other articulates the sensory and felt experience of being, they often also differ in the vision for the future [33]. The quantified self is built on ideas of self-improvement through monitoring, speculating on humans being able to reach their potential and optimal life through understanding its data [17] – while self-reflections using somaesthetics

³"Uneasy lies the head that wears a crown" King Henry the Fourth, Part Two, William Shakespeare.

sensory appreciation are less focused on the optimal, rather on “deepening the experience of their own felt bodily sensations” [33].

Both somaesthetic appreciation and bio-tracking are ways of understanding and ultimately ways for the users to communicate about their bodies. The complex relationship often set up as a faux dichotomy between the objective and subjective experiences of sleep and its physical and mental outcomes, points to an opportunity to draw from both approaches to understand the human experience of sleep – through how it is communicated and socially understood. It is on this note we turn to ‘sleep hacking’ communities online, where the experience of sleep is the core of the discourse.

2.4 Sensing sleep

Many of these recent efforts are built on an understanding of the users’ sleep through bio-tracker readings, using readings from one or more consumer-grade sensors either on body or in the sleeping environment – such as PPG for heart-rate and respiration [6], body temperature sensors, microphone readings, and 3D accelerometer for movement tracking. Sleep sensing has been a growing field, where sleep technology research has put considerable effort into exploring *how* and *when* people track their sleep, often by looking for less obtrusive ways to bio-track to minimise disruption of sleep. This has been approached by leveraging smartphone sensors [16, 93], smart textiles [31], personal radar systems [69], data-driven personal sleep recommendations [20], or even dreams [7, 12, 28]. While mostly designed for individuals, sleep tracking has been extended to research sleep environment tracking [35] and multi-user health tracking [65].

However, earlier work has reported that users fail to see these visualisations as *actionable*; it is hard to know what ones should do to improve one’s score [47]. Zhang et al. argues that there is a need for actionable interventions to improve sleep quality and health [91]. Sleep scores and efficiency metrics can also lead users to try to influence variables that are hard to change, such as sleep phases, instead of caring for influenceable factors of sleep. Ravichandran et al’s review criticize such trackers for rich yet inconsistent data that can sometimes conflict with clinical standards, possibly leading to harm [71]. Ko et al. point out that most trackers lack validity studies and that sensory accuracy may be limited, such as when the bed is shared [39]. Yang et al. found that users struggled in assessing the accuracy and in understanding how inferred values were calculated [90].

Much of the work in this area that has expanded into support of users’ self-tracking practices put increased focus on the user’s agency. Such work includes the SleepExplorer, which aids users to explore correlations between sleep data and contextual information [46], SleepBandit, which supports the user through ‘guided agency’, discussing the balance between scientific rigour and the user’s everyday practices [21], ShutEye that utilises the peripheral display on the wallpaper for aiding users with advice for good sleep [5], SleepBeta that brings agency to teenagers and their sleep through sleep tracking [66], and Self-E which lowers the barrier to users through mediating self-tracking experimentation [19].

In conclusion, where the previous research on sleep changes is often focused on ways people track their own sleep, this work provides an in-depth look at the ways existing sleep hacking forums conceptualise sleep change with the goal to *manipulate* sleep. Through the perspective of somaesthetics [78], and informed by the existing research on collaborative sensemaking and self-experimentation, this work takes the online discussion on sleep change actions as a starting point for a discussion on how to technologically increase users’ agency over sleep.

3 METHOD

The rich source of data presented by public online communities to inform the HCI and CSCW communities on the use and design of technology has been the base for a growing number of

publications (as described in section 2.1). Focusing solely on Reddit, Proferes et al. [67] reviewed 727 papers incorporating data from its posts and comments in the last decade. We situate our data collection and analysis methods within this wide corpus of published Reddit and online health forum studies.

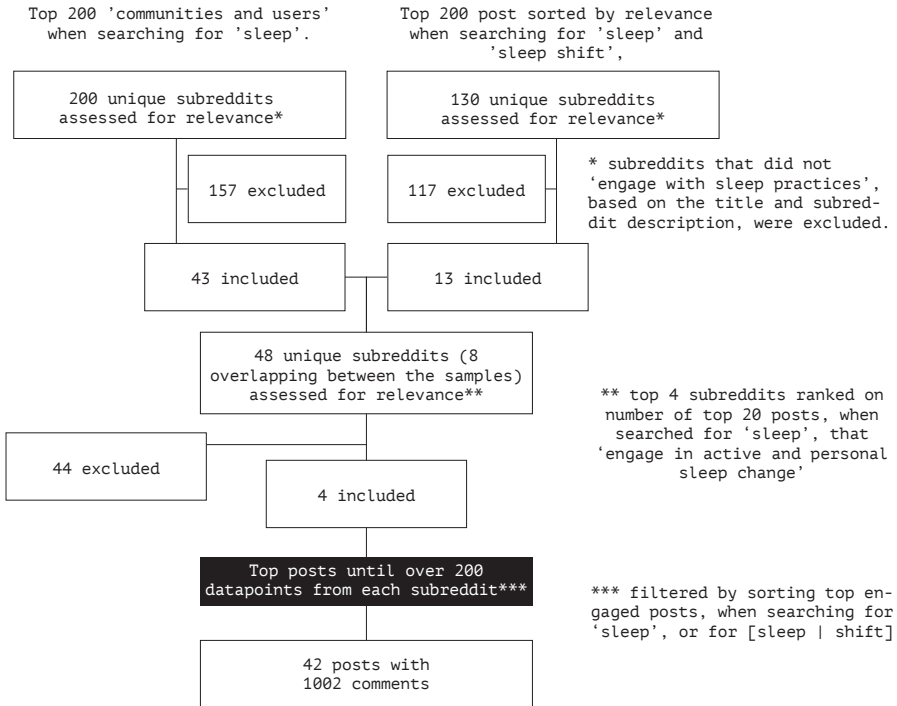


Fig. 1. Process of selecting the data

3.1 Data Collection

Reddit is structured around over a million subreddits [58]. Each of these can be seen as a forum, to which a user can become a member (of most public ones) simply by choosing to do so and electing to see updates from it on their main feed. A user account is shared across all forums, or subreddits, on the site meaning that viewing, joining, posting in, or indeed creating new subreddits doesn't require creating new accounts. Our data selection process began with choosing relevant subreddits, with the goal to identify more than one source of subreddit relevant to the topic of actively changing sleep practices – Proferes et al. reported that 25% of the publication using reddit-data which disclosed this information were based on two to five, and that 49% focused on a single source subreddit [67].

Two searches were carried out, the first one for the top 200 'communities and users' using the keyword 'sleep'. In line with sleep literature pointing to the challenges of shift work on sleep behaviour and regularity [3], we wanted to include posts from subreddits that not exclusively discuss sleep but include sleep discussions around shift work. In our initial search, this group was underrepresented, and as such, we did a secondary, complementary search for the top 200 'posts' sorting by relevancy using two keywords [sleep | shift], resulting in additional 130 unique

subreddits. Each of the 330 subreddits was assessed using initial exclusion criteria, based on the title and subreddit description, where forums that did not engage with sleep practices (such as /SleepPorn/ and /WhatsWrongWithYourDog/) were excluded. This resulted in an initial source corpus of 48 unique subreddits.

We use ‘posts’ to describe top-level contributions to the subreddit, and ‘comments’ for the threaded replies to a post or earlier comment. Within each subreddit a search was conducted for the keyword ‘sleep’ and the resulting top 20 posts sorted by relevance were examined for discussions where the posters could be seen to be engaging with *personal experience of sleep change shared online*. These were counted and the subreddits were ranked in order. Our focus on personal sleep change moved the focus away from communities focused on caring for others, such as children or the elderly, and our interest in how people *actively changed* their sleep naturally drew our attention away from communities around passive tracking through specific technologies.

The resulting subreddits which made up our corpus are the self-control forum /getoutofbed/ (59.3k members) discussing sleep problems, the sleep efficiency group /polyphasic/ (11.2k members), the body hacking focused /Biohackers/ (36.3k members), and the shift workers of /nursing/ (244k members).

Using the Reddit API in March 2021, we collected the data from the top posts discussing ‘active and personal sleep change’ of each subreddit, along with linked media content and all comments, until each source subreddit had contributed more than 200 textual comments. All the comments on the final post were included in the corpus, resulting in each individual subreddit contributing between 208 and 282 to the total of 1002 posts and comments (a total of 77066 words) for analysis.

3.2 Data Analysis

In order to focus on the experiential knowledge represented by the discussions in the subreddits, we used an inductive coding method.

Prior to the analysis of the posts and comments, and as part of the familiarization phase [8], we read and discussed any forum-specific resources, such as pinned posts, recommended tools and community pages. To contextualise the data further, we conducted semi-structured interviews with two sleep researchers over Zoom, each lasting about an hour.

A subsection of the data (first 100 posts and comments from each subreddit) was first iteratively coded using Post-It notes. Through multiple sessions and discussions, we gradually established our codebook [43] to a set of 20 codes. These codes aimed at structuring the discussions around categories such as the role of technology, use of medication, mention of health, social influence on sleep and how sleep was changed.

The coded data was then analysed using thematic analysis [8]. In doing so, we focused our analysis on three core questions on the practice of discussing sleep hacking:

- *What* sleep changing practices were collectively discussed in the forums: How are the communities conceptually presenting tools sleep change?
- *Why* they change their sleep: analysing the discussions on motivation for modifying their sleep?
- *How* they fit sleep into their lives: What problems are they combating by reshaping their sleeping patterns, and what struggles did the users find doing so?

These questions help us understand the structure of communities and the very different practices and motivations for going ‘beyond the norm’ of sleep.

3.3 Ethical Considerations

In presenting the results of our analysis we considered the reasonable expectation of the extent of visibility of the posts from the perspective of the users. While we felt that it was important to provide direct quotes to ground and contextualise the results, we omitted the real usernames of the posters (in line with 90% of the studies reported in [67]). Instead the quotes are attributed to pseudonyms with the prefix to each represents the subreddit the quote was drawn from. P for /polyphasic/, G for /getoutofbed/, N for /nursing/, and B for /Biohackers/ with numbers in order of appearance in this paper.

Reddit supports cross-posting by third parties, resulting in subreddits which are community curated collections of posts and comments from across the site. Such decontextualised sharing of content may be expected by users, and may even be something they covet for greater visibility on the site – they may not want anonymity in the context of public social media sharing [9]. However, we felt it prudent to paraphrase quotes which we as researchers were sharing beyond their intended context when they involved issues surrounding sexual activity or mental health [24, 67] in order to make de-anonymisation more difficult in these cases.

4 THE COMMUNITIES STUDIED

From the contributions we analysed there were four groups of users that we can broadly characterise. These group mainly post in one of the four sub-reddits in focus. All four groups put considerable continuous effort into hacking their sleep. Their posts and discussions expose a range of interesting practices, community-built tools, and knowledge.

The most distinct group are the shift workers discussing working nights in the forum /nursing/. Although not self-described as sleep hackers, they share interest in sleep medication with biohackers, and sleep scheduling practices with polyphasic sleepers. Shifting sleep for night work is a practice developed over time. Posts sharing advice often center around early career nurses asking the community for help in how to tackle sleep in days before shifts, such as user N1 in the following extract.

I will be starting full time night shift in a few days. I have never worked nights before and am not at all a night owl. I love my sleep! I am very much a planner and want to set myself up for success so I would love to hear how other night shifters sleep on the days leading up to/after your shifts.” [N1]

The /biohackers/ forum is for anyone with interest of DIY biology and shares many values with current sleep tracking technology. This community builds understanding of their bodies through self-conducted experiments. In our corpus most posts are inquiry focused, asking for advice on how to improve different aspects of their sleep. *“I would like to improve my poor sleep, which I have a problem with all my life. [...] I am looking for a suggestion for routine or supplement optimization.” [B2].* Replies provided suggestions, often a combination of mental exercises, medication and environmental changes, and were at times paired with relevant literature supporting the claims.

Another set of bio-hackers are the sleep hackers of /polyphasic/. Polyphasic sleep is the practice of dividing one’s sleep into smaller segments in an attempt to minimise the total time spent sleeping. The community builds up a collection of suitable sleep schedules through documenting and sharing nap schedules, sleep stories, and adaptation logs. The community is driven by the ethos, echoed in the following quote, that more time awake is more time alive.

“I guess what I don’t like about the normal sleep cycle is that it just feels like so many wasted hours. If there was a way to increase my Being Alive time, I was down to try it.” [P3]

The last forum in focus is /getoutofbed/ which covers a wide range of people who express a desire to change what they see as their problematic relationship to sleep. This included those for whom sleep itself was problematic (such as narcoleptics or insomniacs), and those for whom troubles with sleep were symptomatic of other mental or physical health issues. The posts aimed to motivate, support and share advice on how to wake up and get out of bed. The threads include motivational anecdotes of weeks with early mornings, people asking for advice on how to wake up, or people asking for moral support in handling chronic tiredness. There is no general consensus in when one should wake up, though those members, such as user G4, that promote early mornings express a general ambition to remove procrastination before and after sleep.

“Everyone claims I am lazy and I am, staying up with my phone at night, but in reality it is just me thinking about mental problems and such, and my my phone is my escape. That is why I cannot sleep” [G4]

While others, as in the quote above, are more concerned with combating the drivers of procrastination and the unfair assignation of laziness.

5 RESULTS

We focus our analysis on the discussions and shared self-reflections around three themes. We first expose what actions are discussed as methods that users take to change their sleep. Second, we highlight the discourse around the goal of alertness for certain purposes at certain times in relation to, and somewhat opposed to, that around the measurement of sleep. Lastly, we shine a light on the co-production of ‘sleep hacks’ and discussions on the struggles they address for users in these communities in fitting their sleep goals around the constraints of everyday life.

5.1 Collaboration around sleep change

In all subreddits, users discussed a variety of actions that they took in order to change how they slept. These discussions involved reporting on their successes and failures, as well as providing recommendations and tailoring of activities to change segments of sleep that were spread throughout the day, involving diet, exercise, ‘motivation hacks,’ and environmental manipulation.

Throughout the building of shared knowledge, the users relied on different *conceptual models* or *framings* of what influences sleep. In line with typical contributions in collective sensemaking [54], these perspectives emerged often as replies to asked questions, where these replies provided both *different perspectives* and *reframing of the question*. In these forums, we identified three general themes of models of actions on sleep: medical, biological and psychological.

5.1.1 Hackers influence their sleep through medical means. The most active way to hack sleep was through the use of medication. The participants built an understanding that the cause and solution of sleep was chemical manipulation. This was not only thought of as taking a pill to solve a problem but as a highly scheduled practice with components after waking up, during the evening and directly preceding sleep.

This was a prominent factor in sleep planning in both the /nursing/ and /biohacking/ subreddits. Medication had an important role in easing onset, sleep maintenance, waking up and staying awake. As expressed by a night worker in /nursing/ there are some work or sleep schedules where one has to pick “sleeping pill dependency or stimulant dependency” [N5].

The medications were varying from over-the-counter alternatives (OTC) such as user N6: “*I sometimes will take unisom (it’s OTC)*”; Prescriptions medication such as ‘Zaleplon’⁴; Hormonal medication using ‘Melatonin’; to less drastic supplements such as ‘Vitamin D’ and ‘magnesium’.

⁴a sedative/hypnotic, used in the treatment of insomnia

Even other medication such as anti-depressant and medication for allergies can often have influence over sleep, such as Trazodone⁵.

“Take 5-HTP in the evening, Ashwagandha 2 h before bedtime, Valerian root might be an option (increases GABA), CBD oil 2 h before bedtime, Relora 30 min before bedtime, Chamomile tea, SAME 20-30 min before bedtime, B6+Zinc + Magnesium” [B7]

As in the quote above, substance use is widely discussed in terms of timing and effect, often recommended with specific timings in relation to bedtime. Some medication and supplements are fitting to take during mornings or daytime, while others are said to be specific to hours leading up to sleep. The prevalence of use of such chemical assistance (some 1 in 3 older adults in the USA take prescription or over-the-counter chemical sleeping aids [52]) seems to be at odds with how seldom such actions are taken into account by commercial or research sleep technologies.

5.1.2 Influencing biological rhythms. Another model users had of their sleep was through the caring for, and planning of, biological rhythms. Understanding the relationships between rhythms of metabolism, circadian rhythm and sleep pressure was a way for users to ground their sleep-changing actions. Yet again we find that the users require extensive scheduling around sleep. Interestingly this provided a motivation for the development of niche, community-developed tools for analysing, sharing and describing such actions.

One way sleep is described is as the result of metabolic processes. By caring for what one’s body is exposed to these processes can be influenced. Many users were careful of their digestion during sleep, promoting a restrictive diet and daily exercise to improve their sleep;

“Want/need to improve ...Deep sleep, consider cyclical keto dieting and saving carbs for dinner; vary and measure what different types of exercise do to your sleep” [B8]

A more ‘medical’ approach is describing biological processes through the chemicals in the body, such as the level glycogen – when one wakes up during the night *“its usually due to the liver running out of glycogen”* [B9] or more general notions that a ‘cleaner’ body sleeps better.

“Clean up your eating as well. I know that when I’m eating clean and not munching on junk food I sleep significantly better” [N10]

Another way to hack sleep quality is by trying to change how the body ‘acts’ during night. The measures of sleep quality vary depending on the technology used to track it and the conceptualisation of sleep by the user. One common measure in /biohacking/ was heart rate variability (HRV), where a more stable heart rate was seen to indicate a more restful sleep. User B11 shared that wearing a mouth guard at night influenced this. *“I started wearing one for my jaw because I grind my teeth at night and found out it does wonders for my HRV.”* Both breathing exercises before sleep, such as the Wim Hof technique, and breathing regulation through sleeping with a taped mouth to force nasal breathing are being repeated as advice for improving HRV and deep sleep:

“I am no expert but I have noticed that doing Wim Hof’s breathing exercises about 3 to 5 rounds right before going to bed puts me into deep sleep according to my whoop strap. Additionally, I have been sleeping with my mouth taped after listening to the audio book Breath by James Nestor” [B12]

Body processes are also influenced by exposure to the environment, with the most discussed factor being light. Light regulation is said to be central in adaption to different sleep schedules and described as key to influencing one’s circadian rhythm. Users described using light exposure to increase alertness, such as staring ‘at the blue sky’ in the morning and explained tiredness during the day and problems falling asleep as being due to over-exposure to blue light close to when they

⁵an antidepressant, used off-label in the treatment of insomnia.

wanted to sleep or underexposure to it when they were supposed to be most alert. Light exposure was also controlled to ease working during the night so as to ensure that “*your body doesn’t really realize its nighttime*” [N13]. Manipulating light exposure was achieved through the use of blinds, masks, and blue light filters to block unwanted light, and full spectrum bulbs which mimic natural light to increase wanted light. It could also be planned in advance, for example using the Entrain app⁶ as suggested on the polyphasic wiki.

Temperature is also described as an influencing factor, with many methods to influence it suggested, as discussed by user B14. These include decreasing the bedroom temperature to “*around 18°C*”, with warmer skin micro-climate “*between 31 and 35°C*”, as well as taking baths, some hours before bed: “*rapid decline in core body temperature for sleep is to take a warm bath or to warm your body for up to 4 hours 1 to 8 hours before bed.*” and timing of warm baths before sleep as it “*decreases sleep latency and increases sleep depth*”.

When sleep goes past what could be called normal patterns, the act of planning sleep can itself be a way to actively hack sleep. Many leverage sleep pressure and their circadian rhythm to be able to sleep when they want. The deliberate buildup of sleep pressure is one of the most common ways to control when one is tired enough to sleep. This is used to shift or ‘reset’ one’s sleep rhythm. Some users report repeatedly using this technique to be able to sleep when they need to:

“*I stay up all night before my first night shift so I can sleep all day*” [N15]

Adjusting the circadian rhythm was attempted through planning when to be exposed to, or isolated from light. Users in the polyphasic forum also discuss the ultradian rhythm, a 90-120 minute cycle of alertness distinct from the 24h long circadian rhythm. To be able to plan around this there is a community build application called Napchart⁷. This calculator (see Figure 2) is used for sketching and sharing of different sleep schedules.

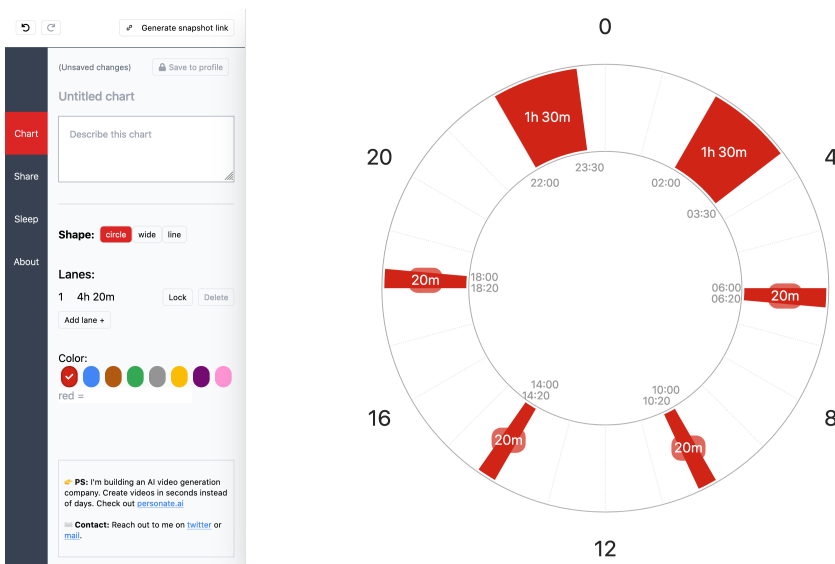


Fig. 2. Napchart showing a 2-core, 4-nap Polyphasic Schedule

⁶<http://entrain.math.lsa.umich.edu/>

⁷<https://napchart.com/>

5.1.3 Discussions about meditation and will. A third way that users are taking effort in changing their sleep is through ‘mental’ methods. While this should not be taken as a description of users’ view of a ‘mind body divide’, there are ways users manage and ‘hack’ their sleep that are separate from bodily rhythms. In contrast to the body’s chemical balance and processes, many users describe sleep as something that is within control – by relaxing and deciding to go to sleep. As posted by user B16, to be able to fall asleep “[y]ou need to be able to relax your mind”.

We see that users are engaging in stress-reducing activities. These methods often included some sort of meditative practice: “*Also good hint is to start doing meditation (properly) and find your inner rest again*” [B16], but also media consumption such as sleep stories and ASMR were recommended. One discussion posted by user B17 particularly highlighted the agency in mental methods by the sleep hackers asking for “biohacks” to exhaust one’s mind – and “*to FORCE your mind to relax*”. This could be practices such as using “visualisations” or daydreams that direct the users’ thinking. User B18 expressed the need to be simulated, as opposed to bored, to fall asleep:

“So regarding doing something boring... I need something stimulating and boring.. maybe like doing math really fast. If it’s something relaxed, it won’t make me relaxed.. sure maybe withing the first 45 minutes of trying to sleep, but past a certain point your just awake, body clock reset, all systems go, you know?” [B18]

This highlights the delicate balance between will and alertness. Many posts expressed the challenges with the discrepancy between decisions made before and after sleeping. This is clear in the painstaking process of trying to wake up early. Users in *r/getoutofbed/* share different ‘motivation hacks’ and tricks to force one self to wake up. Much of the advice centers around the idea of removing ‘brain fog’. User G19 refers to this as *kaizen method* – by taking the morning in small increments, or even gamifying the morning routine, one takes “*will power out of the equation*”. By having to rely on structure rather than decisions, user G20 even express this as having “*trained my brain to wake up early*”.

These three different models were at times providing different actions, such as if morning fog was solved through determination, or through medical assistance. The reliance on shared, contrasting or disputed framing of sleep are at the core of collaborative understanding of how to hack sleep. How users through self experimentation and past experiences continuously make sense of the ways to make change, which we discuss in 6.1.

5.2 Agreeing on what ‘good’ sleep is

Good sleep as defined by current technology is somewhat narrow. Indeed, the concept of ‘sleep hygiene’ was only shared by a subset of participants in these online forums. As much work on sensemaking in online health forums has shown, discussing and forming taken for granted concepts is a core activity of online health communities – characterised as collaborative, or collective, ‘sensemaking’ [54]. In this section, we discuss how sleep itself, and in particular, the notion of good sleep was collaboratively ‘made’ in the online discussions.

Although some of the discussions we studied were about measuring good sleep, we found that users often cared more about awakeness and alertness than sleep itself.

For many nurses ‘bad sleep’ is a certainty. The inconvenience of night work changes discussions about ‘good sleep’ to a discussion about ‘being alert enough’ to do a good job by powering through, staying busy and ‘*enough caffeine to resuscitate a horse*’ [N21]. Many posts, such as this one, report on sleep deprivation having a significant effect on behaviour, judgement and performance – with a higher risk of accidents:

“It is well known that rotating is horrible for workers. More mistakes are made. There is a much higher incidence of serious illness. Good employers don’t do this to their workers”
[N22]

This becomes more acute when attempts to sleep fail. Discussions such as one posted by N23 around how to “*survive a 12 hour graveyard shift when you only had 3 hours of sleep?*” expose how nurses are expected to be able to manage a general lack of sleep using stimulants, willpower and experience. Experience allows nurses to recognise and work around dips in attention and energy.

The prioritisation of work over sleep is not done lightly. Many night workers expressed that their schedules put pressure on their mental health in the long run. This motivated some to change how they live and work to mitigate issues related to long-term sleep disruption. Related posts looked for advice on how to improve happiness while still maintaining the sleep rhythm required for their work. This is not always successful. Nurses that used to work night shift explained having quit due to health issues including feelings of depression or dependency on sleeping aids:

“I got very addicted to sleep medication after seeing a doctor. I also started going to biweekly therapy as I started having such horrible nervous breakdowns due to not sleeping. I really think night shift work changed me permanently” [N24]

Our corpus also includes those who desire to sleep less. For this community, good sleep, controversial to many sleep researchers, is the minimum sleep that satisfies the body’s need for deep and REM cycles. In a constant transaction between alertness and sleep hours, the practitioners of polyphasic sleep aim to reduce sleep as a way to unlock more time being alive. For this group, the quality of sleep was equated to its efficiency.

Lastly, ‘good sleep’ was also discussed in various ways as being sleep of high *measured* quality. For some, a desire to improve different metrics of sleep phase timings, heart rates and breathing was a goal in and of itself. This leads users to the understanding that sleep is not a passive activity, but a process that can be measured, evaluated and altered. Quality is measured in different ways, some using theories of sleep or self-evaluation, but most relied on trackers. This changed the goal somewhat to getting a higher score in the Oura app, as one user stated:

“I am trying to get a higher score in the Oura Ring while sleeping and I have tried cold water exposure, CBD 100mg or melatonin before sleep but I can’t get higher HRV” [B25]

Discussions around tracking often focused on optimising the measurements alone, and less on pairing it with other life quality aspects, suggesting that for the users the data carried inherent value. However, this value often fails to map other values they hold, as expectations around tracking “vary and develop over time” [41]. We see from our analysis that many users have values that the standardised tracking of ‘good sleep’ doesn’t align with, such as short-term priorities of staying alert for work and social activities that are misaligned, or just increasing their ‘time alive’. As such, any notion of ‘good sleep’ isolated from the other aspects that make up a rich and healthy life for any individual may be a simplification too far upon which to base long-term, successful behavioural change.

5.3 Hacking Sleep to Fit with Everyday Life

The most common discussions around hacking sleep in our data center around attempting to change *when* sleep was fit into the users’ daily lives. While the goals of each user group showed in the extent to which they attempted to hack, and the intrinsic and extrinsic methods they employed to realise that change, one constant was the importance of planning and routinising any change in the times of going to sleep or waking up. Each group struggled with the inertia of sleep routines, and the planning necessary to enact change. While in most of the groups changing the timing of sleep was seen as a form of ‘correction’ or meeting a defined goal, for the nurses of r/nursing

changing sleep timing was a repeated – and repeatedly problematic – endeavour to fit in with changing work schedules.

The largest theme in this group discussed how to plan the sleep before a stretch of night-shift, and in between non-consecutive shifts of working at night. Planning your sleep for night work is a logistic puzzle where one has to factor in the ability to sleep at particular hours, how alert one will feel when, and how to meet family and other responsibilities which are tied to a traditional sleep cycle. In between night shifts the nurses discuss the pros and cons of ‘flip-flopping’ – going from being awake during the night, to being awake during the day, and then back again or ‘going vampire’ and continuing to stay awake during the nights they do not have to work on to keep more sleep regularity.

“Do you just vampire it or do you flip flop? If so how do you flip on your last day? Wondering for myself because I have been trying to flip but wondering what methods people have. I’ve heard sleeping till the afternoon on last day of work and then waking up and sleeping again in the evening. Some just push it till the evening” [N26]

As choices such as this highlight, users often had to come to terms with the challenges of living life, for shorter or longer periods of time, with non-normative sleep. These efforts, much like the patterns seen in the discussions in online health communities [55, 63], centred on how to create structure in relation to the disruption of normalcy. The search for a ‘new normal’, often described in relation to severely life-changing events, is the process of meaning-making to establish an everyday life. Through the lens of long-term change and social interactions, the discussions on the forums exchanged and co-created ways to identify and mitigate the challenges in structuring life while living outside of the normal scheduling encouraged and reinforced by nightly sleep.

5.3.1 Slowness of sleep change. In the case of nurses, many prioritised sleep regularity. This is motivated by being less complicated in planning, recommended by their doctors, and encouraged by other users, such as user N27 to be less exhausting – as it is *“trying to live like a normal person on your days off that’s killing you, not night shift”*. Similar to recovering from jet lag, there is a certain slowness in adapting to a change of sleep rhythm. For those that remain on a night schedule, regularity is a matter of maintaining adaptation to a non-normative sleep rhythm. It is a struggle to adapt when one’s body clock is not in sync with society: night shift schedules require planning to adjust to, and maintenance to upkeep, while still scheduling time to see sunlight and have time for the obligations of life outside of work.

In the /polyphasic/ forum, there are established language around adaptation, particularly how to adapt to segmented sleep schedules. In the forum, users share tried and tested (as well as speculative) sleep schedules. These consist of multiple segments of ‘core’ and ‘nap’ sleeps (such as in figure 3). The further these are from normative sleep, the longer and more gradual the adaptation schedules would be. Some users share their process of adaptation through sleep logs with annotations around adaptation success – although for many, entrainment of these complex new sleep schedules was never achieved. These adaptation logs range from textual sleep diaries to those annotated with graphs and, at times, statistics from trackers. They are used primarily to share their experience and experimentation with the process of adapting to and maintaining particular sleep schedules.

We see that these schedules are described in terms of ‘rigour’, flexibility, and sustainability. Once adapted to, discussions are about how susceptible they are to being ‘lost’ due to oversleeping on a segment or if there is room to move naps or cores to meet external responsibilities after adaptation.

5.3.2 Scheduling Sleep is a Social Activity. Sleep scheduling is not done in isolation from society. Work, family, social obligations and personal goals all exert influence. In the cases of nurses, many choose to ‘flip flop’ in order to be on a normative schedule during their days off. They aim to move

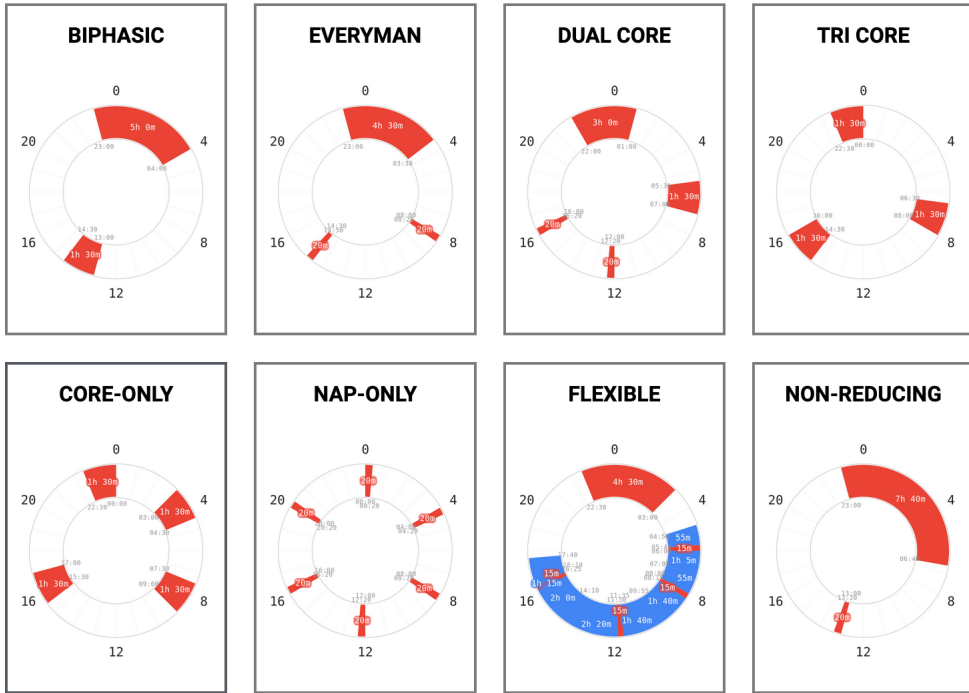


Fig. 3. Different polyphasic sleep schedules

their sleep schedule as far and as fast as possible when they change shifts. This in turn provides the users with the challenge of having to shift between night and day schedules regularly. Shifting sleep is expressed to be very taxing for their mental and physical health. Further, it is described to be logistically complex. It requires the nurses to have plans for how to shift to night work, how to overcome the graveyard hours, and later how to reset their sleep clock.

This perception that sleeping while others are awake is a transgressive act points to how social our individual sleep patterns actually are. The value of the time can be very dependent on when the time is. Some night workers express, such as user N29, the challenges with free time being locked to hours when the society sleeps.

*“It’s *fun* to have downtime if it’s falling around blocks of time that are dedicated to something, but if it just stretches out in front of you with no structure it can be rough ”*
[N29]

Challenges with scheduling around different sleep most often are tied with the prevailing challenges from structuring one’s social relations around sleep. The largest area of concern with changed sleep is how to structure family time. Some of the night shift workers described precisely scheduled times for being with family:

“I’m married with kids, so for me when I wake up in the afternoon it’s kid and wife stuff until my daughters go to bed, then wife stuff until she goes to bed, and now it’s maybe 11p and no one will be up until around 7A.” [N29]

Additionally, sleeping during the day provides is challenging and may not be as restful as sleeping at night. As user N30 posts, daily noise from partners, neighbours or life outside means sleepers

expect that they “*will* be woken up sleeping during the day”. This adds the stress of a “very fragmented sleep” to an often already uncomfortable sleep rhythm.

Rethinking the daily sleep cycle is dependent on social pressure. Breaking social norms around sleep is not always met with acceptance from others. For example, early wake ups are perceived as more ambitious and late sleep patterns are more often seen as lazy:

“I’m a doctor-diagnosed insomniac, PLUS I work nights, and people STILL constantly criticize me for ‘sleeping late.’ Including my therapist!” [G31]

Some of the more non-normative schedules, such as the night shift sleep and polyphasic sleep, are dependent on the person not having social obligations which conflict with the rhythm. We find that some in the /polyphasic/ forum describe having tested alternative sleep schedules when living alone. Work and social settings also play a clear and significant role in normalizing the sleep schedule of society. Working from home and freelance work makes it easier, but so does living in a complementary location such as user N32: “Las Vegas [...] open all night anyway”.

For many in /Polyphasic/ the goal is to break norms – but not as an act of defiance.

“What still excites me too is the fact, that we are somewhat pioneers with what we are doing. [...] but these thoughts, about improving everyones effectivity, inevitably came to my mind when I realised how much polyphasic sleep could do for me as an individual” [P33]

Rather they express the goal of exploring – and building a body of knowledge around – new sleep practices for future generations. There is a common factor with other bio-hacking practices in that the users are prone to explore how their bodies work, and how they can be bent to their will.

“With no clear divisions between the days, my life has gone from being a series of segmented sprints to being a single continuum of activity. It’s thoroughly pleasant, and I’m getting more done than I ever have” [P3]

Further, the exploration of different ways to experience life, in this example going from a daily rhythm to a feeling of continuous activity, becomes both a shared goal and a set of shared experiences around which to build community.

6 DISCUSSION

Our participants were able to support each other in ‘hacking their sleep’ to fit with their life goals, which were often in contrast to the simplistic model of “good sleep”. It is an important point to make that whatever the claims of the sleep literature, for many, the economic and social requirements of life simply demand that they prioritise ‘making do’ over an abstract goal of ‘good sleep’. We focus here on how these communities discussed their body, or Soma, and their felt experiences of the challenges and rewards of sleep change. This, we see, as a resource not only for the design of technology around the body more generally, but as a resource to advance the conversation on *how* to design for and with bodily processes.

We make this argument in four different discussions. We argue that 1) body reflection technology should be built on, and to support, collaborative experimenting and sensemaking, 2) the values of the tracking technology should be aligned with the goals of everyday life, 3) changes to one’s body are inherently slow, which can be supported by algorithmic prediction and visualisations of future perspectives, 4) there is an opportunity in increasing the focus on hacking of ‘felt’ experience in the development of soma-reflection systems.

6.1 Collaborative Bodily Reflections

Our findings show how online communities can play a central role in individuals building an understanding of their bodily processes. Going beyond the personal and reflective practice of understanding somatic experiences, valuable though this can be [23], our participants shared their experiences of their Soma and sleep in differing constellations of requirements and needs. In this sense, their somaesthetic reflection happened collaboratively online, *in the world*.

The personal somatic explorations of the users were the means of establishing shared conceptual models, as in §5.1, of how to tackle the challenges in meeting their ambition of changing how or when one sleeps. These models, and in particular the ongoing threads of discussion, form the ‘repertoires’ of the sleep hackers. These repertoire artifacts, as Mamykina et al. [54] argue, are collaboratively built through the production of the shared online discourse. These discussions point to how social somaesthetic experiences of sleep planning, sleep onset, and waking can be, even if they seem at first rather personal. The shared vocabularies and understandings built up by each community allowed them to communicate their somatic experiences but also to support these processes through the use of different technical systems, such as sleep trackers.

In the case of these forums, much of the communally understood conceptual ideas of sleep are found represented in the discussion. Yet there were key differences between them, of which we highlight the interesting differences between those focusing on nursing and polyphasic sleeping.

The nurses discussed how to ‘flip’ between different schedules and the experiential pros and cons of doing so. Some of these discussions approached the level of somatic reflections [82] although through a very different approach and focusing on the felt experience of foregoing or putting-off sleep in situations with different social, physical and cognitive demands. This resulted in a shared repertoire that encapsulated the timing and intensity of both intrinsic stimulations to overcome the challenges of sleeplessness, such as mental techniques and chemical supplements, as well as extrinsic stimulation through social engagement with others and physically demanding parts of the job – subjects that have been perhaps neglected in Soma research. In this forum, there were seen to be two ‘acceptable’ (although not equally desirable) forms of sleeping; that of ‘going vampire’ and sleeping during the day when on night-shift, and the socially-normative sleep schedule – with changing between them understood to be a difficult process that took time and effort.

The polyphasic community’s effort of collecting an understanding of how sleep can be manipulated resulted in a repertoire with a greatly expanded definition of acceptable forms of sleep. The polyphasic sleepers worked to build collective knowledge by continuously sharing adaptation logs and sleep diaries and even communally building tools for sleep-schedule sharing. Collaboratively, the more engaged forum users create banks of knowledge, by maintaining wiki-structured web-pages, posting informative video resources, and moderating a lively discord server. This placed the knowledge in between the ‘expert posters’ well-edited guides, and the individuals who continuously shared their felt and tracked experiences.

While these resources echoed some of the somatic qualities of the nurses’ forum discussions, with experiential accounts of pushing through sleep deprivation and difficulties in sleep onset as well as waking, the understanding developed of what was causing these challenges – and, as a result, what could result in a solution – was markedly different. The repertoire built up in this community included not only the different patterns of sleep but also the underlying assumption that there was an optimisation possible through routing and timing of sleep that would minimise both the number of hours spent sleeping and the negative impacts on their physical and mental abilities. This resulted in this repertoire turning away from traditional chemical manipulations such as caffeine and sleeping pills, casting them as barriers to achieving the overall goal of ‘natural’ minimal sleep, and towards dietary supplements and routines of exercise and relaxation which

were timed and dosed to exert influence on the underlying bodily processes that they saw as most influential in governing sleep and wakefulness.

In the forums we studied, participants developed their conceptual models (as we described in terms of medical, body processes and mental models in § 5.1) coming from self-tracked data, medical exploration, folklore, or community culture. As recent work in CSCW exploring how elite health users hack medical equipment to fit with their health goals [*In Press*] this work documents forums being used to create new health practices, independent from the direct involvement of medical professionals. Clearly, this can have both positive and negative developments – but it shows how the ‘power’ of forums has gone beyond just supporting the creation of user communities to the creation of new sources of medical knowledge.

As a resource for design, this collective knowledge was built through sharing of individual somatic experiences – but understood through prebuilt concepts that are communally developed. This suggests future possibilities in making soma-technology inspired by, and for, online communities as much as the first-person reflections of researchers. By acknowledging that the efforts of self-experimentation and bodily exploration, driven in part by existing technology, are being used to co-create and form conceptual models of how sleep works, we suggest that we move the development of self-experimenting to co-experimenting with technology. These technologies would provide support in pairing the data and analysis of one’s tracked experiences with peers with similar goals and experiences or related shared discussions from the repertoire.

6.2 Sleep and the social body

With the growth of consumer sleep tracking [74], current sleep technology tends to rely on detecting sleep phases and identifying problematic sleep through quantity and quality measurements [39]. Yet, as our findings show, much of the practice, goals, and understandings of sleep displayed in the forums are built around perspectives not viewed by the sleep tracking systems.

The values encoded into sleep technology are perhaps most apparent in the goals that they encourage for their users. The goal of a long, deep sleep was often at odds with our participants’, which was measured in terms of alertness and time being awake. Current sleep technology is mostly based on accelerometers and heart rate sensors. While the relationship between them and the clinically driven definitions of sleep depths and stages is based on research, consumer sleep technology has repeatedly been criticized for lack of transparency [74], and accuracy [36, 39, 71]. The relationship between what is being measured, what is being inferred, and the outcome for the user can be seen as a version of the Telephone Game⁸.

This challenge has been discussed a lot in the field of self-experimentation. Efforts in this research are exploring how self-tracking and self-experimentation tools can be built in a way to increase agency. But agency over the personal interpretation of one’s self-tracking is not enough to lead to actionable goals [19]. This has been addressed through tools such as sleepBandits. This tool adheres to their defined ‘guided agency’ by trying to address the tension between rigour and demands of everyday life and present the results in a way that is intuitive and continuous. But, work such as sleepBandits, addresses how the tracking is done, these are still mainly built on the traditional perceptions of what ‘good’ sleep is. As for our participants, these are goals and motivations for tracking sleep outside the goals of ‘sleep hygiene’.

This could in turn be addressed by expanding the technological focus to go past sleep to the implications and results of sleep: such as projected alertness. Including the sleep results and relating that to current measures of sleep could dramatically increase the utility of this category of systems. While measuring alertness technologically is more complex [60], prompting the user to

⁸https://en.wikipedia.org/wiki/telephone_game

document their experience of their own alertness could enable longer-term reflection on current sleep statistics. The same could also be done for activities, either through calendar-based data collection or technological activity recognition, and provide a meaningful way for users to reflect on what is encroaching on their sleeping time and if the trade-off is worth it.

We see this as an opportunity for more socially framed sleep tracking systems, grounding sleep tracking in the practices and goals of everyday life through the lens of alertness. This requires the tracking and the management of dynamic wakefulness in daily life as a result of naps, medication, digital engagement, and other sleep-influencing practices – a new form of sensing that is currently being explored through unobtrusive and continuous assessment using smartphones [2]. Allowing users to track what they have ingested and through learning the impact on the individual giving them the tools to interrogate the system as to the expected effects of an extra cup of coffee after dinner, a late night run, or half a sleeping pill could empower them to make informed social yet *sleepy* decisions on the trade-offs between activities now and alertness in the future.

Such updates to sleep goals should also come alongside changes to how sleep is suggested and predicted. As we have shown, for many people sleep is not an activity which fits into life at the same time every day. Adapting to the variations of sleep rhythms of users while still encouraging them to sleep in ways that meet their goals is a challenge. Simply the ability to take into account and suggest naps as well as core sleeping times would be the first step in this direction.

6.3 Designing for the (slow) changing body

A challenge for understanding the change in the experience that attempts at ‘sleep hacking’ discussed above caused was the differing time scales between the action and the result. Each of the subreddits’ discourses has some embedded concept of slow adaptation of the body’s influence on the rhythm and timing of sleep.

Sleep hacking practices were often about short-term problem solving and inducing different experiences of sleep onset or waking. Yet, they all incorporated in different ways the notion of long-term adaptation and entrainment. In contrast to this, consumer bio-trackers often struggle to achieve long-term use. Users tend to lose interest after the first few months [50] – often finding short term usage more useful [44], and not looking back at the data [73]. Liang et al. discussed this in relation to the lack of ‘distal effects’ impacting users’ practices beyond that directly tracked [45]. But as in the case of our findings, when users actively put considerable effort into manipulating and maintaining sleep schedules – long-term change does matter.

As a direct result, some night workers chose to maintain a non-normative yet regular sleep schedule; users valued a certain slowness of their sleep shift. Even less flexible, the polyphasic sleepers put work into documenting their successes in achieving and *maintaining* of their tight patterns of sleep. This ongoing process could take weeks, or even months, to adjust to initially, yet, they were equally interested in how long these patterns could be maintained in the face of the various pressures towards normative sleep. This view on sleep change showed respect for the slowness of adjusting bodily processes. Nevertheless, what they described as the experience was situated in the present. The detailed descriptions of the feeling of sleep onset as influenced by specific proscribed methods, or of the in-the-moment experience of the feeling of forcing an exhausted mind to demand that a weary body place one foot in front of the other until the temporary dip in alertness caused by long-term issues with sleep can pass.

In some cases, this reflection across temporal scales was aided by technology. Polyphasic sleepers would refer to their sleep plans, and the difference between them and the actualisation of them on sleep diaries or the output of trackers, to rationalise experienced dips in alertness or struggles with sleep onset by looking back at missed or moved scheduled sleeping times or prospective changes to their plan to correct in the future.

Soma design already takes into account slow interactions around bodily processes, for example, through the interactions encouraged by the Soma Mat & Soma Lamp [81], so there exist the seeds of methodological approaches to bridging this temporal-scale gap through interaction design. By leveraging the collaborative somaesthetic reflection and sense-making already being employed by online communities such as the ones we present here.

This presents a clear, if challenging, opportunity for technology design. The gap between actions in the presence and long-term outcomes can be bridged through algorithmic support for planning and manipulation of body processes. As computational understanding of individual body processes becomes more robust, based on more accurate clinical models and ever more encompassing sensing, technology can be designed for the space between feedback and feedforward. In doing so, taking the example of sleep, existing models such as the processes of bodily alertness [94] and research on circadian computing [1] can be combined with current actions such as sessions of sleep, exercise, and stimulant use to provide users with a tool that can project current actions into the future and expose consequences and rewards for changes to routine and practice. Design of sleep hacking technology should consider moving the perspective from retrospective reflection to *actionable futuring*. By that, we mean presenting possible future scenarios to a user *alongside* the clearly actionable steps that they could take to achieve it – allowing them to not only compare and contrast goals but also what attempting to achieve those goals would mean in the contexts of their own lives. For sleep, this can allow users to see what activities they may have to move or sacrifice to achieve a certain goal.

6.4 Designing for modified senses

A noteworthy reflection on the consideration discussed in these subreddits was the focus given to the thought on the *removal* and *modification* of a stimulus as opposed to the traditional practice of reflecting on one as it influences the experience of being.

Sensory isolation is often seen as an aid to sleep onset. The methods discussed ranged from attempts to isolate from physical stimuli, for example avoiding light at the blue end of the spectrum, to attempting to isolate the mind from thoughts and memories that would encourage wakefulness. Indeed, many of the actions discussed in §5.1 are ways users can directly influence or isolate the body. Blinds and masks make the body ‘think it is nighttime’, and mental exercises limit or even eliminate the sleeper’s reflection on their own body as it falls asleep. In terms of sleep, at times it helps to avoid such reflection. It is often the stress of being unable to fall asleep that contributes to insomnia, and our self-reflection can underestimate the amount we sleep exacerbating this cycle [87].

The modification of sensory input was possibly more interesting from a somaesthetic perspective. The subreddits discussed a variety of methods to change how the experience of sleep onset and waking *was experienced and felt by them*. From developing a shared understanding of the optimal timings of supplements, sedatives, and stimulants to providing a body of knowledge on the influence different physical and mental exercises could have on these somatic experiences.

Manipulation of the experience of interacting with and through technology is generally limited to changes in the technology itself. There is some Soma design work that relies on meditative and physical exercises in combination with changing technology [32, 84, 88] again this provides a starting point for the development of methods of design and interaction which could incorporate – or at the very least support and work with – chemical alterations in the bodily experience of reality by users.

Aligned with the previous discussion, understanding of sleep and bodily changing practices are aided through the existing online forums. But in terms of modifying sensory experiences, these experiences are not only hard to track – they are hard to communicate. We see value in further

exploring the subject of sharing of how ‘the felt’ is changed. The challenge as we see it here is to go beyond language and iconography as used in the myriad of pain scales⁹, and to leverage personal biometric sensing in a way that embeds the knowledge that these felt experiences – and their manipulations – are not universal.

In the context of sleep, the felt experience of tiredness and alertness are still often represented by simple numeric scales. But the communication of explicit changes to felt experiences applies to many bodily senses: such as hunger, focus, and even pain. They also discussed how one such sense could influence others, opening the way for design that could allow users – through the use of better methods for sharing their relative and absolute felt experiences – to guide others through experiential manipulations with the goal of impacting bodily processes.

7 CONCLUSION

This paper approaches online collaboration around practices of intentional sleep change by investigating discourse in four Reddit forums of ‘Sleep Hackers’ including shift workers in /nursing/, /polyphasic/ sleepers, Over-sleepers in /getoutofbed/, and /Biohackers/.

Keeping a job, caring for family members, and being able to enjoy one’s life are priorities that are more important – at times – than the quality of sleep. This is less problematic for those with ‘normal’ 9:5 jobs, but others for whom professional or personal goals do not align experience many challenges in attempting a normative sleep pattern that satisfies all their personal, social and work obligations. The peer-support and shared knowledge represented in the online communities – a sort of “Computer Supported Collaborative Sleep” – provides opportunities for the design of technology for and with such communities to better support complex socio-somatic contexts.

In this way, the collaborations and reflections around active manipulation of bodily processes – hacking – by our participants can be taken themselves a rich resource for the understanding of the use of technology to collaborate on, monitor, and control bodily processes. They also spark an interesting conversation with research around methods for designing for and with bodily processes, such as Somaesthetics.

This work contributes in highlighting the efforts of creating communities dedicated to body understanding online. It is through collaboration, that individual exploration can be understood. These findings elicit opportunities in design and research for sleep technology – exploring how the social and communal perception of sleep can feed into, and benefit from the development of self-reflection bio-technology.

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