SleepBot - Encouraging Sleep Hygiene Using an Intelligent Chatbot

Steven R. Rick
srick@ucsd.edu
UC San Diego
La Jolla, California

Aaron Paul Goldberg
La Jolla High School
San Diego, California

Nadir Weibel
UC San Diego
La Jolla, California

ABSTRACT

Maintaining good sleep hygiene is a constant challenge in modern lives. Sleep habits are hard to monitor and record, especially when most sleep monitoring programs overlook the necessity of calculating user input. This input is vital in order to change poor sleeping patterns, as it is difficult to identify the source of an individual's problems. Sleep tracking software also struggle with a lack of user transparency and interactivity, leading individuals to mistrust the results these applications generate or otherwise not feel like the insights are actionable. To explore these issues, we designed an interventional chat bot to mediate information collection and interaction between end user and sleep monitoring technology. The SleepBot prompts users with simple questions that attempt to elicit insight into larger problems that contribute to poor sleep and help craft successful sleep hygiene behaviors. Text messaging based interaction eases the process as it is similar to talking with a friend, making for a unique environment in which the user is able to share personal data comfortably.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; *Natural language interfaces*; Ubiquitous and mobile computing.

KEYWORDS

conversational agents, sleep hygiene, behavior analysis, worn sensors, sleep tracking

ACM Reference Format:

Steven R. Rick, Aaron Paul Goldberg, and Nadir Weibel. 2019. SleepBot - Encouraging Sleep Hygiene Using an Intelligent Chatbot. In *24th International Conference on Intelligent User Interfaces (IUI '19 Companion)*, March 17–20, 2019, Marina del Rey, CA, USA. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3308557.3308712>

1 INTRODUCTION

Healthy sleep patterns are crucial to one's well being. To understand the impact of poor sleeping habits and what makes up good sleep hygiene, it is first important to comprehend what potential

causes may exist in an individual's life. As Lacks and Rotert discuss, poor sleeping patterns can lead to weight gain, high blood pressure, and an increased risk of heart disease [3]. Conversely, good sleeping habits can lead to overall improvements in physical and mental well being and the productivity of one's life. LeBourgeois, et al. note that while cultural factors play a role, sleep quality is still highly correlated with sleep hygiene [4]. Poor sleeping pattern behaviors, including eating/drinking before periods of deep sleep, restless sleeping habits in which one does not fall into deep sleep, and constant environmental distractions, all lead to lower quality of life and overall health. Smartphone applications have been explored, such as Sleep Ninja by Werner-Seidler, et al., but focusing around CBT (cognitive behavioral therapy) in an interventional form factor produced mixed success with user engagement [6]. If we consider an approach that is more passive than an interventional application, we can utilize wearable devices to understand sleep behavior. Kolla, Mansukhani, and Mansukhani discuss that consumer devices are increasingly accurate and reliable, but the interpretation of collected data and user engagement then become important for filtering out noise from the devices as well as promoting positive behavior change [2]. To mediate between an active yet interventional application and a passive data collection platform, we reflect on success in the application of chatbots, such as work by Crutzen, et al., and using the technology to prompt reflection and answer questions in a manner that promotes personal comfort [1]. We feel that appropriate design of an intelligent chat agent in tandem with passive sleep data collection can merge the best of both personal user information (such as emotions or gut feelings about sleep habits) with the quantifiable insight from sensors and utilize them in a manner that prompts reflection and positive behavior change to promote better sleep hygiene.

2 THE SYSTEM

Our system is comprised of two distinct elements, 1) a chatbot front end, and 2) a sensor data back-end. These work together to collect as holistic of a picture as possible of a user's sleep behavior with as small of a burden as possible.

2.1 SleepBot and user data collection

Noting a present lack of conversational agents in the sleep hygiene domain, we designed and deployed our own chatbot built upon insight from Mastin, Bryson, and Corwyn with their Sleep Hygiene Index [5]. Leveraging the existing Telegram Bot framework¹ we designed a conversational state machine to engage a new user, collect personal meta data, schedule their wake up time, and inquire

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

IUI '19 Companion, March 17–20, 2019, Marina del Rey, CA, USA

© 2019 Association for Computing Machinery.

ACM ISBN 978-1-4503-6673-1/19/03...\$15.00

<https://doi.org/10.1145/3308557.3308712>

¹<https://core.telegram.org/bots>

about their sleep each morning after they wake. To ensure consistent and precise data collection, we designed SleepBot to prompt a user for input daily. We seek to minimize time between wake and user interaction to ensure data is accurate. Knowing that user preferences and behaviors can be dynamic, we designed options which grant users the ability to provide both feedback about their experience as well as update personal settings like scheduled wake time. Inquiry is managed through a question flow that is responsive to each answer provided to the prior question. For example, if a user states that they slept well, no questions about sleep disturbances are asked. If an individual instead says that they woke up in the middle of the night, questions about quantity and duration of disturbance are prompted. The chat bot makes up the front end to our messaging based system. The SleepBot chat interface itself is similar to many messaging applications available today, shown in Fig 1. This reduces barrier to adoption as the user does not need to learn any new interaction patterns if they are familiar with any modern text based communication platforms.

2.2 Passive data collection and sensors

Going beyond soliciting user insight about subjective experience, we identify the need for other sources of sleep monitoring, such as from sensors either worn on the body or placed near the bed. After testing many different monitoring devices, we found that ambient specialized sensing hardware such as Withings Sleep² or worn trackers such as a Fitbit³ provide the ideal sleep monitoring systems. This is due to these personal activity trackers passively collecting sleep data without user involvement. Worn devices do require that the user wear them to bed (and charge them when appropriate) while ambient devices require no maintenance. User interviews highlighted the importance of supporting personal preference, thus we elected to build a flexible integration rather than only support one brand. If a user has a sleep tracking device (regardless of if worn or not) they can authorize SleepBot to collect their data each night. This is managed via OAuth token and web APIs exposed by individual device manufacturers. These sensors give us a less biased view into the sleep behaviors of each user, telling us about the regularity of their sleep (time to sleep, time to wake), quality of their sleep (disturbances, duration) and more.

3 INITIAL ASSESSMENT AND INSIGHTS

We first deployed the SleepBot without external data collection from worn or ambient sensors in order to test the conversational aspect of the application. We did this for two weeks within a pilot with three users. Immediately we discovered issues when allowing user free form answers, they would not always choose to respond to questions or responded in a way in which the chatbot could not parse. We found that if a user was prompted with provided answers, such as yes/no answer buttons, then they almost always followed up with responses and our system did not run into issues related to understanding. We refined our conversation flow and language used in order to better fit this model and decided to only use open ended free text when absolutely essential. The benefit of the chat

Figure 1: An example conversation flow with the SleepBot

bot platform is its ability to merge standardized survey input (lists of buttons, for example) with natural language that is free form.

4 FUTURE WORK

With a unique and adaptable interface, we next hope to scale up our population, opening up the SleepBot platform to anyone interested in sharing data about their behavior and helping us to continue to develop better ways to promote good sleep hygiene. We specifically plan to next work on reflection prompts which visualize or otherwise summarize insights collected from both user messaging and user sensors. Questions about 1) what to be shown, 2) how to show it, and 3) when to show it will all be addressed in the next iteration of this work.

5 CONCLUSION

Data collected both from subjective experience as well as via unbiased sensors about sleep has the potential to help people build better sleep habits. This interface, SleepBot, could be used to help people better understand their current sleep as well as how to improve it. Merging unobtrusive physical technology with a digital chatbot, each collecting data of different variety, presents an opportunity to further expand work into formal sleep studies and clinical investigations exploring the relationship between sleep and other health outcomes.

REFERENCES

- [1] Rik Crutzen, Gjalte-Jorn Y Peters, Sarah Dias Portugal, Erwin M Fisser, and Jorne J Grolleman. 2011. An artificially intelligent chat agent that answers adolescents' questions related to sex, drugs, and alcohol: an exploratory study. *Journal of Adolescent Health* 48, 5 (2011), 514–519.
- [2] Bhanu Prakash Kolla, Subir Mansukhani, and Meghna P Mansukhani. 2016. Consumer sleep tracking devices: a review of mechanisms, validity and utility. *Expert review of medical devices* 13, 5 (2016), 497–506.
- [3] Patricia Lacks and Monique Rotert. 1986. Knowledge and practice of sleep hygiene techniques in insomniacs and good sleepers. *Behaviour research and therapy* 24, 3 (1986), 365–368.
- [4] Monique K LeBourgeois, Flavia Giannotti, Flavia Cortesi, Amy R Wolfson, and John Harsh. 2005. The relationship between reported sleep quality and sleep hygiene in Italian and American adolescents. *Pediatrics* 115, Supplement 1 (2005), 257–265.
- [5] David F Mastin, Jeff Bryson, and Robert Corwyn. 2006. Assessment of sleep hygiene using the Sleep Hygiene Index. *Journal of behavioral medicine* 29, 3 (2006), 223–227.
- [6] Aliza Werner-Seidler, Bridianne O'Dea, Fiona Shand, Lara Johnston, Anna Frayne, Andrea S Fogarty, and Helen Christensen. 2017. A Smartphone App for Adolescents With Sleep Disturbance: Development of the Sleep Ninja. *JMIR mental health* 4, 3 (2017), e28–e28.

²<https://www.withings.com/us/en/sleep>

³<https://www.fitbit.com/sleep-better>