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**BME802 – Human Computer Interaction**

**LAB REPORT**

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| **Semester/Year:** | Winter 2024 |
| **Lab Number:** | 2 |
| **Lab Title:** | Sleep Biometrics |

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| **Instructor:** | Kristiina Mai |
| **Section No:** | 02 |
| **Submission Date:** | March 7, 2024 |
| **Due Date:** | March 7, 2024 |

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| **Student Name** | **Student ID** | **Signature** |
| Zulfa Varvani | 500951166 | Z.V. |

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**Results:**

After recording for 14 days, the results are tabulated in *Table 1* with respect to sleep quality, stress, and game score. It is important to note that some days were outliers and were replaced with later recordings. In addition, the game was played between 1 – 20 minutes of waking up, and that I had woken up from sleep during religious prayer timings (5 – 6 AM). The mic on the app may have also recorded sounds from outside my house (near a noisy road) or my heater.

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|  | Hours asleep | Deep Sleep | Sleep Quality | Level of stress | Comment on accuracy | Notes | Game score |
| 15-Feb | 4 h 3 m | 58 m | 68 | Low | Accurate, and I woke early |  | 32 |
| 16-Feb | 2 h 3 m | 1 h 41 m | 71 | Low | Accurate as I couldn’t sleep and stayed up |  | 32 |
| 17-Feb | 7 h 9 m | 1 h 32 m | 85 | Low | Low stress and did not wake up until later |  | 66 |
| 18-Feb | 6 h 48 m | 5 h 47 m | 89 | Low | Had better sleep here, relaxed and slept late (was tired so slept immediately) |  | 82 |
| 20-Feb | 4 h 48 m | 2 h 52 m | 73 | Medium | Was working quite late and was more stressed, I also woke up much earlier |  | 36 |
| 21-Feb | 7 h 17 m | 2 h 16 m | 82 | Low | Lower stress compared to the previous day |  | 118 |
| 22-Feb | 6 h 23 m | 3 h 53 m | 87 | Low | Slept much later so I slept immediately |  | 104 |
| 23-Feb | 2 h 23 m | 2 h 20 m | 72 | Low | I slept much later and woke up very early, so my sleep quality was less here (tired in the day) |  | 54 |
| 24-Feb | 4 h 42 m | 2 h 10 m | 72 | Medium | Had longer sleep compared to the previous day, so my sleep was better but still not as good |  | 36 |
| 25-Feb | 6 h 20 m | 2 h 35 m | 84 | Medium | I was a little stressed here, but I did have enough sleep |  | 65 |
| 26-Feb | 4 h 44 m | 2 h 38 m | 73 | High | Had an exam and was to wake up earlier – very stressed as well, the app accounted for this | Napped after my exam | 36 |
| 28-Feb | 5 h 9 m | 2 h 9 m | 66 | High | Very stressed for my exam and my sleep quality was low here |  | 109 |
| 29-Feb | 4 h 53 m | 2 h 3 m | 68 | High | I came home tired and stressed for the next day, so I didn’t have as much quality of sleep |  | 86 |
| 05-Mar | 6 h 49 m | 1 h 36 m | 88 | Low | I was well rested from the previous week, and my sleep had been consistently better |  | 118 |

**Analysis**

1. Towards the later week of recording my sleep, stress from exams or working until late heavily contributed to my sleep quality and I had a much lower sleep score. In addition, when I have high levels of stress, my total sleep had reduced (usually had 5 hours average of sleeping). In an article, I read that “Adults with high stress are more likely to say they are not getting enough sleep because their minds race” [1]. Sleep and stress have a very close, cyclic relationship. With an increase in stress, there’s reduced sleep, and with increase in sleep, there is a decrease in stress. Like on February 16th, though I had low stress, I slept later and I felt more tired/lazy as I woke up and as I was doing my day-to-day activities. It impacted my deep sleep (and sleep quality) of the next day. “Short sleep duration has been shown to be associated with lower levels of happiness” [2].
2. Since the app was measuring my sleep quality and estimating my deep sleep based on an active mic (sound recording), I would say the accuracy is much lower as compared to other polysomnography biometrics. These devices would utilize a variation of sensors that could combine (autocorrelation and cross-correlation techniques) to measure sleep quality. It would account for heart rate, EEG, blood pressure, mobility during sleep and environmental sounds (snoring or sleep walking).
3. As I was consistent with recording my sleep, I started to notice that I wanted to sleep earlier or have more of a consistent sleep schedule to keep my scoring high (February 16th was a test to see my sleep score if I had slept at the usual times I would without caring on the impact of this decision). With a reduced sleep score and increased stress, I had a reduced game score. I really enjoyed the experience of the app on the different options it provided for tracking and improving sleep in various ways, but it could be improved with providing more insights while using the free tier.
4. Sleep deprivation could definitely be seen on February 16th and February 23rd. Although stress was low, the sleep scoring was effected and impacted my day-to-day activities after waking up (the reason for the sleep deprivation was staying up late doing non-work related activities). This is an interesting phenomena I found called ‘revenge bedtime procrastination’ [3] where one would purposefully stay up late to have a few hours of relaxation from a tiring day/week. What I found was that my deep sleep score was very high on those nights, and my REM was less than 1%! Results that are consistent with such scores can actually be fatal as REM is crucial in sleep-wakefulness physiology [4]. This is why, when in high stress days, sleeping early or longer is better for my health, as well as doing healthy activities (like exercises or walks), to avoid pairing high stress and reduced sleep.
5. Fitbit’s are great for tracking sleep as they have various sensors that can monitor sleep more accurately than the app I used for this lab. It uses an accelerometer and a heart rate sensor to estimate sleep stages (cross-correlation method). Length of immobility, heart rate variability, and length of time between movements are among the tracking techniques that the device uses to estimate the sleep stages and score.   
   Another device is the Dreem 2 headband that is a device (mostly for improving a sleeping disorder) that can track sleep activity using EEG. It uses a sound stimuli that can make falling asleep faster as well! It takes in 7 nights of EEG recordings, questions during the day to a patient, and then providing a detailed report on the issues related to sleeplessness with a unique plan on improving sleep.

**References**

[1] "Sleep Deprivation and Stress." American Psychological Association, 2013, <https://www.apa.org/news/press/releases/stress/2013/sleep>.

[2] Feingold, Cailan Lindsay, and Abbas Smiley. “Healthy Sleep Every Day Keeps the Doctor Away.” International journal of environmental research and public health vol. 19,17 10740. 29 Aug. 2022, doi:10.3390/ijerph191710740

[3] Deeg, Janosch. "It Goes by the Name 'Bedtime Procrastination,' and You Can Probably Guess What It Is." Scientific American, <https://www.scientificamerican.com/article/it-goes-by-the-name-bedtime-procrastination-and-you-can-probably-guess-what-it-is/>.

[4] Mathangi, D C et al. “Effect of REM sleep deprivation on the antioxidant status in the brain of Wistar rats.” Annals of neurosciences vol. 19,4 (2012): 161-4. doi:10.5214/ans.0972.7531.190405