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‘SMART WAKE UP’ AND ‘BINAURAL BEATS’: SLEEP APPS AND THE ACOUSTIC MODULATION OF SLEEP-WAKE RHYTHMS

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Introduction

Sleep has become a site of daily monitoring via internet technologies, including mobile applications and wearable devices, as part of a wider normalisation of internet economies and cultural practices of self-tracking and datafication (see O’Neill and Nansen, 2019). This article contributes to the critical analysis of sleep tracking, mediation, and datafication by analysing features in the most popular sleep apps.

A key finding of this analysis is that sleep apps extend beyond the personal tracking of sleep patterns through two novel acoustic features – ‘smart wake up’ alarms and ‘binaural beats’ frequencies. We show how these features operate to organise transitions between waking and sleeping states by directly intervening in and modulating sleep-wake rhythms. In doing so, we argue that these functions draw on histories of both sleep science and acoustic media in attempts to optimise the rhythms associated with sleeping bodies.

Personal Sleep Monitoring

Within the sleep industry, concern for how mobile *devices* disrupt sleep (Crary, 2013) is supplanted by an ideology of innovation in which mobile software *applications* are envisaged as able to produce better sleep through sleep management functions including notifications and alerts, sleep tracking, and relaxation features designed to encourage good sleep ‘hygiene’ (Fuller, 2018). Williams et al (2015) highlight how personal sleep monitoring was enabled by technologies that moved outside the scientific and medical institutions of the sleep lab, and into everyday life through the

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development of wearable devices, mobile phones, and internet applications. Their analysis is helpful for critically positioning sleep's digitisation within wider socio-cultural shifts, however, there remains a lack of close analysis of the sleep *app* market.

Researching Sleep Apps

We undertook a feature and case study analysis of the most popular sleep apps on the Apple App store. This method was aimed at documenting the dominant features, the possibilities afforded by their functions, and the implications of app operations for managing and modulating sleep (Lupton 2014). 100 apps were coded into distinct categories of sleep apps, with the two dominant categories, Sleep Cycle Monitoring and Relaxing Sounds, coded through an analysis of their features, derived from app descriptions provided by the app developers in the App store. Following the app feature analysis, we selected a key example from each of the dominant sleep app categories for case study analysis. The apps selected were Northcube Sleep Cycle Alarm Clock and ilBSoft's Relax Melodies.

This analysis revealed a diverse range of functions for tracking and analysing sleep patterns, as well as features to promote relaxation and rest. In doing so, sleep apps remediate the monitoring technologies of the sleep science lab – polysomnography, actigraphy – to make claims for accuracy and efficacy. Yet, the analysis also revealed how sleep apps go beyond simply monitoring sleep patterns by directly intervening in sleep-wake rhythms through two key acoustic features: the 'smart wake up' alarm function, and the 'binaural beats' sound frequency function. We argue that these features should be understood not only in terms of monitoring or customisation of one's sleep patterns, but as forms of acoustically modulated automation and optimisation of sleep-wake rhythms.

Smart Wake Up: Optimising the Rhythms of Sleep

A novel feature emerging from the analysis of sleep cycle monitoring apps was the algorithmically determined 'smart wake up' function. Rather than setting an exact time to wake, the smart wake up allows users to enter a time period in which the app is able to determine the optimal time of waking based on sensor data on stages of sleep. Sleep Cycle describe their smart wake up function as:

> *a wake-up phase (30 minutes by default) that ends at your desired alarm time. During this phase Sleep Cycle will monitor signals from your body to wake you softly, when you are in the lightest possible sleep state.*

Whilst sleep tracking features offer indirect suggestions for improving the general quality of a user's sleep, the 'smart wake up' feature of these apps claims to directly produce a sense of wellbeing, with several apps promising users will 'wake up refreshed'. The smart wake function diverges from the medical genealogy of sleep *monitoring* functions

that remediate earlier sleep actigraphs, through a computational approach to automation and algorithmic *intervention*. By going beyond measurement, these apps offer a more direct modulation and optimisation of biorhythms by claiming to wake users at the optimal point within the phases of the sleep cycle. The 'smartness' of the app, then, indicates a shift from disciplinary to control technologies for sleep management, based upon adaptive automation of sleep-wake rhythms.

Binaural Beats: Modulating the Frequency of Sleep

Our analysis of the 'Relaxing Sounds' group of apps uncovered a novel acoustic function within customisable soundscape on popular sleep apps, 'binaural beats'. Binaural beats work by simultaneously transmitting different sound frequencies in each ear using headphones (the binaural), which the brain physiologically responds to by producing brainwave frequencies at a rate of hertz (Hz) dividing the two frequency tones (the beat) (Oster, 1973, p. 94; see: fig: 1).

The human brain emits different frequencies in different psychological states, and it is claimed that binaural beats can deliberately produce particular frequencies in the brain – a psycho-acoustic phenomena referred to as 'brainwave entrainment'. In sleep apps the aim is to produce lower frequency waves of brainwave activity, such as delta (approximately 1 to 4 Hz) and theta (approximately 4 to 8 Hz) frequencies, which are associated with relaxed, meditative, and sleeping states.

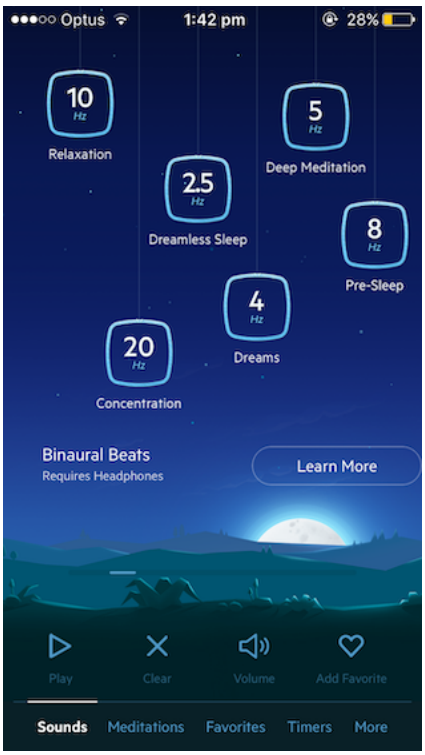

Figure 1: Screenshot of Relax Melodies binaural beats function

Such sleep acoustics can be traced through a trajectory of media theorisation that differs from dominant critical theories of datafication and self-tracking (e.g. Lupton, 2017). Instead they demonstrate the continued cultural significance of environmental media, and in this case 'audible' technologies, for materially shaping our perception of spaces in everyday life (see Sterne, 2003). Histories of *perceptible* media, however, take on new resonances in the contexts of sleep apps and binaural beats for modulating neural-electrical activity. Extending a murky lineage of psychoacoustic attempts to induce states of affect or consciousness, ranging from alternative therapies to the sonic disciplining of spaces of work or leisure, popularised by the Muzak Corporation (Laliberty, 2017), we can see binaural beats as operating within a more intensive perceptual terrain in aiming to modulate brainwave frequencies to induce sleep.

As with the smart wake up function, there is again a delegation of the work involved in entraining the body towards a given state of somnolence. However, binaural beats more directly intervene into the physiological interior of corporeal optimisation. And in this dream of delegation and automation, we can observe a shift in the register of mobile sleep app affordances. There is a shift from the burden of self-management via datafication and tracking to a more passive mode of neurological modulation that organises the self in a cybernetically oscillating operation of transmission-reception, signal-noise, on-off.

References

Crary, J. (2013) *24/7: Late capitalism and the ends of sleep*. London: Verso.

Fuller, M. (2018) *How to sleep: The art, biology and culture of unconsciousness.* London and New York: Bloomsbury.

Laliberty, R. (2017) Audio acid: Design and the psychoacoustic trip. *Journal of Sonic Studies* 14, at https://www.researchcatalogue.net/view/291802/291803/0/0.

Lupton, D. (2014) Apps as Artefacts: Towards a Critical Perspective on Mobile Health and Medical Apps. *Societies* 4: 606-622.

Lupton, D. (2017) Feeling your data: touch and making sense of personal data. *New Media & Society* 19(10): 1599-1614.

Northcube. (2017) How does it work? *Sleepcycle.com* Available at https://www.sleepcycle.com/how-it-works/. Accessed 1 September 2017.

O'Neill, C. and Nansen, B. (2019) Sleep mode: mobile apps and the optimisation of sleep-wake rhythms. *First Monday* 24(6): https://firstmonday.org/ojs/index.php/fm/article/view/9574/8045.

Oster, G. (1973) Auditory beats in the brain. *Scientific American* 229(4): 94-103.

Sterne, J. (2003) *The Audible Past: Cultural Origins of Sound Reproduction.* Duke University Press.

Williams, S. Coveney, C. and Meadows, R. (2015) 'M-apping' sleep? Trends and transformations in the digital age. *Sociology of Health and Illness*. 37(7): 1039-1054.