Expergefactor:
Sonic Interaction Design for an Alarm Clock App

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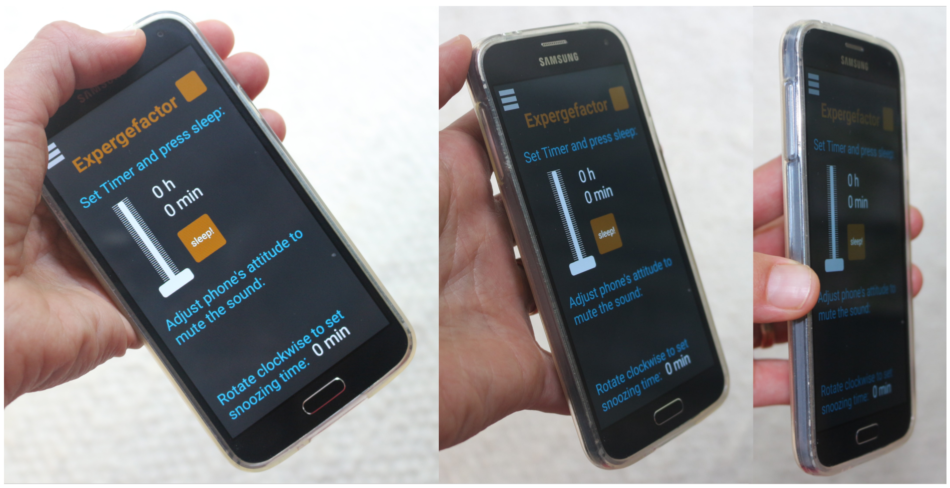

Figure 1: Graphical user interface (GUI) of the Expergefactor. The visual display is limited to the sleeping time and the snoozing time; the program is mainly based on auditory feedback corresponding to rotating the mobile phone.

ABSTRACT

We present a prototype for an alarm clock app that is based on sonic interaction design, called the Expergefactor. It consists of two parts that solely rely on rotating the phone and receiving auditory feedback. In an awakening challenge, the mobile phone has to be rotated to find a random position following sonic clues. For setting the snoozing timer, the phone is turned and gives swelling sonic feedback for each minute more.

CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Sound-based input / output**; Auditory feedback; Activity centered design.

KEYWORDS

sonic interaction design, auditory app, sonification

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1 INTRODUCTION

Waking up in the morning can be a challenge, especially if the night was short or the sleep was restless. Smart technologies are more and more moving into our living environment, thus also into our bedroom. Today, there exists a variety of alarm clock hard- and software that are supposed to ease the process of awakening by utilizing sleep monitoring principles or by creating physical barriers (for instance Clocky, a motorized alarm clock that runs off after your first snooze time expires, see [6]). In [1] the fundamental importance of sleep and new design strategies for alarm clocks are outlined. Sleep monitoring tools adjust the wake-up time to a light sleeping phase. In addition to an untimely wake-up, the process of waking up plays an important role for the mood of the person. Furthermore, the authors describe smart alarm clocks that take external factors into account to adapt the wake-up time.

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Most of these are event-driven, so for instance the alarm time is adjusted to an approaching train station or an important email. Another strategy is the expressive alarm clock where the alarm signal is modified depending on the user's mood. [6] observes design strategies to address self-control dilemmas. The authors specifically describe six design approaches that address the trade off between lingering in bed and getting up on time in the morning: 1) adding new sources of displeasure for snoozing in bed, 2) adding new sources of pleasure to getting up on time, 3) making losses of snoozing in bed tangible, 4) making gains of getting up on time tangible, 5) creating barriers for snoozing in bed, and 6) creating enablers for getting up on time. In this paper, we would like to add another variety of a smart alarm clock which is based on 1) and 5) of the latter. Through self-observation we found that a major issue of awakening is to fall back asleep after the first alarm. An alarm clock that demands not only physical but also cognitive activity from the user, however, might be a key to help us awakening from deep sleep after the initial alarm has been turned off.

Early smartphones and mobile devices such as PDAs had a low display resolution. Consequently, sonification would have been a great possibility to enhance the presented data without the usage of a screen [2]. Nowadays, smartphones have a high resolution, but the screen as a small, single-sided, and two-dimensional display limits the user's space of interaction. For example, if one wants to interact with the device and wants to turn it, the screen cannot be seen. In such cases an auditory feedback is mandatory. In short, adding sonic interaction design to mobile devices enhances the interaction space of the user. Furthermore, there is another reason to focus on sonic interaction instead of the classical GUI-based usage of smartphones. Numerous surveys have shown that a growing number of people are using their phone in bed. This behaviour is believed to reduce both sleep duration and quality [4]. As for alarm clock apps, the first glance on the screen usually happens when the alarm is being turned off or the snoozing timer is set. An alarm clock app based only on haptic and sonic interaction design - without using the graphical user interface - postpones the user's first glance on the screen and hence might reduce the duration of phone usage in bed.

In [9], a hardware alarm clock with a tactile user interface, called the "Tumble Clock", has been designed. The Tumble Clock is designed in a way that allows the user to unbalance its whole body, in order to set and adjust the snoozing time. Thereby, the user is provided with a specifically designed auditory feedback. In a consecutive evaluation, participants were provided with one out of two versions of the Tumble Clock. First, they were provided with an auditory feedback that changed adaptively, depending on the adjusted snoozing duration. The second version had a simple feedback when snoozing has been set. The evaluation revealed that all of the participants, after a learning phase, were able to set the snoozing time in a way they intended. Most participants showed sympathy with the principle of setting the snoozing time in this tactile way. The authors found that some subjects had had initial troubles at adjusting the snoozing time without adaptive auditory feedback, even though they stated it would not be necessary. Based on these findings, we assume that the deployment of an adaptive auditory feedback for snoozing time adjustment is a reasonable feature for an alarm clock.

Note that in our literature review, we focused on the topics of alarm clocks and snoozing related to (sonic) interaction design. We neglected gaming due to the vast amount of apps and literature that are already available, even if our design can be interpreted as an audio only game.

In this paper, we propose the prototype of an interactive alarm-clock app: the "Expergefactor" (archaic for: alarm clock). It is designed as pleasant and amusing alarm clock and implemented as a fully auditory-only alarm clock without any visuals needed in order to turn off the alarm and/ or set the snoozing time.

The Expergefactor is the result of a student group work in a Master's course in sonic interaction design. As it was developed during Covid-19 pandemic, we were restricted to using an interface that many people have at home: a mobile phone. The Expergefactor consists of a GUI to display, adjust and start the sleep timer, a listen-and-balance challenge to turn off the alarm, and a rotation program to set the snoozing time with adaptive auditory feedback. With this concept, we aim to facilitate the process of perking up by claiming both cognitive and physical activity, to reduce screen usage in the morning and are addressing number 1), 5) of the above described design approaches.

In the following sections, we explore the realization of the prototype. We discuss the design of the auditory feedback for both the awakening challenge and the snoozing timer, followed up by a summary of the pilot evaluations.

2 DESIGN AND DEVELOPMENT

The Expergefactor has been developed using the the open source visual programming language Pure Data (Pd). We used the free MobMuPlat app [3, 5] to make the patches accessible on mobile devices. MobMuPlat is a "mobile music platform" for Android and iOS that provides a graphical user interface (GUI) for the audio engine in Pure Data . It suffices to install the MobMuPlat App, load the Expergefactor files on the mobile phone into the MobMuPlat folder and open the .mmp-file. For more detailed installation instructions, refer to the MobMuPlat homepage. The software versions for development were PD-0.50-2, MobMuPlatEditor version 1.80. The Expergefactor has been tested on MobMuPlat version 0.36 for Android.

You may download the sourcecode from https://git.iem.at/sid_ss20/interactive-alarm-clock and a demo video from https://doi.org/10.5281/zenodo.3985022.

2.1 Program Flow

The Expergefactor consists mainly of three parts that are being called successively. At program startup, the GUI as in Fig. 1 gets initialized. It consists of a slider for sleeping-time adjustment, digits to display the set sleeping- and snoozing-duration and a button to start the sleeping timer. The user will set the slider and press the "sleep!"-button in order to start the timer. As the timer runs off, the Expergefactor prompts an awakening challenge as described in Sec. 2.2. Once the challenge is completed, the user may put his/her phone back down and set the snoozing time, as described in Sec. 2.3.

2.2 Awakening challenge

The awakening challenge is designed to demand cognitive as well as physical effort from the user, without the need of a reference to the screen. To do so, it takes advantage of the phone's accelerometer and compass sensors. In principle, the challenge is simple: rotate your smartphone until you find the (randomly assigned) right position and hold it in that position for an amount of time to fade out the alarm.

We chose a redundant mapping to provide different clues, as suggested in [7, Ch. 15]. The mapping was inspired by Ziemer et al. [8], who created a psycho-acoustic mapping for a sonification of three dimensions with a monophonic sound. Their approach was to map a rising/ falling glissando for one axis, and the roughness/beating of the sound the the second axis. If the sound is steady, the center is reached.

Interpreting the sensor data proved more demanding than expected; furthermore, the quality of input varied across different mobile phones. We calculated the roll from the x-axis of the accelerometer data as $asin(x)$, and chose the compass data as independent yaw dimension. Note that it proved important to regularly calibrate the sensors with any app to get a more reliable input.

When starting the awakening challenge, we create a random reference value for the phone's yaw and roll orientation, R_{Ref} and Y_{Ref}. For guiding the user to the reference point we calculate the nearest roll distance from the current position,

$\Delta R = R_{ref} - R_{current}$

$if(\Delta R > \pi) : \Delta R = \Delta R - 2\pi$

$if(\Delta R < -\pi) : \Delta R = \Delta R + 2\pi$

and the nearest yaw distance ΔY in the same way. These control the chord's arpeggio and sustain, respectively. As shown in Figure 2, rotating the phone around the yaw axis results in controlling the delays between single notes of the chord. A rotation around the roll axis increases or decreases each note's playback duration. As a function for the sustain time t_s, we chose

$$t_s = \begin{cases} k_{t_s,1}(1 - e^{-\Delta Y}) + d_{t_s,1} & \Delta Y \geq 0 \\ k_{t_s,2}e^{\Delta Y} + d_{t_s,2} & \Delta Y < 0 \end{cases}$$

so that the maximum and minimum error result in $t_s = 1/32^{th}$ and $t_s = 1/1$ notes, respectively. At, $\Delta Y = 0$, the sustain is $t_s = 1/2$ note. As for the assigned arpeggio, we chose a linear function $t_a = k_{t_a} e^{|\Delta R|} + d_{t_a}$. The note order is being flipped at values $\Delta R < 0$. The parameters are chosen so that there is no arpeggio at $\Delta R = 0$ and $t_a = 14/32^{th}$ notes at maximum values.

As basis for the sound feedback, a sequencer has been created that plays back a four-note midi chord at every full bar, at a speed of $1.120s$ per bar. The type of chord being played back depends on the current distance to the reference point, simply assumed as $\Delta = \Delta R + \Delta Y$. For decreasing values of Δ, it constitutes a 6-2-5-1 progression in a C-Major scale. The structure of descending fifths aims to provide an intuitive guidance towards the desired positioning.

Furthermore, the sounds being played are bandwidth-filtered sawtooth oscillators, where the quality of the filters is controlled by the Δ as an exponential function $Q = K_Q \cdot e^{-\Delta} + d_Q$. The parameters are chosen in such a way that the maximum Δ results in a quality factor $Q = 0$, producing a loud and rough voicing. An $\Delta = 0$, in turn,

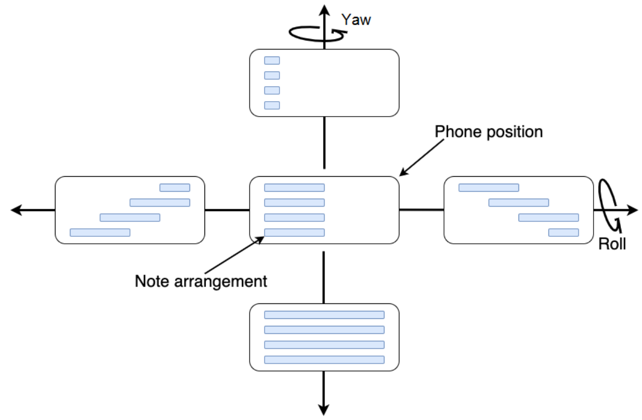

Figure 2: Illustration of the mapping between note sustain and pitch as well as arpeggio and roll

assigns a high quality factor $Q = 5$ to the filter and thus end-up in sounding smooth and thin.

When the reference is reached, the chord becomes more "bright and happy", appears simultaneously (without arpeggio), and sustains for a duration of 1/2 note (regular on-off rhythm). The challenge is successful, if the final-stage chord sounds three to four times in a row, and the sound fades out.

2.3 Snoozing timer

Once the challenge has been mastered, the snoozing timer can be set. The metaphor for our design is an egg timer that is set up by turning and provides a click for each time unit. Our snoozing timer works on the same principle. The smartphone is turned clockwise and gives auditory feedback for each minute of snoozing time set.

In the first stage, the snoozing time displayed on the GUI (Fig. 1) is initialized by 0 minutes. By turning clockwise, for every 20 degrees the counter increments by one minute, while the maximum snoozing time is 30 minutes. With every increase in minutes, an auditory feedback can be heard. If the counter of snoozing time reaches zero again the challenge starts with a new random reference position.

The design of the auditory feedback follows a Model-Based sonification [7, Ch. 16]. We used a physical model of a pipe implemented as wave-guide. The model consists of two delays which simulate the wave traveling forwards and backwards inside the pipe. We chose an open pipe for the feedback sound. The pitch of this pipe sound is initially a 110 midi note. Every minute added, the midi value decrements by 5. Furthermore, the number of minutes controls a low-pass filter. Note that for unknown reasons the sound was different when testing on a PC than it is given from MobMuPlat; for our metaphor, it proved sufficient.

With a normal alarm clock the snoozing time is a fixed value and the snoozing button has to be hit. Even if the snoozing time is adjustable, this usually has to be done before setting the alarm. In our approach, the snoozing time can be interactively set when needed. This involves a longer physical activity as opposed to pushing a button. Furthermore, the adaptive sound design might inhibit a long snoozing time, as it sounds very "heavy" for long snoozing times.

3 INFORMAL EVALUATION

As part of the cyclic development and design process, we conducted an informal evaluation of the usability of the two main elements of an earlier version of the prototype (awakening challenge and snoozing timer). Six participants were asked to engage with both the challenge and the snoozing timer separately. In a semi-structured interview, we asked questions about the impressions of the sound mapping, the voicing, the functionality and if they would use the Expergefactor as an alarm-clock app. The subjects were between 19 and 29 years old. Three of them were female. Three had a musical background. The evaluations were made with an earlier version; their results have already been incorporated into the implementation described in this paper. Still, a few general remarks concerning the not-changed aspects are still meaningful to state here.

In part I, we tested the awakening challenge. All subjects then succeeded in the challenge three times in a row, with varying completion times ranging between 1′10′′ and 4′15′′ (depending not only on the skilfulness of the participant but also on the varying difficulty of the task due to the randomly assigned goal position). Asked for the pleasantness of the sound, three subjects stated they did not like it. As reasons, they indicated the sound was too "annoying" and "piercing". As it is part of our mapping strategy to change the quality of the bandwidth filter, reaching a most pleasant sound only near the correct position, this finding is acceptable. One participant stated, she was not sure if pure auditory feedback would suffice for the challenge and would thus prefer an additional visual feedback. Five subjects found it fun and interesting to explore the challenge. Two were overwhelmed by the wide range they had to turn the phone - we addressed this finding in a way that the reference point is now always within a limited range around the current position. One subject stated, it would be helpful to listen to the full chord progression in advance, in order to gain more clue of the desired direction. A longer learning phase before a next round of evaluation is certainly helpful.

In part II, we tested the snoozing timer. All subjects showed positive reactions in terms of sound design, feedback, simplicity and fun factor. All achieved at setting the timer correctly with closed eyes a few times in a row. Three subjects declared, however, they would find an option to decrease the snoozing time by turning the phone counter-clock wise desirable. This was implemented as described above.

In general, all participants agreed that, after a learning phase, it seemed not difficult to handle awakening-challenge and snoozing. Five subjects could imagine using the Expergefactor as an alarm-clock app if it gets fully developed.

4 DISCUSSION

This paper presents the re-designed prototype of the Expergefactor, a sonic interactive alarm clock. This application is intended as a pleasant wake-up and inhibit the user from reiterating the snoozing function too often. With a conventional alarm clock the only way to turn the alarm off is to hit the snooze button or turn the alarm completely off. With the Expergefactor, cognitive and physical activity is needed to turn the alarm off and set the snoozing time. The challenge and the snoozing time adjustment can be done without any visual distraction - especially from social media - and might therefore enhance sleep and wake-up quality.

The evaluation showed that after the introduction to the mapping all participants mastered the challenge within an appropriate time. The feedback and the mapping of the snoozing timer were satisfying for all the participants. This confirms our design strategy.

The prototype works on Android, but there is a limitation because the MobMuPlat app [3, 5] didn't work in the background with darkened display. We intend to test the prototype as an alarm clock, but for a further iteration a new technical solution has to be found.

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