Somnox Mini

Designing for habit formation of device regulated breathing exercises

Summary

This graduation thesis is a continuation of a previous thesis written for Somnox BV. Somnox Mini was developed to help stressed millennials cope with stress through guided breathing exercises. Several benefits can be gained from daily usage (i.e. better sleep, stress resilience and mood). This project therefore focused on the research question: **how to design the user interaction with Mini to ultimately form a habit of performing breathing exercises?**

Inspired by meaningful gamification (Nicholson, 2015) and implementation intentions (Gollwitzer et al., 2010) a redesigned concept for Mini's companion app was formulated. This app allowed users to track their breathing performance, select exercises from a meaningful sequence and make implentation intentions. Functional prototypes of Mini and its companion apps were developed and tested in a longitudinal study of 10 weeks (n=8).

Following the longitudinal study, explorative data analysis was performed on the gathered data (i.e. exercise logs and survey answers). This revealed phenoma and questions that required in depth questioning. Semi structured data informed interviews were conducted to gather information on the user experience and motivations of the participants. Thematic analysis was performed on the transcriptions of these interviews to identify points to iterate with.

The final iteration of Mini's companion app allows users to freely choose their exercises. When formulating a custom exercise users are asked to make an accompanying implementation intention. For these implementation intentions users receive early reminders. Logs provided by the companion app contain actionable insights for the user to improve with. A new community tab provides users with a source of inspiration for exercises and indirect social pressure to nudge them to perform an exercise if they haven't done so yet.

Introduction

Stress and breathing exercises

Stress can be biologically defined as a physiological response to external stimuli perceived as threats whether that be dangerous predators in ancient times or impending deadlines in modern times. This response serves humans by preparing us for action with an increase in heart rate and increased glucose delivery to the muscles. While stress itself can be beneficial to humans during these moments (Sanders, 2013), a chronic state of stress can become debilitating over time. It can cause headaches, problems with concentration, sleep disturbances, exhaustion eventually leading towards more severe problems such as hypertension, mood disorders and burnout. (Cleveland Clinic, 2015; van Reeth, 2000).

Stress is regulated by the autonomic nervous system. It consists of two systems that balance each other: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) (Waxenbaum, 2020). Upon activation the SNS triggers the stress response while the PNS triggers a relaxing response which includes regenerative processes such as digestion and muscle growth. A large component of the PNS are the vagus nerves. These have a large influence on the immune system and heart rate.

Slow breathing exercises, where practitioners breathe at a rate of 6 breaths per minute, have been shown to trigger a physiological phenomenon called respiratory sinus arrhythmia (RSA). During RSA the heart rate increases during inhalations and decreases with exhalations as seen in figure 1. This synchronization leads towards increased oxygen saturation and increased vagus nerve activity (vagal tone). If practiced regularly, exercise can lead towards decreased stress symptoms, better sleep and improved stress resilience (e.g. quicker recovery from stress-related heart rate spikes).

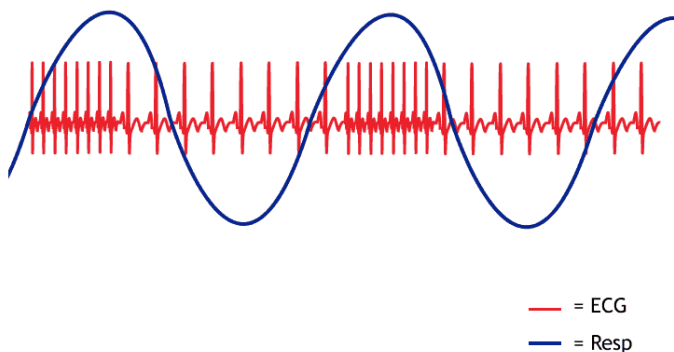Relation between ECG and Respiration Series

Figure 1: a visual representation of RSA (source: https://support.mindwaretech.com/)

With this knowledge on RSA, Somnox has developed a conceptual design for a portable breathing regulation device called Somnox Mini also referred to as Mini (Yip, 2020) (see figure 2). Its design was focused on providing stress relief for the representative persona called Career Carmen, a working millennial (aged between 24 and 35) with unhealthy strategies for coping with stress. While aware of breathing exercises, she is skeptical of their efficacy due to low self-efficacy (e.g. not knowing how to perform exercises) and their prevalent associations with spirituality. Moreover past attempts at adopting regular breathing exercises failed reportedly due to a lack of motivation and time.

Figure 2: Somnox Mini rendering designed by Yip (2020)

Mini was developed to be a portable solution that provides kinetic feedback (i.e. a 'breathing' expansion of the device) to guide users to breathe at 6 breaths per minute. Additionally, using a photoplethysmography (PPG) sensor, Mini provides vibro-tactile feedback whenever it detects RSA in the user's heart rate. This device gives users the self-efficacy to perform breathing exercises at specific rates and gives them insight into their performance during the exercise itself.

This initial design project ended with recommendations to explore ways to foster habit formation for users of Mini to enable them to get the full benefits of slow breathing. Suggestions included context-appropriate reminders, displaying progression based on heart rate variability (HRV) and focusing on fostering intrinsic motivation as it results in longer habit sustainment than extrinsic motivation.

What are habits?

A habit is an action that is performed automatically in response to a specific contextual cue (i.e. time, location, previous activity) (Miller et al., 2019). Habits serve to lessen the cognitive load on the brain while performing the habit in order to free up space to process other thoughts. These habits are neural pathways that strengthen through repetition. Habits can get so strong in people that they end up performing them even when not intended (e.g. habitual phone checking) (Clear, 2018).

This graduation thesis will focus on studying habit formation and intrinsic motivation in the context of forming a habit of using Mini, specifically focusing on answering the question: **how to design the user interaction with Mini to ultimately form a habit of performing breathing exercises?**

It will do so by first providing background information on habit formation, intrinsic motivation and its application in design (i.e. gamification). With that information a concept is made of Mini's companion app with a focus on forming a habit of Mini usage. Three variations of the concept will be formulated based on gaps in the literature and tested in a longitudinal user study. The results of this study will then be analyzed in order to formulate a final concept iteration and design recommendations.

Background information

How are habits formed?

The habit formation process can largely be represented with: a cue, craving, action and a reward seen in figure 3. This model from Clear (2018) posits that once a habit has been formed it gets triggered via cues and is motivated through cravings of an expected reward. For example a social media application that creates the habit of scrolling through your social media feed. The internal feeling of boredom is the cue that triggers someone to start craving a worthwhile distraction. This in turn leads people to open the platform and start scrolling until they find that interesting post able to scratch the itch of boredom. This craving starts out small, but grows with the habit through association with the perceived reward (mental stimulation) when performing the habit (scrolling).
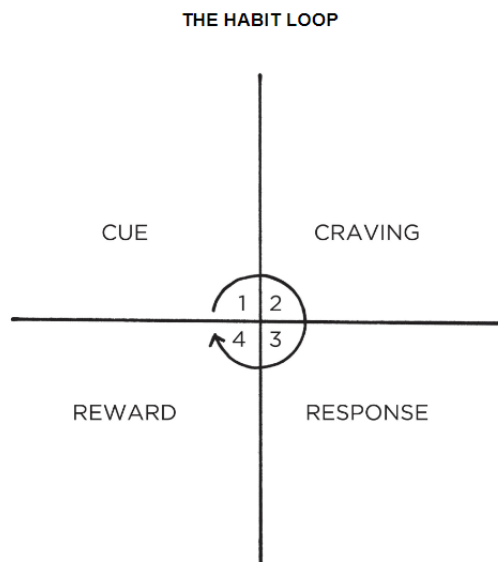

Figure 3: Clear's habit loop (source: Clear, 2018)

This association can also be formed within people through advertising, even if the association does not have any scientific validity. Duhigg (2012) describes how Pepsodent was able to form a habit in the American population through advertising the cue of (detecting) a thin film on your teeth supposedly indicating filthiness, thus creating the need for brushing. While this film was not actually harmful, it was a regularly occurring and easily detectable phenomenon for people who are conscious about their outward appearance. This cue made it easy for the habit of tooth brushing to become as popular as it did.

Important to note is that Pepsodent also distinguished itself from competitors through also making their customers' mouths feel and taste clean after using their toothpaste by leaving a tingly, fresh feeling. This sensation, while not contributing to the cleaning function of the toothpaste, can be experienced as the reward for brushing teeth once it becomes associated with the reward of cleaner teeth. This goes to show that enjoyable and memorable user experiences are more likely to become habitual and in some cases could even be necessary to motivate people to return until the habit has formed.

According to Lally et al. (2010) habits can be formed within 18 to 254 days with an average of 66 days for people trying to develop a healthy habit (e.g. drinking water, eating vegetables or sporting). Any behavior (in a reoccurring context) can become habitual if done with enough repetition, the more frequent a behavior occurs the quicker the habit forms.

Somnox aims to provide the action to a craving of relaxation by providing haptically enhanced and guided breathing exercises. Like many companies they already actively try to inspire this association through their advertising and marketing channels with a focus on relaxation with their distinctive soft and companion-like qualities in the bed and on the couch.

In order to promote habit formation designers should also include the contextual cues (place, time, mindstate and previous activity) before using their products in their advertisements. Potential users could then find themselves craving their products if they find themselves in similar contexts. These cues can also be implemented in the exercises presented in their companion app (e.g. an exercise to recover from a stressful workday or an exercise to boost energy in the morning).

Willpower

Duhigg (2012) describes willpower (the capacity to exert self control) management as an important component of effective habit building. Willpower is described as a resource or muscle that depletes throughout the course of a day. He therefore also recommends planning habits that require willpower (such as working out or eating healthy) early in the day as opposed to at the end where one might be tempted to stay in instead.

Willpower however remains a contested concept within the field of psychology with claims that it can be tied to blood glucose levels (Gailliot & Baumeister, 2007), but is also strongly affected by an individual's belief about willpower as a resource (Job et al., 2010). People who believe in this conceptual model will also be more likely to report having low levels of willpower.

Willpower can be tied to moments of the day where people are likely to accept a prompt to use Mini. Soon after waking up or after a meal (morning or evening) would be good times to ask users for interactions with or without strong rewards. Such moments can be presented as suggested exercises. Somnox should however refrain from framing or describing willpower in these suggestions to prevent perceptions of Mini usage as a chore (that requires willpower).

Explicit habit formation

In the domain of habit formation research a distinction can be made between implicit and explicit habit formation. Explicit habit formation can typically be found in the formation of healthy habits as encouraged by doctors. This form of habit formation relies on a sense of autonomy and conscious effort to form their desired habits. For instance when patients want to eat healthier Gardner & Lally (2013) recommend having the patient choose their own healthy food targets in order to maximize autonomy.

Additionally patients are instructed to think about ways to achieve those goals using simple repeated actions (in order to form habits) and make implementation intentions. These are protocols that patients formulate for themselves to describe how they are going to be performing their habit. This also includes anticipating scenarios that would prevent them from performing their habit and the appropriate responses that would allow them to still perform the habit (Gollwitzer, 1999). When doctors deploy this toolbox, patients are also explicitly told that they will be forming a habit that will sustain healthy behavior even when internal motivation wanes. This awareness of the habit formation process frames the initial weeks of habit formation as conscious investments towards growing this habit thus increasing the motivation to stick to the implementation intention when starting out, a period where habit performance still requires active effort.

Explicit habit formation advice is also found in books that help readers to take control of their habits by convincing them of the power of habits and providing strategies to apply in their own lives. All this knowledge contributes to a higher degree of self determination and self efficacy in turn resulting in more internal motivation to actively form a desired habit (Gardner & Lally, 2013).

Despite possible perceptions of selling 'addictive' products, it is still recommended to make use of implementation intentions. In order to make this desirable emphasis should be placed on the benefits of long term use. The interaction of setting up an implementation intention has to however be simple as the mental capacity of a new user should be focused on performing the exercise. Chang (2020) has also found that users of the first Somnox Robot struggle with information overload from the wide array of

exercises. This means any information secondary to increasing self efficacy in breathing exercises should be kept minimal.

Implicit habit formation

Implicit habit formation comes in the form of persuasive design elements that leverage psychological characteristics to keep users engaged. According to Fogg (2009) the occurrence of a habit is dependent on three factors: motivation, ability and triggers. As long as the user has enough motivation and ability any trigger, whether it be a mobile reminder from a device or internal feeling like boredom, reminding the user of the habit will be sufficient to prompt the action. In order to increase the chance of a habit occurring Fogg recommends improving on the ability factor, meaning making the habit (or task) easier and quicker to do, because increasing motivation would be too difficult and expensive in comparison. In the social media platform example this sentiment is evident in the endless timeline feature commonly found in them. The simplicity of this user interaction combined with the variable reward (Eyal, 2014) of mental stimulation makes it incredibly easy to continue doing for prolonged periods resulting in rapid habit formation of scrolling in the app.
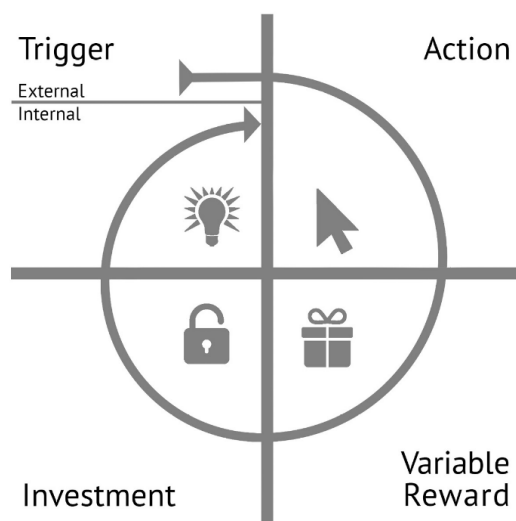
Figure 4: Eyal's hook model of habit forming products (source: Eyal, 2014).

Eyal describes 'investments' in his model of habit forming products and services (see figure 4). These investments are the user interactions that do not necessarily provide value in the moment, but they provide value the next time the user interacts with the application. These investments prime the user to return to the application for an improved version of the application they have already gotten rewarded from. In social media platforms this can be seen in the ability to follow or subscribe to users in order to curate more of their (presumably desirable) content in their future feeds, also priming them to return to the service in order to extract value from their previous investment. Over time these investments can create such a personalized user experience that users feel discouraged from switching to comparable or even better alternatives as they would lose the value of their past investments.

Eyal also describes investments of time and effort. These are collections of past interactions that motivate the user to keep on using the product or service in an effort to rationalize not having 'wasted' time and effort into something not worth further pursuing. These investments can be integrated into design elements that encourage users to build streaks of consecutive uses. While it does not explicitly provide value to the user in itself, large streaks encourage users to keep returning in order to not see that streak go away. Products and services can also tie benefits to these streaks in order to further encourage streak (and as a result habit) building.This can be seen in online video games that provide rewards (f.e. in-game cosmetics) for achieving certain streak lengths. Renfree et al. (2016) also report that streaks are an effective tool to maintain motivation even reporting it to be the most effective within users of Lift, an app aimed at explicit habit formation, even though building streaks gave no external rewards.

Stawarz et al. (2015) however caution designers not to rely too much on electronic alarms (short notice notifications of incoming events) and self monitoring (i.e. habit streak tracking) despite their proven effectiveness. Reliance on these tools can cause habit occurrence to be dependent on these tools. Similarly to external rewards once these triggers stop occurring or stop being encouraging (e.g. not caring about maintaining a streak) the associated habits can also stop occuring. Instead they recommend designers focus on making implementation intentions and reminding users of their plans outside of the context instead of a direct prompt so they can remember to perform the habit by themselves. When the user performs the habit without immediate reminders the association between the habit and contextual cue becomes stronger, more quickly.

Rewards and motivation

Rewards and their resulting motivations can be classified in two types: internal and external. Deci and Ryan (2012) describe internal rewards as relating to feelings and results of self-improvement and joy from doing the activity rather than the external rewards of gaining social approval or (monetary) value. According to Deci and Ryan's Self Determination Theory (SDT), intrinsic motivation comes from fulfilling the human needs of mastery, autonomy and connectedness.

Within extrinsic motivation Deci and Ryan make further distinction between externally and internally regulated motivation. External regulation is typically done merely for the reward or as compliance. Therefore behaviors with external regulations are often experienced as controlled or alienated. If they partially accept these regulations as their own, external regulation turns into introjected regulation.

Introjected regulated behavior happens to avoid guilt or to attain pride as following the regulation becomes tied to being a good person to others around them. As identification with the regulation increases, they can start feeling a personal importance to upholding the regulation. Ryan and Deci refer to this form of regulation as identified regulation.

This self-identification with the regulation eventually culminates into integrated regulation where a person may see the regulation as part of their larger personality and identity. Integrated regulation differs from internal motivation as performing the action will be to achieve an outcome separate from the activity (e.g. working out to maintain your health instead of for the joy of exercising). Clear also identifies self-identification as an important component for habit formation as it allows people to perform their habits even when morale is low.

Gardner (2012) however has found self-identity to be less important in habit formation as opposed to automaticity. This supports Fogg's recommendation to focus on the ability component of his behavior model as it facilitates automaticity (the ability to perform a task with little to no thought).

While effective at motivating people to perform an action they would otherwise not enjoy, external regulation can hinder habit formation in the long run as people are likely to quit the behavior once the external reward or punishment is removed (Stawarz et al., 2015). This can be seen in athletes with intrinsic motivation having longer lasting careers compared to athletes with external motivations (Calvo, 2010). According to Deci and Ryan (2000) external rewards can even undermine intrinsic motivation as it can prime people to tie their sense of enjoyment to the impact of the reward rather than the experience itself.

Meaningful gamification

Fostering intrinsic motivation is an essential part of gamification, the practice of applying game design elements to non-gaming related contexts in order to increase fun and engagement (Deterding et al., 2011). Nicholson (2015) makes a distinction between BLAP gamification and meaningful gamification. BLAP (Badge, Levels/Leaderboards, Achievements and Points) gamification refers to where users acquire points (through actions determined by the designer) to progress levels and compete in leaderboards. Achievements can then be used to direct user behavior outside of the existing point structure in addition to badges that one can use to display their status towards others in the system. This form of reward-based gamification can easily be implemented and have strong effects on short term changes, but as previously explained can hinder long term habit formation if pleasure is only derived from reward accumulation.

Meaningful gamification on the other hand was inspired by SDT to focus on fulfilling needs of autonomy, mastery and connectedness. It also aims to create meaning by relating game experiences back to the player's past. Nicholson describes six concepts to take into account when designing for non reward-based gamification: Reflection, Exposition, Choice, Information, Play and Engagement.

Play revolves around interacting with and crossing boundaries or rules. By providing the user with an environment where failure is permitted or even impossible, users feel encouraged to interact with the environment without fear of making costly mistakes. This lack of rules and boundaries eventually invites users to create their own rules to interact with. According to Nicholson when players get bored of their established rules they can choose to change the rules they wish to play with. Essential to play is having the freedom to choose to engage with a game

rather than being forced to. Playful environments and concepts should therefore persuade the user to interact with them by providing engaging interactions instead of pressuring them with negative consequences.

Exposition is the incorporation of a narrative into the game experience to keep users engaged throughout the game's course by enticing them to return for its finish. Within gamified concepts this allows users to either simulate possible real-world scenarios or view contexts through a metaphorical lens (e.g. a marketing "war" to win customers over) to apply to the real world context. Designers should be cautious not to put too much emphasis on the narrative especially with metaphorical ones (coined analogous narratives by Nicholson). Gamified concepts ultimately wish to impart skills and knowledge rather than provide an interesting story about fictional worlds. It is also possible to let the user create their own story using the game environment, however this would run the risk of users drawing and focusing on unintended lessons.

Choices foster a sense of autonomy within users which in turn (according to SDT) fosters internal motivation. As mentioned about Play, this includes the choice to not interact with the environment. Choice is typically applied to the classroom context by giving students a range of different tasks worth differing amounts of points. They are then simply instructed to acquire points doing exercises of their choice as a measure of their grade. This freedom of choice can however be overwhelming for people with low self-efficacy (Nicholson, 2011). Chang (2020) also came to this conclusion when investigating exercise choice of Somnox 1 users. Nicholson suggests that for such overwhelming contexts users can be presented with a decision about their goals. Afterwards the system can guide the user towards reaching that goal. Badges can then be used as milestones towards their chosen goal instead of as rewards in of themselves. BetterMe, a competitor of Somnox in the meditation space, applies this principle by asking users during on-boarding to pick a goal and presenting them with a daily rotating selection of relevant exercises.

Information is crucial for mastery as it provides the user with the factual information behind their progression. This can in turn further motivate the user to continue with their behavior as the presented information validates their efforts. Nicholson describes three ways of presenting information in the gamified context. A simple graphical user interface (GUI) can provide a clear overview of relevant information. This also brings the possibility to customize the GUI to the user's wishes. Secondly designers can make use of non-player characters in the game. These can be especially fitting when designers make use of an analogous narrative (i.e. a fantasy world with wise sages or war counselors). NPC's can however potentially be perceived as untrustworthy, causing distrust towards all the information presented by the game. Lastly, players can receive information through interacting with game elements. By reflecting on the impact on the game environment of the user's decision, users can become aware of the effects of similar behavior in the real world setting.

Engagement in the context of gamification has two definitions: social engagement and gameplay engagement. Social engagement refers to communication or gameplay involving

other players whether that be for cooperation, competition, exchanging advice or simply chatting. Social engagement specifically addresses the connectedness component of SDT to increase internal motivation. This type of engagement can either be within the game environment (in-game chat services or leaderboards), outside in-person or through the internet (with forums or social media platforms).

Gameplay engagement refers to games' ability to provoke a flow state (Csikszentmihalyi, 1997) within players. Flow state refers to a state of complete engagement with a task at hand where players have enough self-efficacy to confidently complete a task while still being challenging enough to require active attention from the user. In order to reach this state players must be adequately challenged according to their level of mastery. Deviations from this perfectly balanced task can result in either tasks that are boring because of their simplicity or frustrating due to their difficulty. Due to their high self-efficacy, experienced users feel more comfortable to socially engage with others. Nicholson therefore recommends introducing social engagement after letting new users get more familiar with game interactions. This is also in line with Clear's assertions that as a habit forms it becomes part of one's identity, increasing the amount of pride one takes in this behavior and the likeliness that they will socially engage with others who share this habit.

Reflection is crucial in educational games where game experiences have to be connected to the player's personal life in order to draw meaning from them. This is especially the case for gamification where the designer's intent to teach a specific skill, knowledge or long-term change can be made more explicit. Designers should however be cautious as users are likely to draw most meaning from experiences that relate to their own life, even reflecting upon other valuable aspects that the designer had not taken into account. Nicholson identifies three components of reflecting that can be incorporated in a gamification system. Description, where users simply recall and describe their actions throughout the whole game experience. Analysis, where users analyze the actions, the feelings felt upon performing them and relating that back to their personal experiences outside the gamified context. In the application stage the user is then prompted to take action in the real life context by applying insights gained from the analysis. Nicholson states that reflections are most effective if done with groups as it allows players of a gamified context to look at their experiences from different perspectives. The group-oriented nature of the reflections should be made explicit in order to encourage mutual inspiration.

Types of habit formers

In habit formation literature a wide range of tools and techniques are described to aid people in forming or breaking habits. Due to the importance of free choice with (playful) habit formation people are likely to pick and choose which selection works for them. There has however been little research exploring compatibility among tools and techniques. Kirk et al. describe four different archetypes of habit formers in their 2017 article about guidelines to successfully prescribing medical patients healthy behaviors. Rubin's conceptual model of habit formation revolves around internal and external expectations. Similar to internally regulated external motivations, internal expectations are beliefs and values one holds that motivate them to pursue

goals and form healthy habits. External expectations are social pressures from friends, family, colleagues or caregivers (such as a fear to disappoint them or a need for gratification from them) that externally motivate habit formers.

Upholders are natural habit formers that respond well to internal and external expectations. Doctors can simply give them a prescription for behavior and expect them to follow it, assuming the patient fully understood the doctor's instructions. Upholders will easily internalize these instructions and self identify with them by following the prescriptions. Therefore they simply require reminders of their chosen habits to maintain progress. Providing ease of access and use will also be key in facilitating habit formation, as is the case for other archetypes.

Obligers respond well to external expectations, but less so for internal expectations. Thus for instance when obligers are prescribed more exercise they are likely to slack off if left by themselves despite internal expectations and desires to become healthier. Instead obligers are best able to form habits if faced with the possibility of loss of face. Rubin therefore recommends obligers to find accountability partners who can either regularly check up on them or even form the habit together with the obliger. This mirrors Nicholson's recommendation to drive social engagement within users to motivate them towards a habit.

Questioners respond little to external but well to internal expectations because they require strong convincing before adopting new habits. This often means providing strong evidence such as scientific citations or statistics which the questioner can confidently self identify with. Their disposition towards details also makes them likely to desire customization of prescriptions toward their specific needs and desires. Companies that wish to reach this group of users should have a trustworthy reputation and be able to readily provide convincing arguments for their products.

Rebels do not respond well to any expectations, internal and external. As the name implies rebels are quick to reject prescriptions if imposed too strongly. Neither do they care much for external expectations like obligers. Instead rebels are able to form habits when provided with a strong sense of autonomy. By providing a large selection of options with clear pros and cons the rebel can pick which one is most to their liking, whether it be the most effective one or not. For this group a consistently pleasurable and exploratory user experience will be key for habit formation as the promise of long term benefits (i.e. internal expectations) and external expectations won't be enough to keep them engaged for long.

People can determine which archetype fits them best by answering a list of 13 multiple choice questions. Using this questionnaire a tendency towards one archetype can determine the most effective way for someone to (explicitly) form their habit. Despite a lack of (quantitative) research using Rubin's model, according to Rubin most people fall under the obliger and questioner archetypes. Nonetheless, Kirk et al. recommend applying the model to determine what kind of interventions and communication styles could be used to aid people who struggle with treatment adherence.

Career Carmen's persona strongly overlaps with the questioner tendency indicated by her skeptical attitude towards slow breathing exercises and their associations with 'spirituality'. Moreover her tendency to cope with stress in unhealthy ways despite being aware of their negative outcomes and a reported lack of motivation and time is indicative of a rebellious side that will only form the habit if sufficiently persuaded to do so.

While a large portion of the target group might have obliger tendencies, the social deviance of using a 'breathing robot' and lack of self-efficacy will prevent users from actively engaging with social expectations. Once the benefits and sufficient self-efficacy have been achieved users will likely have the pride to display and share their experiences with Mini. This can already be seen in numerous enthusiastically positive Somnox reviews with customers who experience the benefit of a good night's rest.

Incorporation of the Four Tendencies model into designs could be useful to tailor interfaces towards the user's tendency and to help users plan rituals around their tendency. Designers should be cautious of a potential information overload especially for new users whose attention should mainly go to understanding the breathing exercises.

Designing a user experience for Mini

The narrative for using Mini on a regular basis

Mini has been designed around performing slow breathing exercises. Through slow breathing practitioners can trigger RSA (respiratory sinus arrhythmia), a physiological phenomenon where one's heart rate variability synchronizes with their respiratory rate, and stimulate their parasympathetic nervous system for relaxation. RSA can be detected through monitoring heart activity, both ECG and PPG.

Typically a frequency of 6 BPM (breaths per minute) is recommended for beginners (Russo et al., 2017) as it gives the most physiological effects in relation to the required effort and ease of sustainability. However, individuals have unique optimal respiratory rates where RSA and vagal tone is at its highest, also known as their resonance frequency (Schaffer & Meehan, 2020). This frequency can be determined by having participants perform a series of breathing exercises ranging from 4.5 to 6.5 BPM in steps of 0.5 BPM.

In order to validly assess the RSA response for a given frequency, participants should be proficient enough to breathe at least 4.5 BPM without experiencing discomfort such as light-headedness or shortness of breath. Participants should therefore practice slow breathing exercises and gain a degree of mastery before clinicians perform assessments.

The resonance frequency can be determined by assessing the RSA response along six weighted criteria: phase synchrony, peak-trough amplitude, LF power, maximum LF peak, smoothness of the heart rate curve envelope and fewest LF peaks. While all criteria are indications of increased parasympathetic activity, a specific resonance frequency may not

maximize all criteria. Clinicians therefore have to consider all six criteria and pick the frequency that maximizes most of them.

Mini: a coach for slow breathing mastery

Somnox Mini originally was meant to be a companion-like guided breathing exercise device, specifically for slow breathing at 6 breaths per minute to provoke an RSA response. Through its haptic feedback Mini coaches its user on the progress of their exercise, informing them whether their PPG measurements indicate RSA. The companion app could then help keep track of their progress by displaying metrics over time like the percentage of time detecting RSA, time before provoking RSA and resting HRV levels (before engaging in breathing exercises).

Mini's coaching role can however be expanded from mastery of breathing at 6 BPM towards mastery of breathing exercises in general by expanding the selection of exercises. As previously stated Somnox has also tried to get their users more motivated to choose different exercises with their first Sleep Robot. By gradually introducing new exercises as opposed to giving users access to all of them from the start, (inexperienced) users will have a reason to consistently return and not be overwhelmed with too much new information (which could cause them to ignore large parts of new content).

Moreover, slow breathing exercises recommendations can range from 15 to 30 minutes per exercise. With experts recommending two exercises per day this can quickly become a time consuming commitment for new practitioners. EliteHRV provides users the opportunity to enlist in a 10 week program (close to the average habit formation time of 66 days) prescribing a daily regimen of two exercises of 20 minutes (EliteHRV, 2020). In order to keep users engaged over the course of this program, users receive daily audio recordings about stress management through breathing exercises and mindfulness. Even though this approach could be effective for upholders and questioners, the initial weeks of extensive breathing exercises will remain confusing and discouraging for inexperienced breathers without personal feedback to indicate whether they are correctly performing the exercises.

Clear (2018) goes as far as to recommend limiting an initial habit loop to two minutes for optimal habit formation (because of ease of execution), eventually extending it to a more effective goal. Mini should therefore also gradually introduce longer exercises as opposed to starting with 20 minute exercises, especially for the more difficult breathing exercises.

In this mastery narrative other variables of breathing exercises such as pauses and holds can also be introduced, eventually making space for full customization knowing the user will have some pre-existing experience with the variables. Mini could therefore be positioned as an introduction to the Somnox product line with their bigger flagship models offering the longest slow breathing sessions (e.g. 6 to 8 hours) meant for the biggest relaxation exercise, sleep.

The benefits of performing slow breathing exercises

Elliot et al. (2004) found that benefits of guided slow breathing exercises (on systolic blood pressure) can be found in people who use their device for at least 180 minutes over the course

of 8 weeks. This means, as little as 23 minutes per week or 5 minutes per weekday of slow breathing could have a significant impact on the practitioner's wellbeing.

Reward of access as measurement of progression

Within game design, players are often given 'rewards of access' by designers in order to make sure players have enough skill to complete the next level, in turn optimizing the possibility of evoking flow states in players. The specific required skill for these rewards is determined by the designer, whether it be a proficiency with aiming in shooting games or mastering the spatial awareness necessary for puzzle games (Gazzard, 2011).

Given Mini's role as a breathing coach, it is obvious that users could be rewarded for good performances of breathing exercises as this would both make flow states more likely and most accurately reflect the user's level of bodily mastery as following exercises would increase in difficulty both in terms of exercise length and breathing rhythm. Like a gym coach that helps people improve lifting heavy weights, by progressively increasing the weights according to people's abilities they can maintain a sense of progression and motivation without getting discouraged by challenges that seem too difficult to reach in the near future. This proficiency based progression would in theory maximize intrinsic motivation through its focus on mastery. This intrinsic motivation will allow them to keep practicing breathing exercises even after completing the presented sequence especially due to the wide variety of breathing exercises one can master afterwards.

However, given this project's goal of designing to form a habit, players could also be rewarded for adhering to an implementation intention of performing a breathing exercise at their desired time. This variation of progression would directly incentivize users to form a habit (merely through consistently using Mini) as opposed to focusing on improving their breathing capabilities. By making progression independent from exercise proficiency, unlocking rewards becomes much easier and therefore more likely to motivate users to perform exercises.

This is especially important for the initial period where the habit formation is still in its early stages. Atkins et al. (2017) found that optimal engagement with gamified education environments is found when the necessary effort required to earn a reward of access (i.e. a level) follows a Fibonacci sequence. Meaning that the amount of performed habits required to unlock the next exercise should increase by 0,1,1,2,3,5,8,13,21,34,55,89, etc. in order to keep users engaged throughout the habit formation period.

How Mini will form a habit within its users

The background information presented up until now serves as inspiration for design elements of Mini's app. Eyal (2014) recommends implementing as many habit forming elements as possible. The concept of Mini's app will therefore incorporate both implicit (i.e. gamification) and explicit (i.e. implementation intentions) habit formation techniques to promote successful habituation. The app will consist of three components: the ritual, the logs, and the exercise sequence (with its narrative). Inspired by Nicholson's concept of Playfulness (i.e. creating a playful environment)

all components will have an inherent component of reward, the user can choose themselves which one to derive a sense of progression (and resulting motivation) from.

When starting their user journey with Mini, users will be prompted to formulate a ritual (i.e. a simple implementation intention) for using their device (see figure 5). With this prompt the user is explicitly encouraged to reflect on their personal goals with the device and also conceptualize a personal narrative of progression towards a goal of regular use. This process is however kept brief in order to steer the user's mental focus towards Mini's embedded narrative - determining and mastering the user's resonance frequency. As a reward for adhering to their ritual, users perform a one minute HRV reading prior to the exercise. The resulting RMSSD gives an indication of the user's wellbeing in order to both track their progress and reflect on their stress-related needs. The reason for making this a reward is the fact that the reflection of the user's wellbeing is only valid if performed at the same time of the day as the previous measurement (Camm et al., 1996). This value is displayed in the main screen of the app along with a counter displaying the amount of times users performed their rituals (see figure 6).
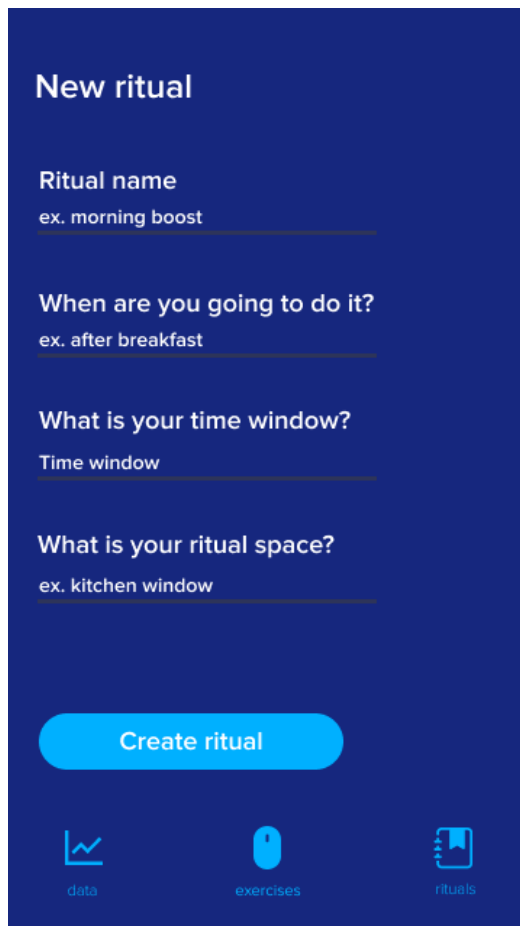

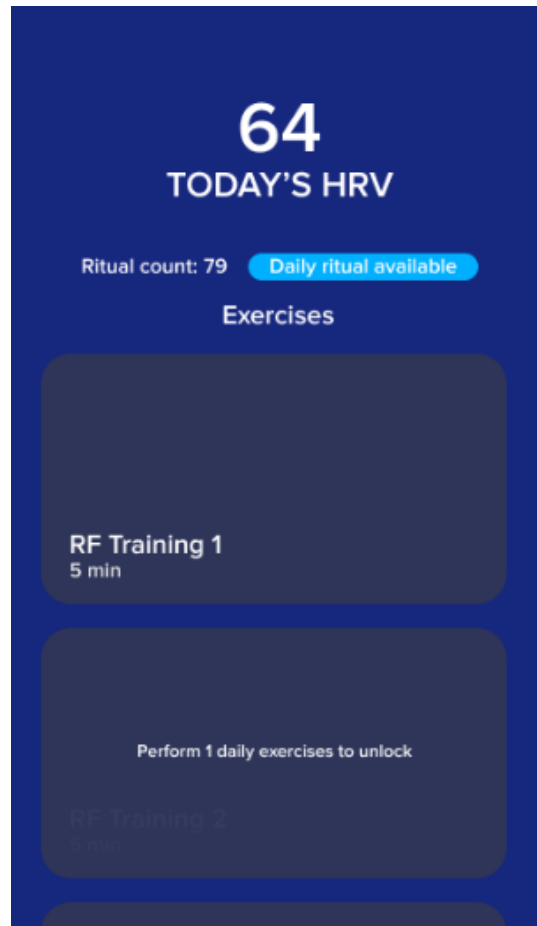*Figure 5: Planning a ritual in the app*   *Figure 6: The exercise overview of the companion app*

The second component of the app is an overview of the exercise logs captured from using the device. Inspired by Nicholson's concept of information inspiring motivation, this overview gives

the user the information and ability to track their performance over a larger span of time as seen in figure 7. Logs are comprised of the following data points:

- RSA Ratio: the percentage of time a user displayed RSA throughout an exercise. Using this metric users will be able to gauge their ability and progress to provoke an RSA response through breathing exercises.
- RSA Quality: the amplitude between the highest heart rate and lowest heart rate throughout the exercise. This metric is used to determine the users resonance frequency and is displayed in order to pre-emptively show the user which breathing ratio worked well for them.
- Resting HRV: as previously mentioned an HRV measurement is done when users perform their ritual. This value reflects their stress levels and can be tracked over time using the logs for a sense of progression in their stress resilience.
- A timestamp to provide the user and research team with a chronological overview of the user's exercises. This overview can then be used to determine how consistent the users made use of Mini.
- Difficulty level: the user is given the choice of a difficulty level based on the margins at which Mini registers an RSA response. The difficulty level ranges from beginner to intermediate and advanced. This option was given to users to prevent feelings of frustration resulting from consecutive exercises without any provoked RSA, ultimately preventing them from enjoying the intended habit.
- Exercise name: habitual usage is independent of the exercise selection. Similar to the habit of going to the gym, each session can vary in terms of exercise selection. But it can nonetheless indicate whether a user feels motivated to complete the sequence of exercises. Participants are given the autonomy to stick to the same exercise throughout the study period if they wish to do so.
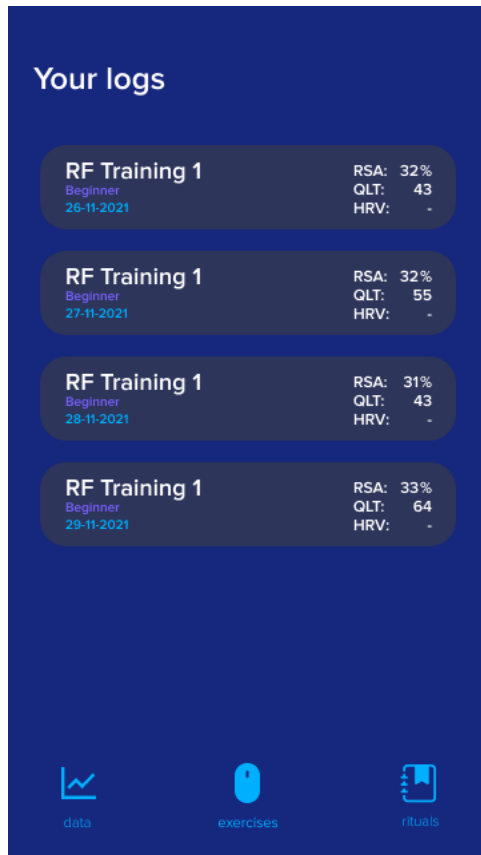
Figure 7: The overview of logs shown in the app

The last component of Mini's app is the narrative users progress through as they perform breathing exercises. This narrative is based on the mastery of breathing exercises (resonance breathing and breathing at different ratios) and manifests itself in the sequence of the progressively more difficult exercises. The first narrative and purpose of the sequence is to determine the resonance frequency of the user with five exercises of five minutes. Five minutes was chosen as that is the minimal duration to get physiological benefits (Elliot et al., 2004). The first of these five exercises starts at a breathing rate of 6.5 breaths per minute. As users progress through the sequence the breathing rate drops with increments of 0.5 BPM ending at 4.5 BPM. Once the first five exercises have been performed enough times the resonance frequency is determined based on the amplitude of the measured heart rates (Schaffer & Meehan, 2020). Proceeding exercises increase in duration to a maximum of 20 minutes to gain maximum benefits as specified by Chaitanya et al. (2022). Moreover irregular breathing ratios are introduced to give the user the confidence to explore the wide range of existing breathing exercises (Pranabreath, 2022). Once users have progressed through all the exercises they should have sufficient self-efficacy and mastery to formulate their own exercises. Giving the user the option to customize at the end of the sequence prevents information overload and provides a goal to strive towards for Questioners who wish to customize exercises to optimally fit their needs. The full sequence of the exercises can be found in table 1. This component of the app rewards users with their resonance frequency and the eventual ability to customize their exercise as seen in figure 8.

Exercise order	Exercise name	Duration (minutes)	Rhythm IN-HOLD-OUT-HOLD (seconds)
1	RF Training 1	5	4.6-0-4.6-0
2	RF Training 2	5	5-0-5-0
3	RF Training 3	5	5.5-0-5.5-0
4	RF Training 4	5	6-0-6-0
5	RF Training 5	5	6.7-0-6.7-0
6	Resonance breathing 1	10	?-?-?-?
7	4-7-8 Breathing 1	5	4-7-8-0
8	Box breathing 1	5	4-4-4-4
9	4-7-8 Breathing 2	10	4-7-8-0
10	Box breathing 2	10	4-4-4-4
11	Resonance breathing 2	20	?-?-?-?
12	Custom	…	…

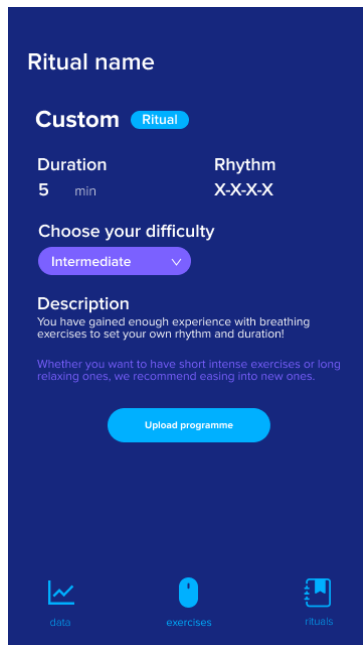*Table 1: an overview of the available exercises for Mini*
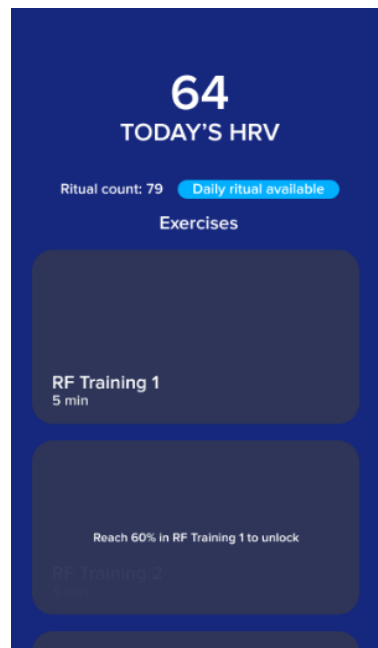

Figure 8: Customizing an exercise

Figure 9: Performance based reward of access

What remains contested however is the implementation of rewards of access in consumer products. While rewards of access allow designers to pace the information load and optimize the engagement with their game designs (Gazzard, 2011). A lack of control over non-gamified product experiences can be perceived as restrictive rather than challenging (and therefore be demotivating rather than motivating). As previously mentioned two types of rewards of access can be identified: a proficiency-based reward of access (as seen in figure 6) or a ritual-based reward of access (as seen in figure 9).

In order to answer the main research question "How to design the user interaction with Mini to ultimately form a habit of performing breathing exercises?" the following sub questions should also be answered:
1. Is the Mini capable of creating a habit in their user?
2. How is the user experience of Mini and its companion app?
3. What (de)motivated participants throughout the study?
4. What factors contribute to an adherable ritual with Mini?
    4.1. What factors got in the way of forming a habit with Mini?
5. Which type of reward of access is most effective at promoting habit formation, if any?
6. Is there a relation to the Four Tendencies and the ability of users to form a habit using Mini?
    6.1. Is it beneficial for users to be aware of their Tendency prior to forming a habit?

Methodology

In order to evaluate the proposed design's efficacy at habit formation and the effect of rewards of access, a prototype of Mini was tested with users in a longitudinal study. Participants (n=8) between the ages of 24 and 35 with a full-time occupation (i.e. individuals fitting the Career Carmen demographic) were recruited to use a Mini prototype over the course of 10 weeks.

At the end of the study period, participants were asked to measure their habit formation and motivation and classify their tendency using a survey. Exploratory data analysis (EDA) was then performed on the gathered data in order to identify unforeseen user behavior to be further expanded upon in data informed interviews (DII).

During the DII participants were asked to describe their experience with Mini, motivations, annotate their habit formation process and, given insight into their tendency, reflect on their rituals. The qualitative data gathered from these DIIs was then thematically analyzed to identify factors that ultimately impacted habit formation for the participants and answer the research questions.

Prototyping

Figure 10: Prototype of Mini consisting of box with microcontroller and battery and separate unit with actuators and PPG sensor.

The prototype given to participants includes a battery powered physical device capable of simulating a breathing motion and providing vibro-tactile feedback based on PPG sensor readings from its user (see figure 10). Through a Wi-Fi connection this device can then register a log each time the user has performed an exercise. In addition to the physical device participants were given a companion app through which they can choose their desired exercise, see their resting HRV, make an implementation intention (referred to as ritual) and see an overview of their recorded logs as specified in the concept (see figures 5, 6, 7).

Longitudinal study

A duration of 10 weeks was chosen in order to test Mini's capacity for habit formation as it takes an average of 66 days for people to form a habit (Lally et al, 2010). In order to test the impact of different types of rewards of access participants are randomly assigned amongst 3 groups with differing companion apps (see Appendix A):
- Group A will receive a reward of access to new exercises based on their ability to adhere to their ritual.
- Group B will receive a reward of access to new exercises based on their best performance (RSA ratio) with a given exercise.
- Group C will act as a baseline group to determine whether the effect of rewards or restriction of access has a significant impact on the habit formation process.

At the start of the study period users were briefed on using the device with their companion app. Moreover participants are briefed on interpreting resting HRV values as it is crucial for them to look at changes over time rather than absolute values in order to draw conclusions regarding their stress resilience (see Appendix B). Participants are contacted in case no new logs have been generated within 7 days. This is done to ensure prototype functionality and to gather

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qualitative data about their (de)motivations as soon as possible if the participant wishes to discontinue the study. Participants were given complete autonomy to use the device as frequently as they wanted (or in accordance with their ritual) in order to maximize internal motivation (Deci and Ryan, 2012) and test Mini's ability to form a habit.

After the 10 week period participants filled in a survey (see Appendix C) to measure their self reported behavioral automaticity index (referred to as SRBAI) of performing breathing exercises (Gardner et al., 2012). This quantitative measurement displays the degree to which a habit has been formed and shows how consistent the Mini was at forming habits in their user (and answering sub question 1). Additionally the survey asks participants to measure their motivation at the beginning and end of the study using a Likert scale. This measurement is included in order to gauge the impact of their experience using Mini on their motivation to perform exercises. Lastly this survey will also contain the quiz necessary to determine which habit forming tendency they belong to (Rubin, 2017). The result of this quiz is shared with the participant to test its practical value for ritual planning and look for trends amongst tendencies.

Exploratory data analysis

The collected data was then visualized by graphing performance metrics (i.e. RSA ratio, quality and chosen difficulty level) as seen in figure 11 and 12 in order to identify possible relations between performance and ritual adhesion before and during the DII. By plotting the distribution of the timestamps of the logs as seen in figure 13 ritual adhesion were assessed, but also non-ritual uses were identified for further discussion during the DII. Lastly by plotting the logs in a calendar format (see figure 14) gaps in usage were identified to inquire about during the DII and assess whether usage was consistent but infrequent (i.e. once per week). Moreover the visualization of ritual adherence and reward obtainment was used to identify possible impact on use frequency.

Data Informed Interviews

DIIs were performed semi structurally in order to dive deeper into the issues preventing participants from forming their habit, whether that be due to personal circumstances or unpleasant user experiences. The DII was performed remotely using Miro and Zoom to record transcriptions. Miro was chosen as a medium due to its ability to easily present and annotate data visualizations. See Appendix D for an example of a prepared Miro board.

At the start of the DII participants were asked to describe their user experience with the Mini prototype (both the app and the device) in order to answer sub-question 2. Furthermore participants from group A and B were asked to describe their experiences with the rewards of access to answer sub question 5. Afterwards participants learn about their tendency and are asked about their stances on incorporating external expectations to increase their chances of forming a habit (in order to answer sub question 6 and 6.1). Then participants were asked about their ritual and whether pre-existing habits interfered with their ability to adhere to the breathing exercises (answering sub question 4 and 4.1). Using the calendar plot (see figure 14) participants are asked to explain notable gaps in usage (to answer sub question 4.1). Lastly, to

answer sub question 3 participants are asked to describe their motivations and to explain whether their motivation has changed over the course of the study.

Thematic analysis

Thematic analysis will be performed on the transcriptions resulting from the DIIs due to their qualitative and varied nature (Saldana, 2013). Analytic memos were made of the transcriptions as an initial coding cycle. These annotations were then recoded eclectically in order to make the memos more easily categorizable to ultimately formulate the themes that impacted habit formation for the participants.

Findings

In this section the initial overview of data gathered from the prototype and survey is presented and analyzed to direct the DII. The resulting Miro board used for the DII can be found in Appendix D. Furthermore the themes resulting from the thematic analysis of the transcriptions are presented.

Exploratory data analysis results
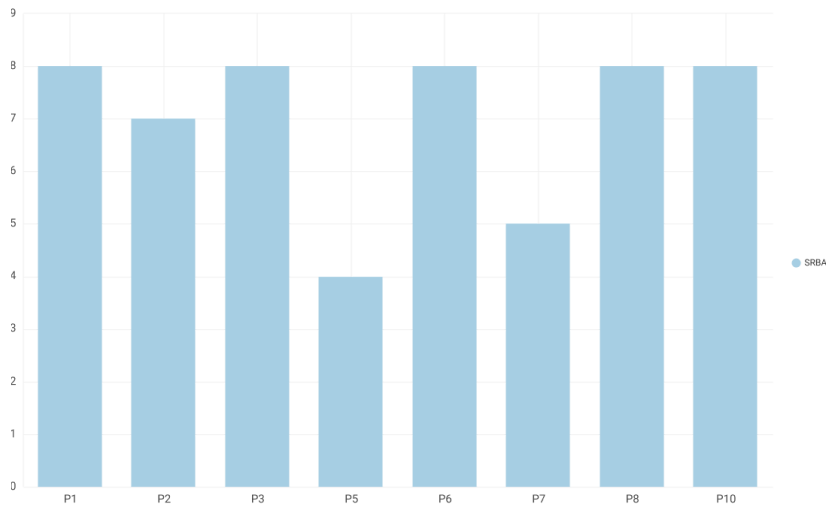
Figure 11: Reported SRBAI of performing breathing exercises

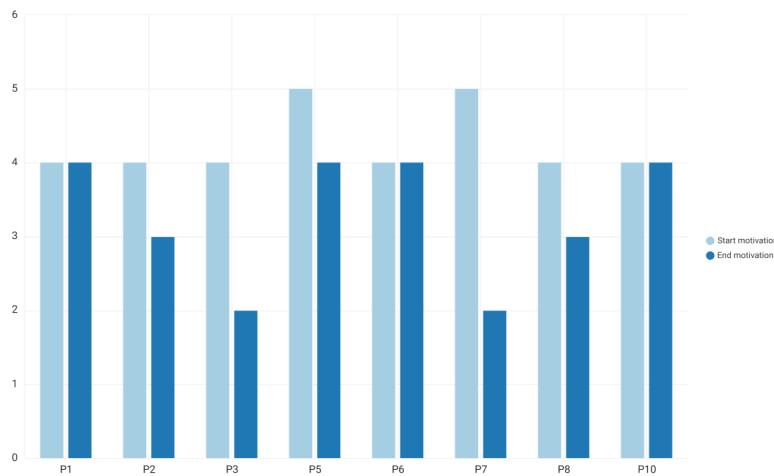**Figure 12: Participant responses to the 5 point Likert scale: "I feel motivated to perform breathing exercises"**

P1	Obliger	P6	Obliger
P2	Obliger	P7	Obliger
P3	Questioner	P8	Obliger
P5	Questioner	P10	Obliger

Table 2: An overview of the tendency classification resulting from Rubin's (2017) quiz.

Participants were not able to successfully form a habit of performing breathing exercises (see figure 11) with a maximum of 8 out of 20 on the SRBAI (i.e. all participants disagreed with statements about having developed a habit of performing breathing exercises). Nonetheless 6 participants still reported feeling a moderate degree (i.e. 3) of motivation for performing breathing exercises (see figure 12) of which 3 participants reported a constant level of motivation. In the following DII participants were asked to explain their motivations and why it did or did not change.
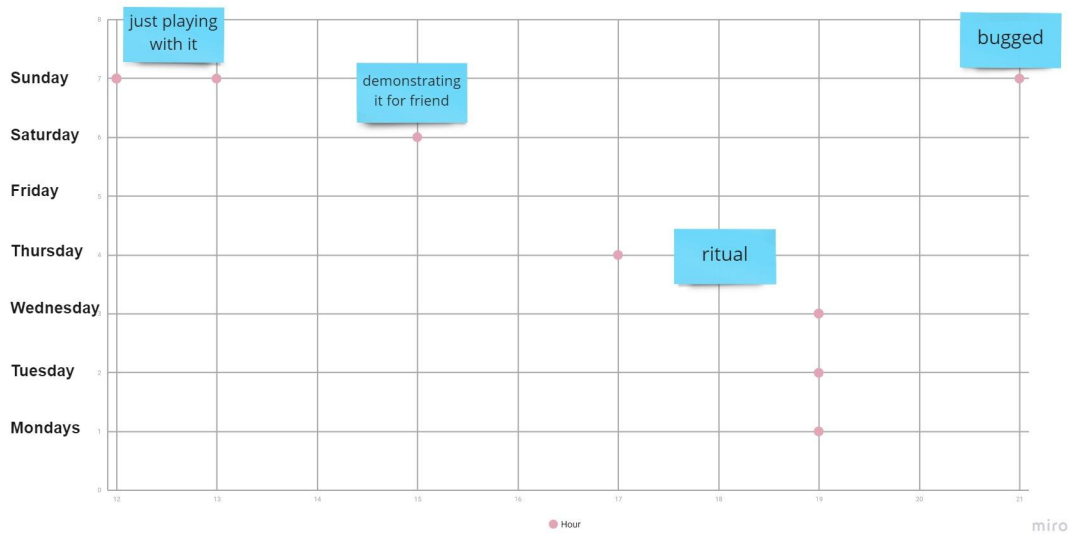
Figure 13: Annotated scatter plot from participant 1

The scatter plots of timestamps (see figure 13) reveal that some participants performed multiple exercises at different moments than their ritual. These plots were used in the DII in order to identify other use cases which could even turn out to be unregistered rituals.

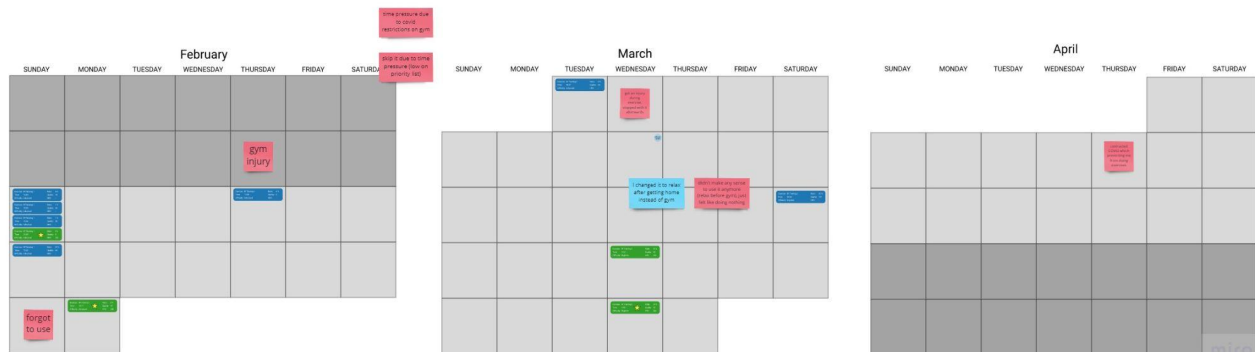*Figure 14: Annotated calendar plot of participant 1*

The calendar plots (see figure 14) show that participants have had multiple periods longer than 14 days of not using Mini. These gaps were presented and annotated by participants during the DII in order to identify the reasons for inactivity. Moreover participants will be enquired about

possible changes to the ritual context that happened throughout the study as it could have also been the reason for inactivity.

Thematic analysis results

From the DIIs several pain points in the user experience and interface were mentioned as reasons discouraging them from frequent usage. The presented themes are illustrated using quotes from the transcriptions.

Theme 1: UX/UI issues got in the way of starting a breathing exercise, ultimately getting in the way of forming a habit.
Mini's shape made it difficult for some participants to hold during a breathing exercise and in two instances caused discomfort in the hand and wrist. The breathing plate pushed the device out of the participants' grip when it expanded upward. Moreover the height of the expanded device also causes the wrist to bend upward, one participant diagnosed with RSI noted that the device could at times cause discomfort in their wrist. Another participant who initially used the device on their nightstand noted that they switched to putting it on their chest due to experiencing paresthesia in their arm during the exercises.

Participant 2

"[Performing exercises was] A bit clumsy due to the size of the breathing device. I sometimes felt that I couldn't get a proper grip while holding it and due to me not being able to properly hold it, it caused it to be a bit distracting."

Mini was also reported to be too big to bring along on vacations or others (i.e. partners or parents). For multiple participants this caused the Mini to be out of reach for a week while they still would have liked to perform breathing exercises. Others experienced technical issues with their prototypes preventing them from performing exercises until a replacement was provided. These prolonged periods without breathing exercises made it all the more likely for participants to forget about using Mini.

Participant 2

"I think it [feeling demotivated] was mostly due to technical issues. Those were perhaps a bit demotivating."

Setting up and charging the device were also mentioned as pain points. Even though participants were able to use the device without having to open the app, some were not aware of this. Causing them to open the app every time they wanted to perform an exercise. While some participants found setting the device to be straightforward and simple, others found the app buggy and difficult to use. One participant mentioned that they did not like having their phone close to their bed (their ritual space), a preference other individuals who are mindful of wellbeing can share. Charging was also bothersome for some as their ritual space (i.e. mostly beds) did not have a place to charge. This at times caused participants to forget about the device altogether.

Participants who had some amount of experience reported wanting more freedom of exercise choice. This was especially the case for participants who got rewards of access, but were not up to the task of unlocking the last exercise (giving them access to full customization).

Participant 7
"I found it a bit difficult that I saw this whole list of things that I could do, but I could only reach it if I did certain exercises at a certain time. While I really wanted to just try them all out immediately. I was like 'Oh come on, let me try this one.'"

Despite briefing all participants at the start of the study, some participants mentioned finding both acquiring rewards of access and the different difficulty levels to be unclear. Notably, participants did not reach out to the researcher for clarification. This was also the case with the logs provided by the app. The provided metrics were not actionable enough to use for improvements causing them to eventually be ignored altogether.

Participant 5
"Well, it made me think, like, what could I do better? But then I wouldn't know what [to do]."

Theme 2: Breathing exercises have a baseline motivation informed through the proven benefits of performing them.
All participants were initially motivated to sign up for the study because of the reported benefits of performing breathing exercises (improved sleep, focus, stress resilience and lower resting heart rate) and the possibility of receiving aid for these exercises from a device. The concept's novelty kept many (n=7) interested during the initial weeks of the study.

Participant 6
"I thought it was very innovative, something new so I was really curious. And I was always bad with my bed ritual so I thought it would be nice to have this. When you told me about the company. I really liked the idea behind it – something to hold to get you to sleep. So when you told me about this I thought it could be a nice stepping stone."

This initial motivation stemming from the (scientifically proven) benefits kept participants motivated at the end of the study despite not successfully forming a habit of breathing exercises. Since participants still valued their health and well being they still see the benefits and motivations to pick up the habit.

Participant 3
"Yeah, I guess because I know that it's still valuable. [...] That's also why I did it [exercises] when it didn't work with wi-fi. I felt like in the end, I shouldn't be doing it for you. I should be doing it for myself."

Theme 3: Progression can be a double edged sword for affecting motivation.
Many participants were also focused on progressing through obtaining rewards of access. Participants who did not deal with rewards of access even used their own imposed metrics of progression (i.e. improving their RSA ratio). This group of progress focused participants however also reported feeling demotivated when faced with stagnating or even declining scores. Especially so because the generated logs lacked clear actionable feedback to improve on their exercises leaving participants demotivated and confused about progressing. Participants that planned on making frequent usage of the device were also demotivated by the fact that they failed in implementing their ritual as often as they would have liked.

Participant 3
"But I also haven't looked in a long time actually, and I started using it less so then I was like, I didn't expect it maybe to improve. And then first, when I did expect to improve and didn't, then I guess I kind of lost my, uh. Motivation."

Many participants mentioned the notion of 'generally low motivation' stemming either from excessive stress in their personal lives or even physical injuries. This lowered general motivation caused them to drop multiple habits that they were upholding up until that point, even further demotivating them to pick the habit back up.

Participant 2
"I wasn't motivated less due to the product, but life in general. Like being less motivated to do anything at all."

Participants who were more focused on achieving a state of relaxation instead of progressing each session from performing the exercise reported less changes in motivation. While they also used it at a less regular pace they felt more motivated to perform longer exercises as five minute exercises were sometimes too short to feel sufficiently relaxed.

Participant 10
"Oh, It's [the exercise] over. So I'm just like 'Okay, I'm just doing it again' because I guess at that moment, I felt the need to use it [for longer]."

Theme 4: Rituals should be planned around stable contexts. If the context changes, so should the ritual until it can be consistently adhered to.
Four participants changed their ritual after initially planning it with the app. Only one did so successfully however as the other participants were not able to keep the same frequency of exercises after changing. Changes included ritual space (e.g. to the bedroom from the couch, to a different bedroom) and timing (e.g. from after dinner to after a morning shower). The participants who unsuccessfully changed their ritual were forced to do so due to moving, company and physical injury. After changing ritual spaces participants did not think about further readjusting even though they were aware of the need for it (i.e. from their struggle to adhere to their ritual).

Participant 6
"At some point I moved the ritual place from my couch to my bed. I would first do the ritual then go straight to bed instead of looking at my phone. And then when I brought it to bed I kind of stopped using it."

Rituals moreover should have an immediate purpose. Users were most likely to pick up Mini if they felt an immediate need for the relaxation it brings (e.g. feeling stressed before sleeping or feeling unfocused for an upcoming activity). Conversely users were more likely to forgo exercises if the immediate need for them was absent (e.g. vacation or not being able to do the activity for which focus was desired). One participant even noted that using Mini felt like a chore at times despite enjoying the exercises themselves.

Participant 10

"I think that the times that I use it outside my bedtime is when I remind myself 'I'm not relaxed right now. Let's just try to [use the] mini device, to try if it does relax me or not.'"

Furthermore users often forgot to perform their rituals if they had put their prototypes at a different spot than their ritual space. Reasons for doing so included packing it to bring along and storing it away before going on a vacation. Moreover charging locations differed from ritual spaces as users preferred to charge it away from their bed. Thus upon entering their habit context (i.e. time and location) Mini wouldn't be visible to trigger them to remember it.

Participant 2

"For me, it's not that I don't want to do it, but I just straight up forget it and then by putting it on my desk, that's how I force myself to see the object and think about it."

Theme 5: Rituals were skipped due to tiredness, time pressure and social pressure.
During the calendar annotation section reasons for skipping their rituals was also discussed. Five participants planned the ritual before going to sleep - three of them wanted to replace their pre-existing habit of scrolling on their phone before sleeping.These users reported that often they skipped their ritual due to them feeling too tired to perform the exercise instead, going straight to sleep even though the breathing exercise could help them prepare for a better night's rest. However if these users had enough energy to perform an exercise they would sometimes perform multiple exercises in order to get the level of relaxation they desired before going to sleep.

Participant 8

"Sometimes I'm just too tired [to perform an exercise]. Then I just throw everything off and fall down [asleep]."

Similar pressure was felt by participants who planned their ritual during the day as hunger for breakfast or being late pushed them to skip their five minute exercise. This group of daytime users used their ritual to get focused for another activity (e.g. work or gym exercises). Four users used it during the daytime not as part of a ritual but spontaneously to acquire immediate relaxation.

Participant 1

[I skipped exercises] Mostly due to the time. Like rushing back home. So getting food. Watching something, or at least or I have to do something before going to the gym. So it was like it didn't really fit my schedule. Even though this was short, it wasn't on my priority list.

Other factors for skipping included the presence of company as three participants preferred to skip it in that context. Pressure to skip the exercise was not only internal (i.e. feelings) but also external with the company actively distracting or discouraging users from performing their exercise. These pressures are likely due to the social deviance of using Mini.

Participant 10

"I guess another reason is that. When my boyfriend is here with me. Then I would also not think about doing the ritual because he's next to me."

Theme 6: Accountability for breathing exercises is preferably kept at a minimum despite users being aware of the possible benefits.

When discussing accountability in regards to breathing exercises participants reported mixed feelings. While six participants were classified as obligers (see Table 2), two of them expressed interest in having a breathing coach. Others expressed hesitancy towards the idea of having a breathing coach due to perceiving them as too demanding and/or breathing exercises to be an activity best done privately. Participants generally preferred the accountability to be similar to a relationship with a peer rather than an authority figure.

Participant 2

"I feel like a coach would be too restricting, or perhaps too forceful. Where as an acquaintance. I think that would be fine."

All participants agreed with their classification, thus obligers did acknowledge that they would benefit from some form of external expectations. A prerequisite for the source is the autonomy to perform the exercises at their own time. Two participants mentioned liking social pressure from seeing whether friends of theirs had performed their ritual (i.e. with Duolingo classes or fitness workouts) since it met the aforementioned prerequisite. Three participants specifically preferred to not have any accountability towards any person, only desiring reminders from the app self. In order not to forget to use Mini, many (n=7) participants reported a desire for reminders, even going as far as to attribute the lack of them as the main reason they stopped using the Mini.

Participant 7

"If it [the external expectation] will be someone that would for example, call me at exactly 10:00 o'clock and say "OK you have to do it now.". I would be like "No this doesn't work out." but [I would prefer] if you can see from others or maybe from one other person that they have done theirs [exercise] [...] and you haven't done yours.

All participants mentioned feeling motivated by external expectations from the researcher and the study to finish the course of the study. One participant even reported waiting for a prompt from the researcher to start using Mini again.

Participant 5

"Sometimes I was kind of waiting for you to help me [with a reminder]. Yeah, unconsciously, but maybe a bit conscious."

Discussion

In this section the themes are first discussed and compared to the existing literature. From the themes design recommendations will be given to inspire an iteration of Mini answering the main research question (i.e. "How to design the user interaction with Mini to ultimately form a habit of performing breathing exercises?"). Lastly the sub questions are answered based on the findings and discussion.

Discussion of the themes

Theme 1: UX/UI issues got in the way of starting a breathing exercise, ultimately getting in the way of forming a habit.
Mini should be easy and even pleasurable to use, set up and maintain (e.g. charge). Fogg (2009) already described the importance of usability for habit formation. Battery management for Mini (and other Somnox products) should be taken into account as health conscious millennials such as Career Carmen are becoming increasingly wary of taking devices into bed. Three participants had an active desire to decrease or eliminate phone usage in bed and for good reason as Rod et al. 2018 show that it negatively impacts sleep quality.
Ideally users should be able to set their devices before actually performing the ritual (e.g. when receiving a reminder hours ahead) in order to both ease the start of a ritual but also help users avoid screen time at night. Since users also showed a desire for less screen time at night Somnox could think about incorporating wireless charging stations in order to make it more attractive to store them near users' beds (or ritual spaces) as opposed to next to the other wired (phone) chargers.

Information incorporated in the app should be simple, accessible and gradually introduced in order to avoid confusion resulting in lower self-efficacy since it in turn leads to more difficulty adhering to implementation intentions (Gollwitzer & Sheeran, 2009). This was especially the case for the logs where background information could have been provided for users who forgot the initial briefing on the metrics. While the RSA ratio was interpretable in terms of progression the logs should be enriched with actionable insights in order to help users further progress whenever they seem to stagnate. This need for actionable insights has also been described by Ravichandran (2017) who also promotes technology transparency. Details such as RSA quality should however be reserved for more in-depth screens though as participants found it to be distracting and confusing when trying to interpret their logs.

Theme 2: Breathing exercises have a baseline motivation informed through the proven benefits of performing them.
This novelty was for many participants a reason to join the study. Lomas et al. (2017) have also described moderate amounts of novelty as stimulating for motivation. Since breathing regulation devices are still novel Somnox has the opportunity to be *the* physical interface for any breathing exercise related digital content their users come across.

Somnox could provide media inspired exercises relevant to trending topics and share these through their own media channels. However, caution should be taken with incorporating content

into notifications as ritual reminders serve a particular role at the beginning of the habit formation process. Notifications should therefore be reserved only for reminders instead of risking to form a habit of disregarding notifications (due to lack of interest in content). An exception to this would be if a user has not used their Mini for extended time or has not chosen to plan a ritual.

Theme 3: Progression can be a double edged sword for affecting motivation.
While mastery is a component of intrinsic motivation (Deci & Ryan, 2012), progression or gamification of behavior can also lead towards negative impact on motivation. As demonstrated by participants who reported feeling demotivated after stagnating. This is also reported by Toda et al. (2017) who name indifference, loss of performance, undesired behavior and declining effects as possible negative effects of gamification. This was even more so the case for participants who had rewards (and therefore restrictions) of access to content. These users experienced extra frustration as other content remained unavailable without proper guidance for improvement. Somnox should be careful explicitly framing forms of progression, as progression also creates opportunity for stagnation and demotivation if that proceeds for a long time.

When provided with quantifiable data, participants with unrestricted exercise selection still chose to measure their progression. This is also mentioned by Nicholson (2015) who suggested that when provided with a playful environment (i.e. an environment without any inherent rules) players will eventually start enforcing their own rules onto the environment. Because of the inherent purpose of the first five exercises (i.e. determining their resonance frequency) and progressing difficulty users still followed the presented sequence despite their ability to freely choose the order.

Participants who focused on fulfilling the purpose of their ritual instead of progression based on performance metrics reported less fluctuations in their motivation. This suggests a more stable approach to progressing as breathing exercises practitioners would be to only provide actionable insights (towards their goal of more relaxation) and forgo concrete progression metrics altogether. This would be an argument against the implementation of SDT in interaction design due to it being too risky without guaranteed improvement over time.

Theme 4: Rituals should be planned around stable contexts. If the context changes, so should the ritual until it can be consistently adhered to.
While implementation intentions have been reported to be effective at fostering habit growth, formulating an effective one can be difficult. Gollwitzer et al. (2010) suggests several guidelines to formulate one effectively (e.g. using an If-Then format instead of When-Where-How and carefully choosing conditions), even going as far as to recommend doing it collaboratively.

Instead rituals can be identified if the user is given a period at the start of their user experience using the device organically. After that period (e.g. a week) users can then more realistically estimate a viable ritual frequency and condition. Alternatively collaborative formulation could be

applied to some degree through displaying rituals on user profiles. This sharing of data could serve as inspiration for users to set realistic frequency goals and purposes.

Theme 5: Rituals were skipped due to tiredness, time pressure and social pressure.
When planning night rituals it can be advantageous to recommend ritual spaces away from beds in order to stimulate usage without the immediate stimuli from the bed to go to sleep (without performing the ritual). One participant had shown consistent use when the ritual was located in their living room, but faltered once they had changed it to their bedroom. This is consistent with Clear's (2018) recommendation to keep habit spaces separate.

Moreover users should also be advised to pick a private space as the presence of company proved to be detrimental towards fostering the habit of performing breathing exercises either because they form too big of a distraction or actively demanding precedent over the ritual. This could be due to the social deviance of performing breathing exercises as described by Fogg (2009). This can decrease over time as breathing exercises become more generally accepted in the general population.

Theme 6: Accountability for breathing exercises is preferably kept at a minimum despite users being aware of the possible benefits.
While Rubin (2017) identifies leveraging external expectations (e.g. forms of accountability) to be crucial for habit development amongst obligers. Less is known about what influences people's willingness for incorporating accountability. Participants mentioned that having a dedicated breathing coach for a small and personal activity such as the breathing exercises largely seemed unnecessary. Rubin however does describe solutions for habits where accountability partners are less desirable such as using tracking apps with reminders, setting reminders yourself and announcing one's desire to form a habit on social media.

All participants expressed a desire for reminders to help them build their habit of performing breathing exercises. Caution should however be taken as Stawarz et al. (2015) warn designers from conditioning behavior towards responding to a reminder as opposed to the intended ritual context. Therefore they recommend these reminders to be delivered at a much earlier time in order to minimize the chance of behavior being conditioned to respond to the reminder. Somnox could send their users a prompt to turn reminders off after performing a large number of breathing exercises. This also frees up the possibility of sending notifications for different reasons than reinforcing a ritual (e.g. new exercises or features).

As previously mentioned incorporation of sharing rituals amongst friends (e.g. connected via socials) could be useful for inspiring viable rituals. Effectiveness of the ritual can be demonstrated through displaying players' ritual count. Both Nicholson (2009) and Deci and Ryan (2012) recommend incorporating social interaction (e.g. social engagement and connectedness) to increase internal motivation.

1.   Is the Mini capable of creating a habit in their user?

Mini was unsuccessful at creating a habit within the participants. After periods of inactivity such as vacations participants struggled to pick it back up. Participants therefore also expressed a strong desire for reminders from the companion app.

2.   How is the user experience of Mini and its companion app?

While all participants found the exercises themself relaxing, the relaxation quickly dissipated once the exercise was over. With their first few exercises participants had to get used to the vibro-tactile feedback of Mini. Upon receiving feedback it was initially still perceived as a surprising or exciting experience, getting in the way of their relaxation. Once acclimated however, exercises became relaxing to perform. Technical issues with the app or device however made it cumbersome to use at times.

3.   What (de)motivated participants throughout the study?

Motivation remained constant to some degree due to the health benefits and the participants' general desire to improve their health. When participants were faced with stagnating or decreasing progression, an inability to improve their performance was demotivating. In turn, an increase in progression reportedly increased motivation.

4.   What factors contribute to an adherable ritual with Mini?

Mini and its ritual space should be visible to the user prior to the ritual context (e.g. in the bedroom instead of the living room if performed after showering). The ritual space should be a place conducive to relaxation and free from distractions. Rituals are easiest to adhere to if planned at times with little time pressure such as before going to sleep or in the morning before engaging in work. Planning the ritual as preparation for a following activity (such as sleep and work) also makes users more eager to perform longer exercises.

4.1.   What factors got in the way of forming a habit with Mini?

The placement of Mini's charger should be near the ritual space. This can be difficult for people who plan their ritual on their bed and prefer not to charge devices near it.

5.   Which type of reward of access is most effective at promoting habit formation, if any?

Without adequate feedback to improve their performance, rewards of access are best avoided especially in the case of performance based rewards of access. With no means of improving, users were faced with the prospect of never unlocking other exercises. Moreover, more experienced breathers wanted to explore different options prior to achieving the rewards. This ultimately caused frustrations within users. Participants without rewards of access were still able to track their progress based on the generated performance metrics. Moreover, due to the embedded narrative and indications of difficulty in the exercise selection, participants independently followed the sequence as they gained more self-efficacy with breathing exercises

rather than staying with a single exercise. Thus sequence enforcement through the use of rewards of access was unneccesary.

6. Is there a relation to the Four Tendencies model and the ability of users to form a habit using Mini?

Amongst the participants who were classified as obliger there was little desire for direct external expectations regarding breathing exercises. Instead participants reported a desire for reminders in place of a person. Due to a lack of variance in tendencies amongst participants no conclusive statements can be made regarding other tendencies.

6.1. Is it beneficial for users to be aware of their Tendency prior to forming a habit?

Awareness of one's habit tendencies was not shown to be particularly useful for planning breathing exercises if the aforementioned design guidelines are followed. According to Rubin (2017) upholders would benefit mostly from reminders while rebels can be triggered with new exercises. This is also the case for obligers and questioners respectively.

Recommendations

In order to answer the main research question (i.e. "How to design the user interaction with Mini to ultimately form a habit of performing breathing exercises?") this chapter will provide an answer by giving design suggestions for iterating Mini's concept based on the presented findings and discussion.
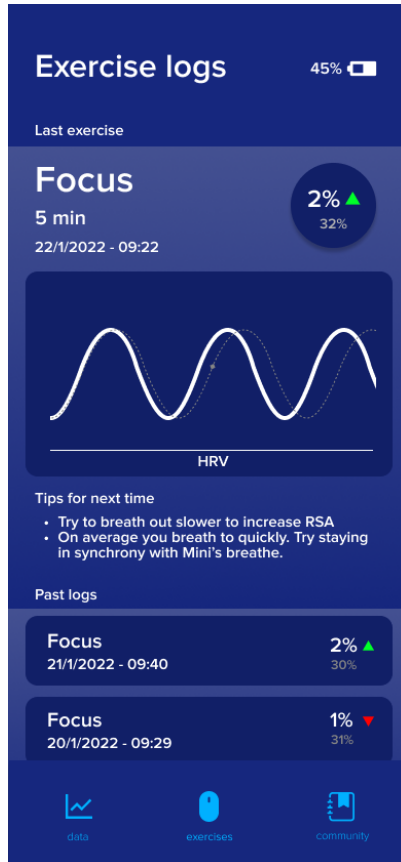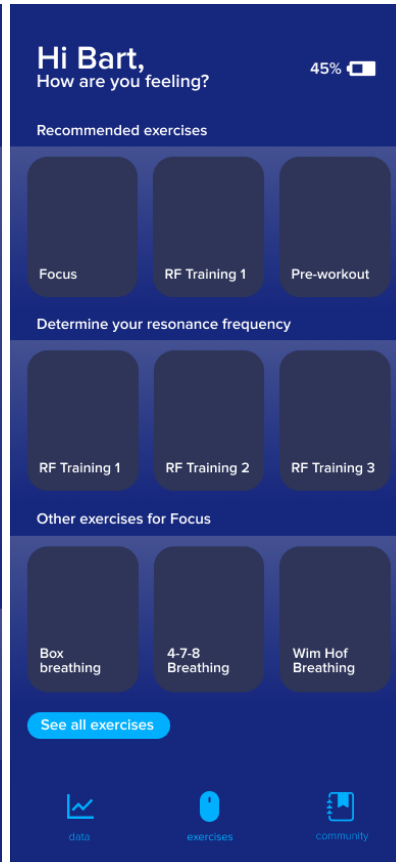

Figure 15: Data tab

Figure 16: Exercise tab
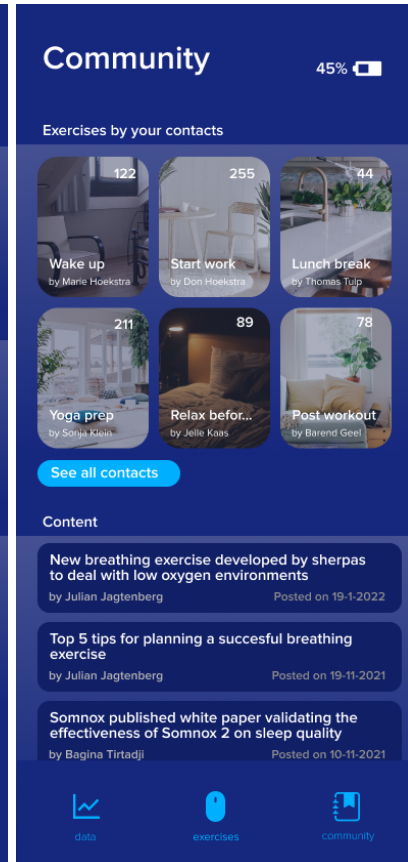
Figure 17: Community tab

Mini's embodiment

Mini's shape should be redesigned to be smaller in order to better fit their user's hands. When redesigning its shape, the expanded form of Mini should also be easy to hold on to. The haptic feedback provided by Mini should also become more subtle in order to make its emergence less sudden.

Logs

Because Mini gives haptic feedback when detecting RSA, users of Mini will inherently have a metric by which they can judge their performance. Therefore while logs should not put an emphasis on overall performance metrics, users should still be able to quantify their

progression. Instead the emphasis should be placed on providing actionable insights towards improving their exercise performance the next time they pick up Mini (see figure 15).

Exercises

None of the participants made active use of the HRV measurements. It can therefore be scrapped from the exercise selection screen in order to make room for a section with recommended exercises see figure 16. These recommendations will include the resonance frequency trials and exercises based on a particular purpose indicated by the user while onboarding.

Participants will have access to all exercise from the start. However in order to regulate the difficulty of exercises and an adequate challenge to users, the app will automatically adjust the strictness of Mini in response to prolonged periods of progression or regression in RSA ratios.

Rituals

In place of planning rituals as a separate concept, users are guided to think of ritual contexts when creating custom exercises. During the customization process users will be asked about:
- A purpose behind the exercise (e.g. Relaxing before sleep).
- Their exercise space (e.g. On their bed).
- How often they plan on performing the exercise per week (e.g. On working days).
- If they wish to receive reminders of their exercise.
- Exercise specifications (e.g. breathing rhythm and duration).

Community

These exercises can then be shared amongst contacts that have connected a social media account to their Somnox account. In the community tab (see figure 17) users will be able to see the exercises performed by their contacts in addition to a counter representing the amount of times the exercise has been performed. Sharing this information serves to motivate others to reach high counters on their exercises and inspire contacts with viable examples of custom exercises. Moreover digital content relating to breathing exercises and Somnox can serve as inspiration to make more extensive use of their Mini - ultimately forming multiple breathing exercise habits.

Figure 18: An early reminder of the exercise

Reminders

If allowed, users can receive early reminders of their exercise (see figure 18). These can eventually stop occurring once the user has built a habit of consistent usage (e.g. after performing the exercise 70 times) in order to make the habit of performing exercises independent from receiving a reminder. Alternatively users could measure their SRBAI and decide to turn their reminders off based on the result.

Limitations

Due to the limited number of participants further validation through research is required of the findings. Throughout the longitudinal study several participants had prolonged periods (longer than 7 days) with malfunctioning prototypes hindering them from forming a habit. If these technical issues were prevented more conclusive statements could have been made on the effectiveness of Mini's ability to form habits.

Moreover throughout the study multiple participants reported ailments ranging from COVID to RSI and physical injuries affecting their motivation to perform exercises. Incidents such as these make it difficult for habits to form in general as people will be likely more focused on passive recovery rather than following their healthy virtues.

The end of the longitudinal study got delayed throughout the period. As a result participants were approached much later (e.g. in some cases more than 10 weeks later) for the survey and DII. This hindered participants' from recalling their feelings and user experiences during the DII. Using the calendar plot, participants were however able to recall their activities by comparing it to their own agendas.

Throughout the study participants were contacted in case of 7 days of inactivity. This was done in order to acquire qualitative data about motivations as quickly as possible. However, it also served as a reminder for participants who simply forgot to use Mini. Over time this practice got

suspended, lowering the chance of successful habit formation for participants who would have otherwise been able to do so.

The themes presented in this thesis should be further validated. Due to the subjective nature of thematic analyses it is recommended by Saldana (2013) to cross reference themes and coding with other researchers. Since this graduation thesis was performed by a single student, it is recommended to have another design researcher perform qualitative analysis on the transcriptions. Validation can be done by comparing the resulting themes of both researchers.

Acknowledgements

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Appendix A: Randomization table for participant grouping

A Randomization Plan
from
http://www.randomization.com

18 subjects randomized into 3 blocks
To reproduce this plan, use the seed 16396
along with the number of subjects per block/number of blocks
and (case-sensitive) treatment labels as entered originally.
Randomization plan created on 2/21/2022, 11:37:46 PM

1. A_____
2. C_____
3. C_____
4. B_____
5. B_____
6. A_____
7. A_____
8. A_____
9. C_____
10. B_____
11. B_____
12. C_____
13. B_____
14. A_____
15. B_____
16. A_____
17. C_____
18. C_____

Appendix B: Provided information sheet

In this document I will provide a short overview of things to keep in mind while using the device. This will allow you to make sense of your progression going forward.

The rituals
The point behind the rituals is to encourage users to make a habit of performing the exercise at their own chosen time. Performing the ritual will give you a HRV measurement from which you can deduce your progress towards a relaxed baseline. Generally an increase in HRV over time indicates you should feel more relaxed and stress resistant. A decrease should indicate that you are becoming more stressed and less resistant to stressors. While a normal HRV can range between 20-200 ms, everybody has a personal baseline. Thus **it is most important to look at the changes in your HRV and subjective experience of stress** rather than focus on reaching a specific HRV target.

It is important to note that **you can have a HRV that is too high**. If your HRV increases very quickly over a short amount of time it could indicate that your body is in 'recovery mode' from prolonged periods of stress or illness. That is why it is important to take your subjective experience in mind while assessing your HRV. If you have a high increase in HRV but you feel tired and lethargic instead of relaxed and energized, it could mean you are currently recovering and should take it easy instead.

Exercises
The device is mostly designed around performing **resonance breathing** exercises. This means slow breathing at a specific frequency in order to provoke a relaxation response in your body. The breathing frequency with the biggest relaxation response differs per person so in order to determine your optimal frequency we first need to be comfortable performing the exercise at different frequencies (6.5, 6, 5.5, 5 and 4.5 breathes per minute). Once you can comfortably perform all exercises it should become clear which frequency best fits you (based on the Quality metric). This 'resonance frequency' is determined by the app upon unlocking the "Resonance Breathing" exercises.

Logs
The only data collected from the exercises are a timestamp, the type of exercise and your performance metrics. Below you can see an explanation for the performance metrics:
- Quality: The quality of your relaxation response, meaning the difference between maximum and minimum heart rate over the course of the exercise. This metric is used to determine your optimal breathing frequency.
- Ratio: How much percent of time we measured a relaxation response during your exercise.

Later on in the study you can also get access to other breathing exercises (box breathing and 4-7-8 breathing). While these do provide you with relaxation they do not specifically provoke the relaxation response we can measure (and give feedback for). Thus it is important to assess

these exercises with the HRV and subjective effects it has on you rather than looking at your performance metrics.

Appendix C: Survey prior to DII

End-of-study survey

Hi, thank you for participating in my study! In order to gather insights on your experience throughout the study you are asked to answer a couple of questions.

mingzalieu@gmail.com (not shared) Switch account

* Required

What was your participant number? It is mentioned in your login account but feel free to ask the research team! *

Your answer

At the start of the study I was motivated to form a habit of performing breathing exercises

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly agree

I am currently motivated to form a habit of performing breathing exercises

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly agree

Next   Clear form

Never submit passwords through Google Forms.

Assessing your habit formation

In the following section we will measure how habitual performing breathing exercises has become for you

---

Deciding to perform a breathing exercise around your ritual time is something I do automatically

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly Agree

Deciding to perform a breathing exercise around your ritual time is something I do without having to consciously remember.

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly Agree

Deciding to perform a breathing exercise around your ritual time is something I do without thinking.

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly Agree

Deciding to perform a breathing exercise around your ritual time is something I do before I realise I'm doing it

○ Strongly disagree

○ Disagree

○ Neutral

○ Agree

○ Strongly Agree

Four tendencies framework

According to the Four Tendencies framework there are 4 'tendencies' for habit formers:
- Upholders: people who naturally have an easy time forming new habits by sticking to either self-imposed or prescribed restrictions or routines.

- Obligers: people who form habits the easiest when they are held accountable by authority figures (such as coaches or doctors) or acquaintances (such as friends or team members).

- Questioners: people who need thorough convincing that a habit will be effective for them, usually through scientific arguments and tailoring towards their needs.

- Rebels: people who mostly form habits when given full autonomy to form the habit as they wish since they respond negatively to prescriptions especially when restrictive. Someone who doesn't form a habit most efficiently, but in a way that they are comfortable with.

With the following questions we will try to determine whether your 'habit forming personality' had an influence on your study experience. We will further talk about this in the upcoming interview.

Have you kept a New Year's resolution where you weren't accountable to anyone—a resolution like drinking more water or keeping a journal?

○ Yes. I'm good at keeping New Year's resolutions, even the ones that no one knows about but me.

○ I'm good at keeping resolutions, but I make them whenever the time seems right. I wouldn't wait for the New Year; January 1 is an arbitrary date.

○ I've had trouble with that kind of resolution, so I'm not inclined to make one. When I'm only helping myself, I often struggle.

○ No. I hate to bind myself in any way.

Which state best describes your view about your commitments to yourself?

○ . I make a commitment to myself only if I'm convinced that it really makes good sense to do it.

○ If someone else is holding me accountable for my commitments, I'll meet them—but if no one knows except me, I struggle.

○ I bind myself as little as possible.

○ I take my commitments to myself as seriously as my commitments to other people.

At times, we feel frustrated by ourselves. Are you most likely to feel frustrated because . . .

○ . My constant need for more information exhausts me.

○ As soon as I'm expected to do something, I don't want to do it.

○ I can take time for other people, but I can't take time for myself.

○ I can't take a break from my usual habits, or violate rules, even when I want to.

When you've formed a healthy habit in the past, what helped you stick to it?

○ I've found it pretty easy to stick to habits, even when no one else cares.

○ I did a lot of research and customizations about why and how I might keep that habit.

○ I could stick to a good habit only when I was answerable to someone else.

○ Usually I don't choose to bind myself in advance.

If people complain about your behavior, you'd be least surprised to hear them say . . .

○ You follow your good habits, ones that matter only to you, even when it's inconvenient for someone else.

○ You ask too many questions.

○ You're good at taking time when others ask you to do something, but you're not good at taking time for yourself.

○ You only do what you want to do, when you want to do it.

Which description suits you best?

○ Puts others -clients, family, neighbors, coworkers- first.

○ Disciplined - sometimes, even when it doesn't make sense

○ Refused to be bossed by others

○ Ask necessary questions

People get frustrated with me, because if they ask me to do something. I'm less likely to do it (even with a boss or client).

○ Tend to agree

○ Neutral

○ Tend to disagree

I do what I think makes the most sense, acoording to my judgment, even if that means ignoring the rules or other people's expectations.

○ Tend to agree

○ Neutral

○ Tend to disagree

Commitments to others should never be broken, but commitments to myself can be broken.

○ Tend to agree

○ Neutral

○ Tend to disagree

Sometimes I won't do something I want to do, because someone wants me to do it.

○ Tend to agree

○ Neutral

○ Tend to disagree

I've sometimes described myself as a people-please.

○ Tend to agree

○ Neutral

○ Tend to disagree

I don't mind breaking rules or violating convention - I often enjoy it.

○ Tend to agree

○ Neutral

○ Tend to disagree

I question the validity of the Four Tendencies framework

○ Tend to agree

○ Neutral

○ Tend to disagree

Back   **Submit**   Clear form

Appendix D: Prepared Miro board of participant 1

You're SRBAI (habit automaticity index) is: `8 out of 20`

YOUR USER EXPERIENCE

How would you describe your experience performing an exercise using the Mini device?

`...` `...` `...`

How would you describe your experience using the mobile app with your exercises?

`...` `...` `...`

YOUR HABIT TENDENCY

According to the Four Tendencies quiz you are: `an Obliger`

Looking at past habits you have developed, would you agree with this classification? Why? `...`

Would you be comfortable having an accountability partner for breathing exercises?

a coach | an acquaintance | a co-breather | `...`

YOUR DAILY ROUTINE

Your ritual was `... at ... after ...` You envisioned doing this `X` times per week

Do you already have an established ritual/habit around this time?

`...` `...` `...`

Were you trying to build any other habits throughout the study period?

`...` `...` `...`

Did the ritual replace an existing ritual?

`...` `...` `...`

Knowing about your tendency would you change your ritual? How?

`...` `...`

Did you use it outside your usual ritual time? Were there other rituals?

`...` `...` `...`

Filling the gaps

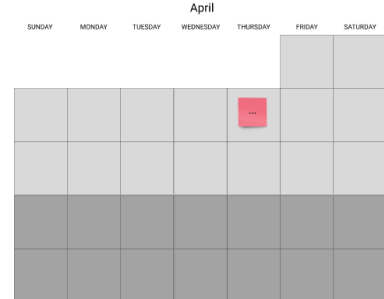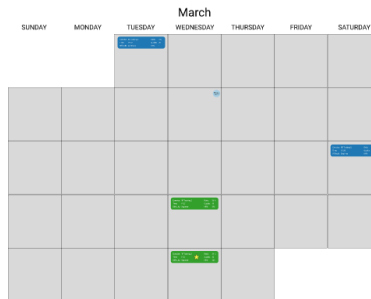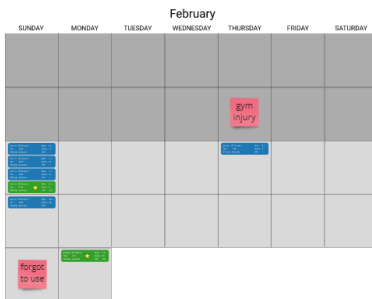Can you identify the times that you stopped and the reasons for doing so?

I've pre-filled some of them using notes from our exchanges - feel free to correct or specify them if necessary

Was there anything you changed when continuing?

I've pre-filled some of them using notes from our exchanges - feel free to correct or specify them if necessary
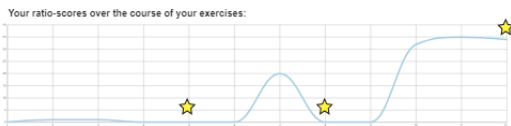
February

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				gym injury		
forgot to use						

March

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

April

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

YOUR MOTIVATIONS

Advanced
Intermediate
Beginner

Why did you decide to change difficulty level (when possible)?

Did you feel motivated or demotivated by your performance?

Your ratio-scores over the course of your exercises:

Your quality-scores over the course of your exercises:

⭐ = unlocked exercise

Where there any specific events that were motivating? If u want/can u can move the post-it onto the graph
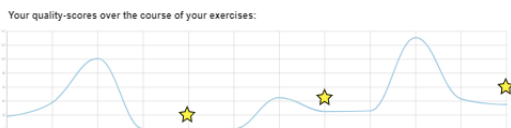
Where there any specific events that were demotivating? If u want/can u can move the post-it onto the graph
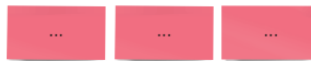
Your motivation started at [4 out of 5] and ended at [4 out of 5]

This did (not) change because of: | ... | ... | ... |

At the start of the study you were mostly motivated by: | ... | ... | ... |

When prompted, why did you want to continue with the exercise? | ... | ... | ... |

Was there a goal for joining the study? | ... | ... |

Were you able to reach your goals for this study? | ... |

IDE Master Graduation
Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name	_____
initials _____ given name _____	
student number	_____
street & no.	_____
zipcode & city	_____
country	_____
phone	_____
email	_____

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD   ( ) DfI   ( ) SPD

2nd non-IDE master: _____

individual programme: ____ - ____ - ____ (give date of approval)

honours programme: (_____)

specialisation / annotation: (_____)
(_____)
(_____)

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair _____ dept. / section: _____

** mentor _____ dept. / section: _____

2nd mentor _____

organisation: _____

city: _____ country: _____

comments
(optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

TUDelft

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair _____ date ___ - ___ - _____ signature _____

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC

Of which, taking the conditional requirements
into account, can be part of the exam programme _____ EC

List of electives obtained before the third
semester without approval of the BoE

○ YES   all 1st year master courses passed

○ NO   missing 1st year master courses are:

name _____ date ___ - ___ - _____ signature _____

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ○ APPROVED   ○ NOT APPROVED

Procedure: ○ APPROVED   ○ NOT APPROVED

comments

name _____ date ___ - ___ - _____ signature _____

Initials & Name _____ Student number _____

Title of Project _____

TUDelft

_____ project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple.
Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date _____ - _____ - _____   _____ - _____ - _____ end date

INTRODUCTION *
Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

space available for images / figures on next page

Initials & Name _____   Student number _____

Title of Project _____

TUDelft

introduction (continued): space for images

image / figure 1: _____

This heartbeat rhtyhm is simulated through a vibration motor

image / figure 2: _____
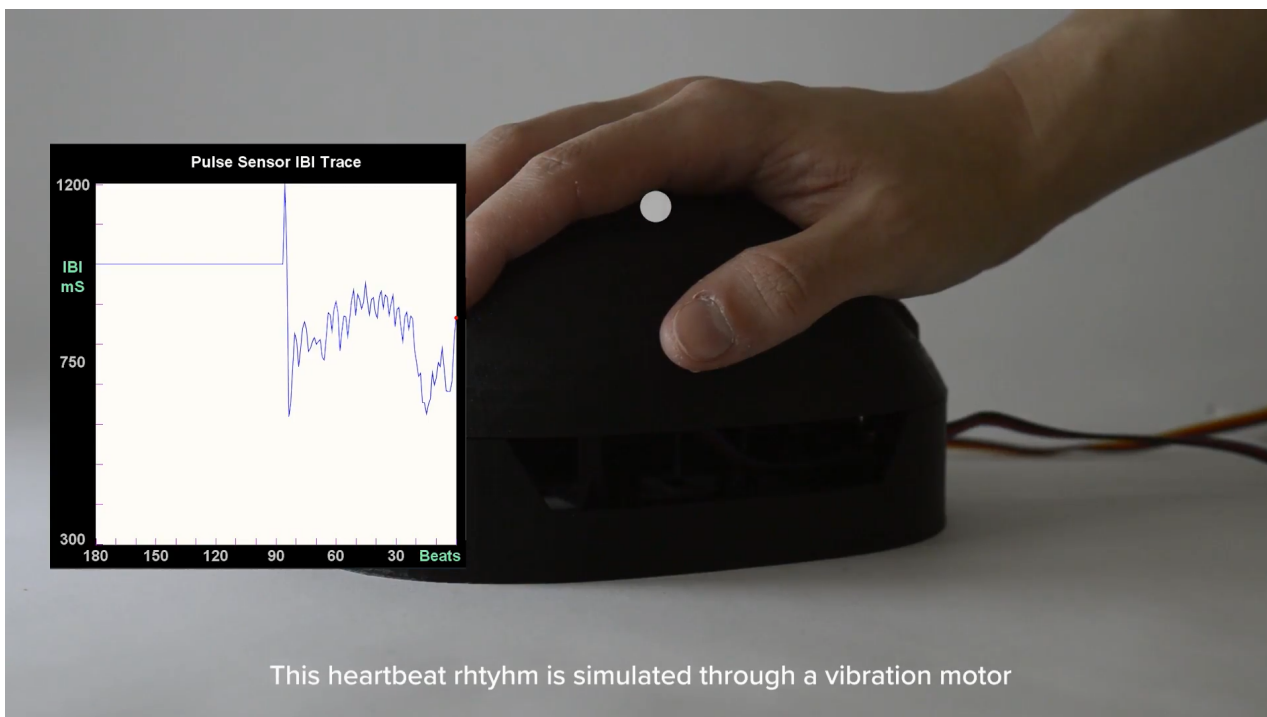
Initials & Name _____ Student number _____

Title of Project _____

TUDelft

PROBLEM DEFINITION **
Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

ASSIGNMENT **
State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Initials & Name _____   Student number _____

Title of Project _____

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date _____ - ___ - _____   _____ - ___ - _____ end date

Initials & Name _____ Student number _____

Title of Project _____

MOTIVATION AND PERSONAL AMBITIONS
Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

FINAL COMMENTS
In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name _____   Student number _____

Title of Project   _____