How can Sonic Interaction Design Influence Smartphone Distractions in the Home-Office Environment of Young Teleworkers

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ABSTRACT

This study presents a refreshed view on a common distraction in the home office environment: smartphones. The aim of the research was to find out if the use of auditory feedback can help to decrease the disctractions that it adjoins. Young teleworkers where asked to use a research probe for three weeks in which they had to place their phone during their workday. During this longitudinal field study, the probe measured the amount of times the teleworker took their phone out of the device and gave auditory feedback or no stimuli at all. A baseline study was performed in which participants had to write down the amount of unlocks at the beginning and end of their workday. When compared with the baseline study the data of the field study shows a positive impact on the amount of distractions when using auditory feedback.

KEYWORDS

Telework, Smartphone, Sonic Interaction Design, Behavior Change

1 INTRODUCTION

As result of a global pandemic, companies strongly advised their employees to work from home at the beginning of 2020. This resulted in a sudden increase in home-based telework all over Europe. A study from Eurofound [16], showed that an average of 36,5% of the 63,353 participants started to telework fulltime as a result of the pandemic. In comparison, before the outbreak only 15% teleworked daily or occasionally. Telework can be defined as work that enables employees or students to work remotely from home with the help of IT facilitated by their employer or school. According to Hartman et al. [21] and Jensen [26] the most promising benefit for individuals and organizations is the potential for an increased productivity. Although the telework survey from James [25] shows positive results, little conclusive scientific evidence is available that proves that this increase in productivity actually occurs [4][28] Most of the existing telework research done on productivity also compares non-teleworkers with teleworkers [5][8][14][23][28][40]. Van der Meulen et. al [34] concluded that these studies are hard to compare with each other since they show significant differences in who 'classifies' as a teleworker. Additionally Van der Meulen et. al propose that next to the extent of telework, the differences in workplace distraction levels play a role in the lack of evidence within telework research.

These distractions can be characterized in two ways. First, they can either be internally generated (e.g. stress, anxiety, etc.) or externally generated (caused by work place, noises, etc.) [27]. The practical examples of distractions that are mentioned in the aforementioned study are still present today. However, this study is conducted before the widespread introduction of the smartphone and their adjoined distractions [11][36]. The researcher believes that a general lack of research regarding telework [34] and the immense impact of smartphones on our daily lives demand exploration of its impact on the productivity of the teleworker in his natural habitat: the home-office.

The search for a way to gather insights in the smartphone distractions of teleworkers led to the development of CODI, a desk-based phone holder in which users had to place their phone at the start of their workday. The device noticed when and measured how often the phone was taken out of its holder. The two groups of participants which had to work with CODI for almost 3 weeks either received auditory stimuli or no stimuli at all when they took their phone out of the device. A recent study by Meyer et. al [35] concluded that increasing the self-awareness about productivity at the office through self-monitoring improves workers' productivity. The auditory feedback integrated in CODI should therefore create a sense of self-awareness about the smartphone usage with the user every time the smartphone is taken out of the device. The aim of this study is to explore whether auditory feedback can be used in order to create more awareness about peoples' smartphone unlock behavior. This studies' hypothesis is that an increased self-awareness will decrease the amount of daily smartphone unlocks which will result in less smartphone distractions while working. This links CODI directly to the

theoretical pillars of the emerging young research field, *sonic interaction design* (SID), and *self-monitoring*.

2. THEORETICAL BACKGROUND

Sonic Interaction Design & Auditory Perception-Action Loop

According to Senan [46], sound within SID is considered as an active medium that is concerned with the multisensory, tactile and performative aspects of the sonic experience. As a recently emerged research field, SID is similar to the current telework research field in the way that the current knowledge is built on the existing fundamental knowledge in the designated field, which for SID is sound. In order for both fields to develop, they require new perspectives and methods. SID aims at exploring new roles of sound in human-computer interaction. One of the topics the field explores is the use of sound as a means for communication in a closed-action interaction loop [18].

Within a closed-action interaction loop, a sound producing interface is manipulated by a user, i.e., the user performs actions that will change the state of the interface, and the auditory feedback affects in turn the manipulation behavior of the user [18]. CODI is designed with a closed-action interaction loop in mind and CODI's deployment should give insights in the manipulation frequency and duration within this loop. In this research, the smartphone should be seen as a physical token which is part of the auditory interface. The manipulation of this interface equals taking the token, i.e., smartphone, out of the device. Applied [15][45] and experimental [33][43] settings in which similar designed interactions have been used, uncover the tight coupling between auditory perception and action [1], the so-called auditory perception-action loop [18].

Neuropsychological research hypothesizes that the human brain processes action-related sounds caused by humans (e.g., the sound of someone sneezing) differently than non-action sounds (e.g., rainfall) [39]. Although identified in monkeys' brains [30], the cause of this neuropsychological phenomenon, the so-called audio-visual mirror neurons, lack hard evidence of presence within the human brain. Based on human experiments, Pizzamiglio et. al [39] suggest that action-related sounds trigger the humans' brain mirror system, together with a specific motor area activation. This should represent the "how was the sound made"- mechanism within the human brain. On the opposite, the non-action sounds purely consist out of the acoustic and perceptual properties, without corresponding motor area activation as shown by Lahav et. al [31]. De Lucia et. al [13] suggests that hearing an action-related sound might next to activating a representation of how the sound was made, also unconsciously cue the listener to react to the sound. It would be interesting to see if a reaction is also triggered by the sound of the designed research artefact.

Self-Awareness

"Informative messages on one's behavior lead to a rise in awareness, but awareness doesn't lead to a change of the said behavior" [44].

This quote is a well-supported belief when talking about self-awareness as a precursor of behavior change [44][12]. Seimetz, Kumar & Mosler [47] found that to be true for public awareness campaigns focusing on handwashing. Rao & Halady [42] on their turn suggested the opposite when it comes to raising awareness for climate change and as mentioned before, Meyer et. al [35] concluded a positive change in productivity when self-awareness about work productivity was increased in an office environment. This shows that the creation of self-awareness as an instigator for behavior change with regard to home office smartphone distractions offers possibilities.

Richard [44] suggests that awareness could bridge the gap between awareness and corrective action if some specific components are in place. Behavior exists as part of a bigger context. According to him, it are complex systems build from interconnected building blocks that have specific boundaries (i.e. cultural). He claims that these systems, and their accompanying boundaries are formed by individuals life experiences, groups dynamics, etc. All these components form an individual's system that will determine the probability of the behavior and reaction in a given context.

According to Fogg [17], behavior is a product of three factors: motivation, ability and triggers. His Behavior Model suggests that by either increasing motivation or simplifying the task, external triggers can work in order to reach a desired behavior. CODI will be deployed in order to see if a returning subtle audio cue can be a strong enough trigger to see a change in smartphone distractions and therefore could bridge the aforementioned gap.

3. RELATED WORK

It is important to mention that after thorough research to find similar studies that use auditory feedback in order to effectuate behavior change, not many papers came up.

KAIROS

A recent example of a desk-based design research artefact that focuses on the smartphone usage of office workers is KAIROS [41] (Figure 1). Prudon used the bounded-deferral principle in a physical application in order to explore possible interactions users can have with the smartphone notifications they receive. The core proposal of the bounded-deferral method [24] is to delay incoming notifications when users are perceived to be busy. The device perceived whether users' were unfocussed by measuring sound and movement data. It's design can be summarized as a small container which could open and close in which participants had to place their phone.

It opened step by step until the user could take out their phone. Every step was represented by a lower threshold for the perceived state of focus. KAIROS completely opened up when the user was at the lowest perceivable state of focus and therefore the most prone to distractions.

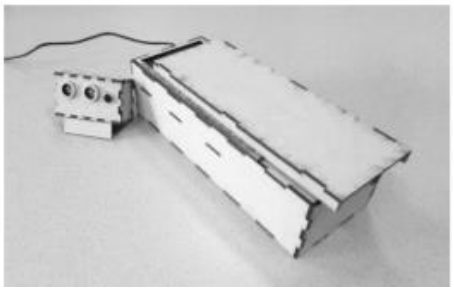

Figure 1: KAIROS and its accompanying sensor box. (Prudon, 2019)

AudioResponse, EntranceSound and RainForecasts Bakker, van den Hoven and Eggen [7] explored interactive systems using peripheral sounds. They build on the vision of Weiser [51] who envisioned that the computer of the future would blend in with its environment. They saw potential for audio to be used in *calm technology*, which was introduced by Weiser and Brown [52]. They describe it as " technology that engages both the center and periphery of our attention and in fact moves back and forth between the two". Bakker, van den Hoven and Eggen used three systems that used audio as calm technology: the AudioResponse, EntranceSound and RainForecasts. All three where placed in a shared office environment for three weeks in order to explore how interactive auditory systems could be designed for the periphery. Where the EntranceSound and RainForecasts were more focused on sonification in order to inform users according to the research, the AudioRespons caught the eye of the researcher since it also used sensor data in order to generate a specific tone to create awareness.

4. RESEARCH DESIGN

To gain insights in the smartphone pick-up behavior of teleworkers, a physical probe called CODI[1] was created (Figure 2). The probe was constructed out of laser-cut MDF layers that are glued on top of each other to create a solid build.. Inside the probe, a hollow space was incorporated where a self-designed PCB was placed that obtained a HS-SR04 ultrasonic distance sensor (Figure 3). This sensor measured the times the phone was taken out of a dedicated smartphone slot which was incorporated in the top layers of the probe. This slot was designed to fit the phones of all the largest common consumer brands. The use of phone/screen protectors was also incorporated. The slot physically covers the participant's view on their smartphone screen (to which extend depends on the type of phone). Non-functional parts of the MDF layers have been cut out in order to reduce weight as can been seen in Figure 3.

Figure 2: CODI in use.

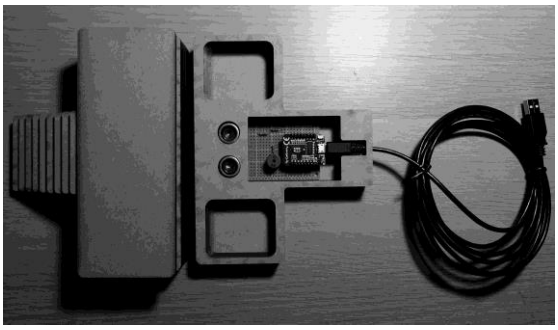

Figure 3: CODI's internal features.

A physical desk-based device was designed. It needed to be bound to one single location due to connectivity reasons which will be elaborated on further in this section. The probe came with a two meter long USB cable in order to give participants as much physical freedom as possible for plugging in the device. Every time the participant started his workday, the device needed to be powered in order to measure data. When they stopped working at the end of the day, it needed to be unplugged in order to reset for the next day.

The data that CODI gathered was send to the online Data Foundry platform [20]. In order to do so, an OOCSI [19] connection between the ESP8266 inside of CODI and the user's Wi-Fi network was established. Since CODI was programmed to only connect to one Wi-Fi network, it needed to be bound to one single location in order to work.

Sound Design

The final probe was designed with two conditions: a baseline condition with no auditory feedback and a condition which was programmed to give auditory feedback every time the participant took the smartphone out of the probe.

In order for the sound not to be intrusive or judgmental, I suggested that the auditory cue should be a short, subtle and pleasant pitched sound. In order to make it as neutral as possible, it should not be a sound that quickly could be related to any auditory cues already existing in the everyday lives of the participants. I chose for a pure tone with a specific

[1] CODI is a simplified wordplay of Covid. Which in turn refers to the global pandemic which heavily influenced the way this research was shaped.

frequency since there is a lot of research already been done in the past on how the human mind perceives specific frequencies and what their effects are or might be.

Research shows that the moderate frequencies, e.g., 300-750 Hz are perceived as most pleasant, i.e., the least annoying [32][37][50]. Within this frequency range, there are multiple frequencies that belong to the so-called Solfeggio frequencies. Recent research on this topic suggests that these frequencies have or can have a positive impact on a human's physical and psychological state of being [2][3][10][29]. Although there is research available, the Solfeggio frequencies are not yet a prominent topic in sound research. The available research however inspired me to base my sound design on one of the solfeggio frequencies: 528 Hz. In order to not make the auditory que to intrusive, its length is only a half of a second.

CODI will use self-monitoring as a strategy for intervention of the smartphone unlock behavior of young teleworkers in the home office environment. The research is designed to create awareness for their own behavior and hopes to measure a change in behavior at the end. In the next section it is described how the research is performed.

5. RESEARCH SETUP

This study was conducted in two stages which will be described in detail below.

Baseline study

The first stage was a ten workday-long baseline study with ten participants (average age: 23, gender: 7 male, 3 female). These participants were recruited based on their age and their current work situation through social networks. Three participants where young professionals working from home and seven participants were university students either working from home full-time or part-time from home and part-time at the university. This baseline study was conducted in order to get initial insights in smartphone distractions among young teleworkers. During this study, the participants were asked to keep a daily diary (Figure 4) of the amount of smartphone unlocks during the classic 9-5 working hours. They had to note down their smartphone unlocks at 09:00 and at 17:00. Although students in general have more freedom when it comes to when they work during the day, these specific times where chosen because the young professionals that participated in this study were still bound to these hours. Smartphone unlocks where chosen as spearpoint in this baseline study and in this study in general since I believe that unlocking your smartphone is where the true distraction starts. Compared with only viewing the notifications on your lock screen, unlocking your smartphone literally opens up a digital world with unlimited access to social media and other platforms in which it is easy to get lost in.

In addition to the daily diary of their smartphone unlocks. Every participant was asked to fill in a mini-questionnaire at the end of their workday. In this questionnaire, participants were asked about their experienced distractions and efficiency on that specific day. The contents of this questionnaire can be found in the Appendix A.

Name:		Age:		
	Amount of screen unlocks			Daily 1-minute survey
Workday	9:00 AM	5:00 PM	Workday Total	
1			-2	https://nl.surveymonkey.com/r/89XGXB5
2			-2	https://nl.surveymonkey.com/r/896W2GH
3			-2	https://nl.surveymonkey.com/r/895HQ93
4			-2	https://nl.surveymonkey.com/r/8YD7529
5			-2	https://nl.surveymonkey.com/r/8YC8SQY
6			-2	https://nl.surveymonkey.com/r/8YB7DVS
7			-2	https://nl.surveymonkey.com/r/82JVWZG
8			-2	https://nl.surveymonkey.com/r/8CY9XBW
9			-2	https://nl.surveymonkey.com/r/8C77NW5
10			-2	https://nl.surveymonkey.com/r/8CQ9WRY

* The -2 takes in account the two times you need to check your phone to get the data.

Figure 4: Daily diary as used in the baseline study.

Longitudinal Field Study

To elicit a longitudinal picture of user's everyday smartphone behavior and to further evaluate the role of sound in this context, a longitudinal field research was necessary to record possible change in behavior [38]. Hazelwood [22] recommends that ambient displays should be deployed over longer time periods. According to Bakker, van den Hoven and Eggen [6], this has three main reasons: (1) making the user get used to the presence of the artefact, (2) to prevent the artefact from being perceived as "new" in its physical context by the user and (3) to unlearn existing habits. Taking into consideration the above mentioned, the design of the study was governed by one main research question: can auditory feedback effectuate a decrease in smartphone distractions in the home office environment of young teleworkers?

This section further describes two different setups of the longitudinal field study. An initial setup as originally planned and the final setup which differs from the initial for various reasons which are also described in this section. The initial setup of this longitudinal field-study, i.e., the deployment of CODI, consisted out of 4 weeks, 15 participants, 10 research artefacts and three different conditions (Table 1).

	Group 1 (n=5)	Group 2 (n=5)	Group 3 (n=5)
Week 1 & 2	Silent Mode	Constant Mode	
Week 3 & 4	Silent Mode		Changing Mode

Table 1: The initial setup of the longitudinal field study.

CODI's first condition gave no auditory feedback when taking out the smartphone from the holder and should be used by Group 1, i.e., the control group. Group 2 should use CODI in a constant mode. This mode was programmed to give a constant auditory cue every time the user would take their smartphone out of the holder. Condition 3, as planned to be used by group 3, was equipped with a auditory cue that changed it's tone by increasing the frequency based on the amount of unlocks that have been measured during the day. The data of the baseline study regarding the amount of the average smartphone pickups would have been used to design a sound change from

pleasant to unpleasant with a change in frequency per X amount of measured unlocks.

Since the research budget would only allow a maximum of 10 artefacts to be made, the three groups could not test the three conditions at the same time. As can be seen in Table 1, group 3 needed to wait for group 2 to finish in order to start. In order to properly compare the results of Group 2 and 3 with the control group, group 1 needed to use the silent variant during the entire duration of this field study.

During the build of the research artefacts, two of the ten research artefacts suffered a hardware failure. This resulted in a decrease of needed participants from 15 to 12. After many efforts to recruit participants using social networks and my own social circle, the amount of participants got stuck at eight when it was time for the study to begin. This was mainly because possible participants didn't feel comfortable sharing their Wi-Fi data in order to connect an unfamiliar artefact that would send their data to an unfamiliar online platform. Because of this, some changes were made (Table 2)

	Group 1 (n=4)	Group 2 (n=4)
10 days	Silent Mode	Constant Mode
10 days	Constant mode	Silent Mode

Table 2: The final setup of the longitudinal field study.

As can be seen in Table 2, two main changes were made in the design of this study: (1) condition 3, the "changing mode" got canceled and (2) due to less participants, the study switched from a between-subjects study to a within-subjects study. When it came down to importance, the silent and constant mode were the most relevant since they bring sound down to its two most primitive states: "on-off". The switch to a within subject also gives the advantage that it is less likely that a significant difference that exists between the silent mode and the constant mode will covered by random noise and therefore stay undetected [9]. Next to that, the run time of the study was shortened due to some unexpected software errors which caused a delay in the starting date. Since every participant was a student, the 9-5 working hours were changed to "when you start working – when you stop working".

Although all eight participants (average age: 23, gender: 7 male, 1 female) started the study, only three of them completed all 20 days and experienced both conditions. Participant nr. 8 forgot his CODI at the TU/e, which was the location of which he worked the most (3 days per week) before the stricter lockdown forced him to work from home. He felt that his experience was not representative of the intended study setup and therefore his quantitative data was omitted from the research. While personally switching the conditions at the home of participant nr. 7, the artefact rejected to re-connect to the Wi-Fi network. After multiple tries, reboots and adjustments, he was excluded for the further duration of the research. During the data analysis of participant nr. 7, his measured data seemed to be flawed. Therefore also his quantitative data from round one was excluded from this research. Participant 4 accidentally uploaded a code for his own project onto CODI a couple days after swapping conditions. In-between, he only used CODI for one workday. He therefore only experienced the silent mode. Participant nr. 5 and nr. 6 also only experienced the silent mode. Participant nr. 5 had to go in quarantine right after swapping conditions at another location then where his CODI was located and had to stay there until he recovered and participant 6 took a work break during the holidays which started two days after I switched the conditions of her CODI. At the end of the deployment phase, six of the original eight participants were interviewed about their experience (Appendix B).

This study resulted in both quantitative and qualitative data. Where the former investigated the frequency of participant's smartphone unlocks during a workday, the qualitative data obtained from the semi-structured interviews were used to give more insights into the individual practical background of the quantitative data.

5.FINDINGS

Baseline Study

Ten daily diaries were received at the end of the baseline study which resulted in 100 data points which all represented a specific amount of smartphone unlocks for a specific participant on a specific day. This dataset resulted in an baseline average of 43,28 smartphone unlocks per workday (Figure 5).

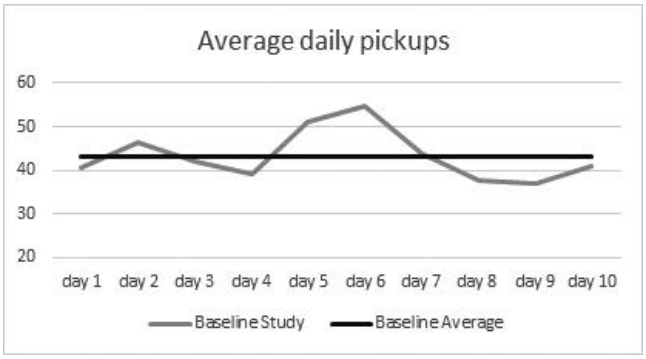

Figure 5: Baseline average.

Week 1, i.e., day 1-day 5, can be viewed as a week in which the participants had to get used to their new task [6]. After the first week of measuring, a trend can be recognized in week 2. The smartphone usage the first day after the weekend (in-between week 5 and 6) rose with 26,3% when compared with the baseline average. This might be the result of the weekend in which participants did not monitor their smartphone usage. Week 2 shows a decline over the course of the next three days with a maximum 32,6% decline on day 9 compared to day 6.

Next to the data from the daily diaries. Quantitative data was also received from the mini-questionnaires filled in at the end of every workday regarding efficiency and distractions. These

mini-questionnaires were filled in a total of a 100 times. Users had to rate their efficiency (Figure 6) and their distractions (Figure 7) based on Likert-type scales [49].

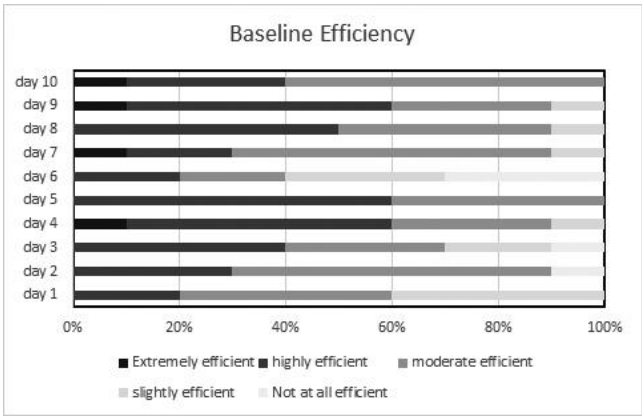

Figure 6: Baseline level of efficiency.

According to figure 6, participants rated themselves the least efficient at the beginning of their workweek on Day 1 and Week 6. The influence of the weekend can be seen when we compare day 5 with day 6. We also see a maximum rise of 150% in participants rating themselves as highly efficient over the course of week 2 and a 200% increase in participants who managed to reach their average efficiency level by the

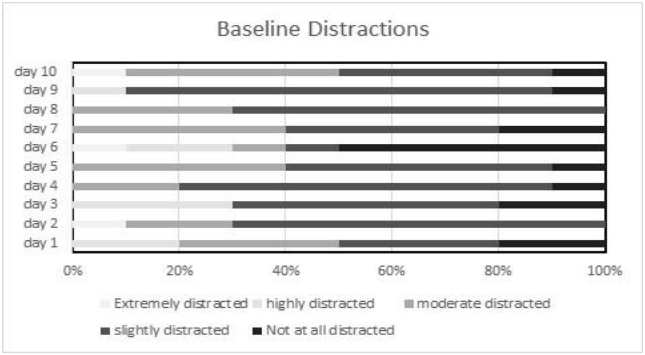

Figure 7: Baseline level of distractions.

These findings correlate with the decrease in smartphone unlocks retrieved from the daily diaries. Although Figure 7 shows an increase in participants who rated their distraction level less than average during the course of week 1 and week 2, there can also be seen an decrease in the amount of participants rating their distraction level as not at all distracting. A clear trend therefore could not be established for these results.

The baseline study hints at a positive influence of self-monitoring on the amount of smartphone unlocks per day. It also shows a correlation between the decrease in smartphone pickups and the increase in work efficiency. However, it must be mentioned that the data from the mini-questionnaires can be prone to human error. Although a daily notice for the questionnaire was send (almost) every day, participants sometimes forgot to fill in the questionnaire at the same day as they filled in the daily diary. It can therefore be possible that some filled questionnaires did not represent the correct data due to an uncorrelation between the actual level of efficiency and distractions on a specific day and what they remembered from it the next day or the day after. I also believe that in order to discover trustworthy trends, the length of this study should have been longer.

Longitudinal Field Study

The initial quantitative data analysis of this longitudinal field study was supposed to be a comparison of the amount of measured unlocks from the silent mode and the constant mode throughout the whole duration of the study. The gathered results from the field study however turned out to be more difficult to compare with each other and with the baseline study as initially expected. This had several reasons which will be explained using Figure 8.

As aforementioned, participants of the field study where specifically asked to only use CODI when they were actually working. In figure 8 you will see the data of participant 2 who happened to work 8 days during the first round. 8 days of use during round 1 was also measured for participant 1. The other four participants either used CODI 4 days (3 participants) or 6 days (1 participant). Next to a strong variation in days of use, there are also strong variations in terms of usage duration. The time between the first and last pickup on the 4th day of using CODI for participant 2 was 9 hours. Six days later on the

7th day of using 3 hour and 16 minutes. On this 7th day, there was however a break between unlocks recorded that lasted 2 hours and 14 minutes. Many of these breaks have been recorded and it is unknown whether these were actual breaks or periods in which participants were focused on their work for a longer period of time then average. In the semi-structured interviews, participants did however mention that sometimes they forgot to unplug during work breaks or that they forgot to use CODI at all on several occasions.

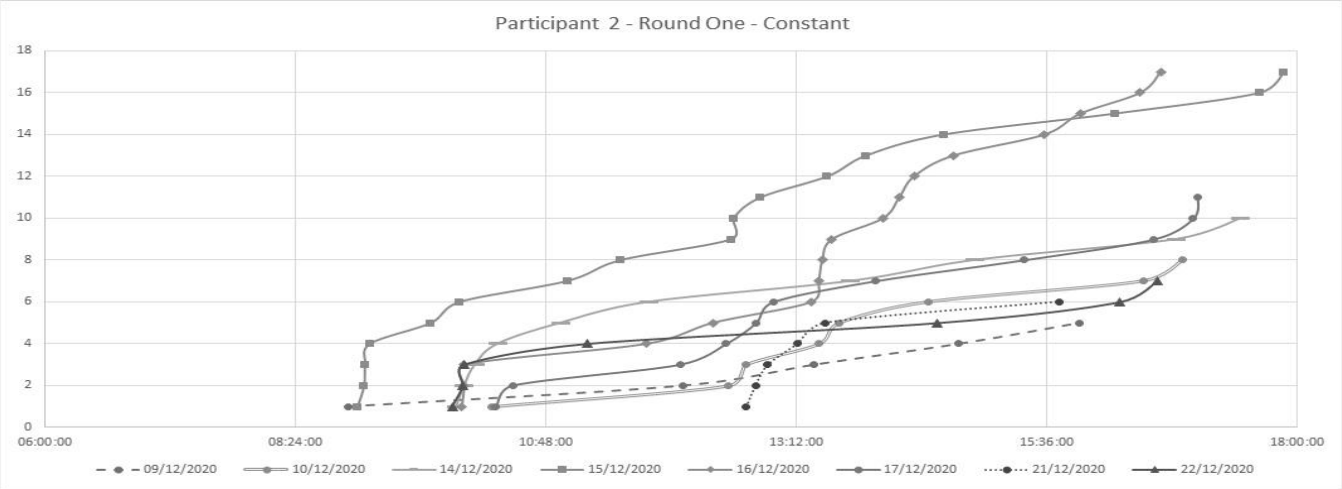

Figure 8: Unlocks per day of participant 2.

Since the amount of unlocks per day could not be properly compared with each other and with the results of the baseline study, the time between the unlocks was investigated over the course of the study for participants 1, 2 and 3 since they were the only participants who experienced both conditions. This data can be seen in Figure 9. Intervals longer than one hour are perceived as breaks and are not factored in.

Figure 9 shows the average intervals in minutes for any given day that participant 1, 2 and 3 used CODI. However, these days were not all consecutively. There are days in-between in which the participants either didn't work or they forgot to use CODI. The influence of these days are hard to measure and require further research. It is also important to note that the listed days in Figure 9 are based on the days of use. This means that day 3 for participant 1 was on the 12th of December but for participant 2 this was on the 14th of December. All three participants started with the constant mode and finished with the silent mode. The figure shows that the average intervals in general are longer in case the auditory feedback was present when participants took their phone out of the device. This results in a longer period between smartphone unlocks which would suggest a decrease of

smartphone distractions during the day. Since there are less days of use measured for the silent variant, more research is required in order to confirm this finding.

Although the baseline study was designed to measure the amount of smartphone unlocks and not the duration of the intervals between the unlocks, an average interval could be calculated since the variables time, 09:00 to 17:00, and amount of unlocks were known. In this calculation, an average lunch break of 33 minutes was included in the calculation [48]. This data has been plotted against the data of Figure 9 and can also be seen in Figure 9. The figure shows clearly that the intervals between smartphone unlocks during the baseline study averages around 10 minutes (10 minutes and 29

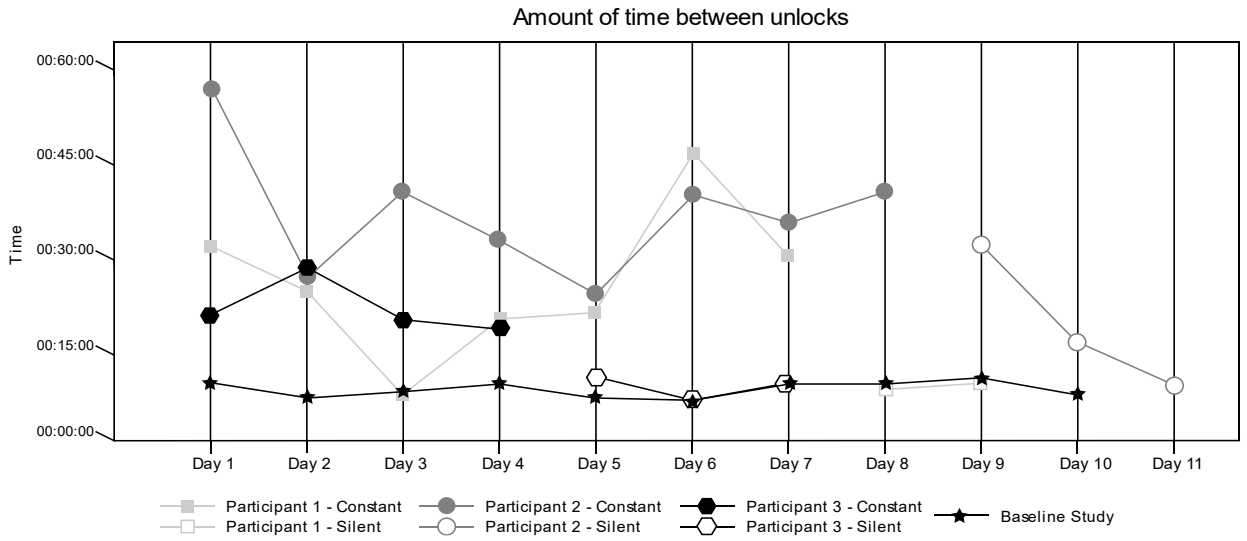

Figure 9: Average intervals between unlocks.

seconds to be exactly). In order to properly compare the data and determine whether there are any statistically significant differences visible between the datasets, the data needed to be thoroughly analyzed. First an ANOVA with repeated measures was performed. In this analysis, the use of CODI with and without auditory feedback were the two independent variables and the interval duration between smartphone unlocks was the dependent variable. This study used an average of all datapoints from the three participants per round in order to create a larger dataset for the Silent variable. The results are shown in Table 3.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
IntervalTime	Wilks' Lambda	0,740	2.817[b]	1,000	8,000	0,132

a. Design: Intercept
Within Subjects Design: IntervalTime

Table 3: Overview of repeated measures ANOVA results.

Table 3 shows that there is no statistically significance (Sig. > 0,05) for the differences in the interval duration between the use of the two conditions of CODI. Another repeated measures ANOVA was performed with different independent variables: (1) the baseline study and (2) the use of CODI with the auditory feedback. The dependent variable remained the same: interval duration. The results of this analysis can be seen in Table 4.

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
IntervalTime	Wilks' Lambda	0,294	21.579[b]	1,000	9,000	0,001

a. Design: Intercept
Within Subjects Design: IntervalTime

b. Exact statistic

Table 4: Overview of repeated measures ANOVA results.

Table 4 shows that there is statistically significance (Sig. < 0,05) for the differences between the smartphone unlock interval times of the baseline study and the use of CODI with auditory feedback.

The statistically insignificant outcome of the first repeated measures ANOVA in Table 3 may be influenced by the small amount of datapoints, i.e., days of use, of the silent variant of CODI. An increased sample size, i.e., more days of use of the silent variant, should result in more reliable results with greater precision and statistical power. In the researcher's opinion, the sample sizes of both conditions should be larger in order to make a conclusive statement about the influence of the designed sound on the smartphone unlock behavior. The second analysis in which the more reliable outcomes of the baseline study, in which there was no auditory feedback, was compared with the use of CODI with auditory feedback, hints however at a change of behavior as a result of the implemented sound. However, it is hard to determine whether this indication of behavior change resulted solely due to the sound or if the use and design of CODI, an ambient artefact, also formed a physical barrier that influenced the users' behavior. In order to shed a light on whether the measured values match the participants' experiences in using CODI, the insights of the six semi-structured interviews are described in the Qualitative Results section below.

Qualitative Results

6 semi-structure interviews were done, with each consisting of 10 prepared questions (Appendix B). A variety of non-prepared questions have been spontaneously asked based on the answers of the participants on the prepared questions. 56 quotes distilled from these interviews were divided among 4 clusters, namely *Awareness* (20), *Physical Interaction* (15), *Sound Interaction* (13) and *Task Delegation* (8). In this section, the findings from each cluster will be briefly elaborated.

Awareness

This cluster focuses on statements about the awareness of the participants' smartphone usage. As mentioned before, the goal of this study was to see if the use of auditory feedback would create awareness for smartphone unlock behavior which in turn would effectuate behavior change. Not only did users mention the impact of the auditory sound on their awareness, they also mentioned the impact the physical action on its own had on it.

"What I noticed the most is that my awareness about my smartphone usage increased by just using the device"

"I really believe that this form of feedback worked very well for me. I don't know if this had led to a decrease in my usage but at least you are now aware of it"

However, several users mentioned that after using CODI for a longer period of time, the willingness to act according to their level of awareness slowly started to fade away.

"Although I knew I should, at a certain moment, the urge to put my phone back into the device after using it became smaller"

"In the beginning, CODI had a real influence on my life. It was really like: I should not take my phone because it is placed in CODI. After using CODI for a while, I started to care less. The newness faded away and CODI blended into my surroundings"

Physical Interaction

In this cluster we will describe how participants physically interacted with CODI and what the effects and reactions on its use were. The interviews clearly showed that the participants liked the fact that CODI was a physical artefact that was located at one specific spot on their desk.

"I really liked the fact that I had a designated spot for my phone"

"Normally I often forget where I placed my phone when I need it, CODI gave me a fixed place to put away my phone. This was nice"

Participants also mentioned that the presence of CODI and the fact that their phone was placed in it formed a physical barrier which required extra effort in order to use your phone.

"The idea that my phone was placed in CODI raised the threshold to take it out again which increased my workflow"

"When I realized my phone was placed in CODI whenever I felt the urge to take it, I thought: nevermind, I will take it later"

As aforementioned, CODI was also designed in order to cover a smartphones' screen. However, a variety in phone sizes impacted CODI's cover abilities. Since people were afraid for scratches when they placed their phone with the screen down in CODI, it resulted that in some cases participants could still see their touchscreen light up whenever they received a notification. Since they were not able to tell by a quick look who send it or what it was, they could not quickly rate the notifications' importance. Two users mentioned that this even increased their urge to watch.

"Because you see your screen light up but you don't see what notification it is, you start thinking: can it be something important, which for me increased the urge to watch, just to be sure I didn't miss something important."

Sound Interaction

A second trend participants mentioned was about their interaction with the auditory feedback and how they perceived it. Participants generally found the presence of the sound to be pleasant and positive. One participant mentioned that he even missed the sound when he switched to using the silent condition.

"When I have to compare the round with the auditory feedback to the silent one, I think that getting a sound is definitely better for me. It was for me also a reminder that I had to place the phone back"

"It was an acceptable sound, not disapproving, not approving."

"I was used to getting the sound, so when I used the silent variant I started to miss the sound"

The constant variant of CODI was only designed to give auditory feedback, or any feedback whatsoever, when the phone was taken out it. However, some participants mentioned that they would have appreciated it, if they received some sort of feedback in other cases too.

"Because you didn't receive any feedback while using the silent variant, you also didn't know if the device was still working. Which I found to be unpleasant sometimes"

"I only received feedback that the device was still working whenever I took it out. Would have been nice if you also received feedback when you put it back in or when it was correctly placed in the holder"

Task Delegation

An interesting finding was that participants started to delegate tasks they would normally do on their phone, to their computer/laptop. Participants switched from using WhatsApp on their smartphone to using the web-based variant of it. One participants mentioned that because he could type faster using the web-based variant he had the feeling that he spend less time on his phone. Another participant mentioned that if he decided to reply using WhatsApp Web, he did not get distracted by other notifications and social media as normally the case was when replying using his smartphone.

"Whenever I used my smartphone to reply, I normally was distracted for a longer time because I got mixed up in other notifications. I felt that this was less using the web variant of WhatsApp."

"Because I type quicker on my laptop I spend less time replying which I think had a positive impact on my productivity"

6.DISCUSSION

Interpretation of Results

This section will answer the research question formulated through an analysis of the findings of the qualitative and quantitative data.

RQ: *Can auditory feedback effectuate a decrease in smartphone distractions in the home office environment of young teleworkers?*

Looking at the results, the researcher believes that these support the original hypothesis in which was stated that giving auditory feedback whenever a user wanted to use their smartphone would result in a decrease in distractions since a sense of self-awareness for their own behavior would be created. Although most participants indicated that their awareness about their smartphone usage considerably increased, they couldn't tell if or how much their smartphone usage decreased (See *Awareness*). The quantitative data retrieved by CODI on the other hand indicated that a change took place. Although the amount of smartphone unlocks was hard to compare, the time intervals between unlocks was found to be the most representable to analyze for this study. Although the data shows statistical insignificance (Sig. > 0,05) between the two conditions of CODI, a comparison of the results of CODI with auditory stimulus with the baseline created a statistically significance favoring the use of sound as feedback in order to change behavior. Most participants mentioned that both the physical interaction and the auditory feedback influenced their awareness (See *Physical Interaction, Sound interaction, awareness*). It therefore is harder to pin down whether the measured behavior change in comparison to the baseline study is effectuated more by the physical interaction users had with CODI or by the auditory feedback they received. Although the study reports a positive influence on the interval duration during pickups, a longer study is needed to measure the long term effects. This is mainly since

participants noted that they started to feel like the urgency of ignoring notifications and not interacting with their phones started to fade away (See *Awareness*) at the end of the deployment phase. A longer deployment is necessary in order to measure the long-term effects of this phenomenon on smartphone distractions in the home office.

Boundaries

Probe Design

Although putting many thoughts into the design of the probe, it's function, namely, that it should be non-intrusively measuring as much data as possible whenever participants took out their smartphone and was able to give clear auditory feedback, was predominant in this study. Since eight identical artefacts needed to be made with limited time and resources available, the researcher made the choice for a "good-enough" approach. During the design of the probe, it was assumed that due to the measures as a result of the corona virus, participants would only work from home. CODI was therefore programmed to be able to connect with only one Wi-Fi network. In the weeks after however, the participants seemed to started working at the university more often which made it harder to collect as much data as possible since there was no time left to make changes in the code. Therefore they were asked where they worked the most days in a week. When the answer was "my house" or "the university", their personal probe was designed to connect with that specific Wi-Fi network. However, if they worked at two different locations during the week, the expected dataset would automatically decrease in size since this would result in less days of usage. Furthermore, since it was a within-subjects study, the device conditions needed to be swapped in the middle of the study. First this was tried online. The researcher tried to guide the participants through the different steps that needed to be performed in order to upload the code of the other condition. This however only seemed to work for one participant. All the other seemed to experience difficulties. Therefore the researcher had to visit every participant in person, with proper measures, in order to switch conditions. It might therefore be convenient for future research to program an automatic condition switch based on dates.

Data Gathering

Since the study originally was designed in order to analyze the amount of smartphone pickups during a workday, it didn't measure the amount of time you spend on your phone after unlocking it. This study shows positive findings when it comes to the intervals between pickups but it's unknown how this interval was divided in terms of activity. It can for instant be that the participant just took a quick look and then put it back in the holder for 15 minutes before taking it out again. On the other hand it is possible that the participant looked at their phone for 15 minutes, placed it back and instantly received another notification which initiated another smartphone session.

7.CONCLUSION

Although recent research on it seems to be lacking, studying distractions in the home office environment is still relevant today, possibly more than ever. Since the introduction of the smartphone, a whole new world of distractions are formed which theoretically merely exist digitally, but seemed to have found its impact in the physical world. This study aimed at exploring how to auditory feedback can decrease the impact of these distractions by making young teleworkers more aware of their smartphone unlock behavior. Ten participants first performed a baseline study in which the amount of daily smartphone unlocks was measured. This study was followed up by a longitudinal field study of three weeks with six participants. During this field study a research probe has been deployed in the home office environment of the teleworkers to measure the amount of smartphone unlocks. After the field study, all six participants where interviewed using a semi-structured approach in which they were ask to elaborate on their experiences using CODI. Based on the gathered data, the researcher can conclude that the use of auditory feedback has potential for effectuating a change in smartphone unlock behavior of young teleworkers. Since participants of the baseline study did not used the probe, the exact impact of the sound design, as percentage of the total impact of the probe, however was hard to determine. The researcher however believes that this study offers insights in the opportunities of using auditory in order to decrease smartphone distractions and in behavior change in general.

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APPENDIX

A – Mini-Questionnaire

1. Did any unusual events influence your phone usage today?
2. How would you describe the amount of phone based distractions during work today?
    - Extremely distracted
    - Highly distracted
    - Moderate distracted
    - Slightly distracted
    - Not at all distracted
3. How efficient was your workday today?
    - Extremely efficient
    - Highly efficient
    - Moderate efficient
    - Slightly efficient
    - Not at all efficient

B – Interview Questions

These questions were asked in dutch (●), and translated to English (○) for the purpose of this paper.

- ● Hoe heb jij het gebruik van CODI ervaren?
- ○ *How did you experience using CODI?*
- ● Ben je het ook wel eens vergeten om je telefoon erin te stoppen? In het geval van ja: wat was je gevoel en reactie toen je dit realiseerde?
- ○ *Did you forgot to place your phone in CODI sometimes? If yes, what was your reaction when you noticed this?*
- ● In welke van de twee onderzoek rondes gebeurde dit naar jouw gevoel vaker? Bij de stille variant of bij de variant waarbij je getriggerd werd door geluid?
- ○ *During the use of which condition did this occur more often in your opinion?*
- ● Waren er bijzondere momenten die je zijn bijgebleven?
- ○ *Are things happened during the course of using CODI which you specifically remember?*
- ● Vond je het prettig om CODI te gebruiken? En waarom?
- ○ *Did you like using CODI? And why?*
- ● Veranderde de actie zelf jouw bewustzijn omtrent het gebruik van je smartphone tijdens werkuren? Waarom wel/niet en hoe?
- ○ *Did the physical action on it's own change your awareness regarding the amount of smartphone distractions during your workday? Why and how?*
- ● Wat was jou gevoel toen je je telefoon eruit haalde en het geluid hoorde?
- ○ *What reaction did you had when you took out your phone and you heard the sound?*
- ● Wat vond je van het geluid en waarom?
- ○ *Did you like the sound and why?*

REFLECTIONS

Before the start of this project, I felt a bit overwhelmed by the status a research project had within the master because design research is where the department of Industrial Design stands for. The fact that for the first time during this master, I could not rely on group members for mutual support made me have to get out of my comfort zone. For me this seemed to be really beneficial when it comes to developing my existing and learning new skills. Since I was the only designer on my team, I had to do everything myself. I therefore was able to shape and form this project in a way I wanted it to be. Well not quite how I initially wanted it to be, but as close as I could taking the restrictions laid upon all of us in consideration. I was able to explore topics which closely related to my vision and interests. I feel the urge to design for social impact. How can I really make a change in the lives of people. During the early phase of this project, I also thought in such a way in order to find something that was a societal problem but was still researchable. Not only based on my own experiences, but also based on the stories of people I talked to. Friends, family, my fellow students and my coach, Bart Hengeveld.

While exploring several selected topics, I really learned to revise and refine research scopes and how to gain a good overview of the research areas by exploring existing related theories and work. My final research topic as described above was the outcome of the this exploration. Since I personally also relate to this topic, it sparked my own enthusiasm to investigate the impact of a possible solution: auditory feedback.

In order to gather as much data as possible, as much participants as possible needed to be used for this study. Due to only a specific amount of time left for this final deployment. It was necessary to design the probe in such a way that it could be recreated as quickly as possible. Several iterations of my research artefact have been made. I really tried to keep it as simple as possible by narrowing it's functionalities down to the basic necessity of being able to measure distance and give auditory feedback when needed. As a very practical and hands-on fellow, the building phase was something I looked

forward to. Not just the physical building but also the electronics an programming part. I knew this was going to be a challenge since these where not my best developed fields of interest. Until this project, I somehow focused on different parts of a project whenever similar work had to be done in a group project. As aforementioned, this project made me step out of my comfort zone since I had to do everything myself. I sat many hours in the d-search lab creating the PCB and the software for the artefact. I experienced that when you really dug deep in the matter, it was actually easier than I thought. Not easy in a sense that I learned everything in one day and build it the next day but easy in a sense that it could all be narrowed down to basic principles and human logic. It really opened a world for me. The help of other's who where far more experienced than me helped a tremendous amount as well but the learning curve in my opinion was the steepest when I explored this world myself. It however took a little longer than expected to create the final prototype. At that time seven more had to be recreated. This really learned me to be flexible in my research and to look for solutions that would not impact the quality of my research.

Research used to be my least favorite part of design. But since I now know what performing design research can accomplish and what it entails, my appreciation has grown. Not only my appreciation for research but I also feel that I've grown as a designer. I've learned to apply the skills I already have in a totally different and new context. A context which pushed me to learn new skills and showed me the importance of always being able to substantiate your design choices on existing theories or literature. I must say that I enjoyed the process and that I look back at a successful project.