Pen-pen: a wellbeing design to help commuters rest and relax

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Pen-Pen: A Wellbeing Design to Help Commuters Rest and Relax

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ABSTRACT

We report on the design process and evaluation of *Pen-Pen*, which is a design combining a neck-cushion, a mobile app, and a multi-modal feedback loop to help commuters relax and rest during commuting hours. The design process of *Pen-Pen* includes a series of inquiries, which identified "support for relaxation" and "location based arrival notification" as desires of commuters, and "mindfulness" and feelings of "autonomy" as relevant determinants of commuters' wellbeing. We evaluated *Pen-Pen* in the field with five commuters, and through an online survey with 68 participants. Our results indicate that using *Pen-Pen* has the potential to increase feelings of rest and autonomy, and to foster mindfulness through the feedback loop which feeds back spatial audio based on user location and finger touch. Especially commuters who reported to be less mindful and easily stressed anticipate *Pen-Pen* to be useful for them.

CCS CONCEPTS

• **Human-centered computing** → *Auditory feedback*; Field studies;

KEYWORDS

Commuting, Positive Computing, Wellbeing

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1 INTRODUCTION

Over the years, commuting distances and the number of commuters have been increasing in many countries. For example, in Germany about 60% of employees commute, with the average commuting distance increasing between the years 2000 and 2015 by 21% [9]. A study analyzing data from the German Socio-Economic Panel from 1985 to 2003 found a clear correlation between commuting time and general satisfaction. People who commuted 22 minutes per way, which was the average commuting time back then, were on average less satisfied with their lives [15]. Despite its negative effects, many people still have to commute due to limited availability of appropriate housing and job options.

In order to improve commuters' wellbeing, we have decided to follow a *Positive Computing* [5] approach, which advocates to develop software by addressing a subset of specific wellbeing determinants throughout the design process, such as mindfulness, resilience, or empathy.

In this paper, we describe *Pen-Pen*, which aims to help commuters to gain control over desired relax and rest routines during commuting times. Based on ideation sessions and six contextual inquiries we identified mindfulness and autonomy as the relevant determinants for commuters' wellbeing, and used them to continuously inform the design of *Pen-Pen*. Furthermore, we report on an evaluation of *Pen-Pen* based on a field study (see Figure 1) and an online survey, considering the wellbeing determinants mindfulness and autonomy, and also exploring (anticipated) usefulness of the design. Out of all participants of the online study, mostly those who scored low on mindfulness (which was established based on self-reports) were interested in using *Pen-Pen*. Four out of five participants of the field study thought using *Pen-Pen* consistently would slightly improve their mindfulness and autonomy. All five participants could see themselves

Figure 1: Interviewing a car commuter during the field test.

using *Pen-Pen* in the future. The positive effects of the app on wellbeing were clearly increased by the (physical) neck cushion and the kind of embodiment that it facilitated.

In the next section we present the relevant related work and describe the terms and technologies that serve as background for our work. We then describe the ideation and information gathering process that led to our design, followed by a presentation of our prototype and implementation. Finally, we report the results of our evaluation, consisting of a survey and a field study, and discuss these results.

2 BACKGROUND

The impact of commuting on people's subjective wellbeing was studied by Chatterjee et al. in 2017 [6]. They evaluated data from 26.000 workers living in England between 2009 and 2015. Their analysis showed that an increase in commuting time reduced wellbeing, since it decreased job satisfaction and leisure time satisfaction while increasing strain. Only active commuting like walking and cycling increased leisure time satisfaction. While long commuting times had a more significant negative effect when using the bus, trains were more suitable for longer journeys. Long commutes had a smaller effect on job satisfaction of workers who were under 30 years old or people with lower income. This might be due to a higher acceptance of long commute times within this group. Employees' attitudes towards long commute times were also influenced by the extent to which they felt able to choose where they work.

It is often assumed that people choose to commute because they get compensation, such as a better job or housing. However, Stutzer and Frey [15] found that the disadvantages of commuting seem to outweigh the advantages. Evaluating data collected by the German Socio-Economic Panel showed a significant negative effect of commuting. Longer journeys to and from work lead to significantly lower subjective wellbeing. People might still choose to commute because they overestimate their ability to adapt to the daily stress caused by commuting. They concluded that further research is needed to fully understand people's decisions with respect to housing, job search and commuting.

A study by Ettema et al. [8] investigated how activities performed while commuting affected commuters' satisfaction with travel. Talking to other passengers had a relaxing effect, but only on the way home in the evening. This positive effect seemed to depend on the commuters' mindset. People who engaged in activities related to entertainment and relaxation were less satisfied with their travel. This suggests that these activities are chosen due to boredom or stress and cannot fully balance out those negative emotions. To actually improve their wellbeing, commuters who chose these activities during their travel seemed to need some form of support to make their activities more relaxing. Working or studying during a commute had no effect on satisfaction. These activities might however make other parts of a commuter's life more pleasant.

One way to address stress is mindfulness-based stress reduction therapy (e.g., [12]). Fellow researchers have investigated how biofeedback and technology design can be utilized for mindfulness practices (e.g., [1, 10, 13]). In contrast Niksirat et al. [14] developed a framework using the attention-regulation process. They encouraged users to perform slow, conscious movements on the screen of their smartphones while being provided with visual feedback and soft sounds which are supposed to help recovering from mental fatigue. Evaluations showed that this increased their attention and improved mood and general wellbeing. These positive effects were even achieved in busy environments. Therefore, the app can be used during everyday life, for example while waiting for an appointment.

Positive Computing

While the presence of technology in our lives has increased greatly during the last decades, overall happiness remained roughly the same [5]. As the use of computers and technology started mostly in the workplace, traditional software design focuses on productivity, efficiency, speed and accuracy. Software engineers believed that improving these factors would result in an increase in happiness for the user. However, results from psychology showed that this assumed correlation is rather small.

In contrast to this traditional approach to software design, Rafael Calvo and Dorian Peters [5] suggest an alternative which they call *Positive Computing*. It eliminates the desire to optimize productivity and other proxies and focuses on improving wellbeing directly. To achieve this, it combines

research from various other areas such as psychology, human computer interaction, education, and design.

To simplify designing for the vague terms wellbeing and happiness, Calvo and Peters [5] present several wellbeing determinants, specific factors that were shown to increase wellbeing. In our project we address two of these factors: autonomy and mindfulness. Ultimately, the assumption is that by improving these factors, general wellbeing can also be improved. Autonomy can be measured by the *Index of Autonomous Functioning* created and evaluated by Weinstein et al. [16]. Mindfulness is a state of concentration that is created by concentrating on what is happening at the moment, which can be measured by the *Mindful Attention Awareness Scale* from Brown et al. [4].

Commuting

Commuting describes the task of regularly traveling between different places, often between home and work or school. There are various reasons for commuting, such as a difficult housing market, better job opportunities or the wish to spend time with family. Research has shown that commuting has a great impact on daily life patterns by reducing sleep and leisure time. The car as mean of commuting is often chosen with an underlying desire for control. However, it was revealed that driving by car does not increase commuters' influence over their situation [11].

Public transport is mainly chosen by commuters because of its lower costs. On the other hand, this mode of transportation was shown to be the most troublesome because of idle waiting times, more changes between vehicles and frequent delays, which lead to a late arrival at work. Inside a train or bus the commuters were often in discomfort, due to the vehicles being overcrowded and noisy. Active forms of commuting such as biking or walking were shown to have a positive impact on satisfaction with leisure time. Unfortunately, active commuting is usually not possible or undesired for longer range commutes because it would take up too much time [7].

In order to improve the commuting experience of people who cannot use active forms of commuting, we focused on passive commuters, especially passengers in a car or train who don't have to concentrate on driving and can use their commuting time for other activities.

3 IDEATION

We started the design process with an open ideation workshop brainstorming aspects that influence people's commuting experiences. These aspects were categorized into thematic groups such as "vehicle choice", "reasons to commute" and "stress creators".

As determinants for wellbeing a basic set of 14 factors was available; i.e., autonomy, compassion, competence, engagement, meaning, motivation, positive emotions, relatedness, resilience, gratitude, empathy, altruism, self-awareness, and mindfulness. First we identified 10 of these factors as potentially relevant for commuters. We then randomly combined several aspects from different groups along with the factors and tried to generate stories about how these factors are impacted by the chosen aspects. This gave us a first impression to the domain and on how different details can influence a commuter's experience both positively and negatively.

In a second workshop we created a mind-map of goals and issues which commuters face during and around the commute. We collected ideas on how to counteract these problems or support the commuters at achieving their goals. There were several issues like delays or accidents that could not be solved with technology. We decided to concentrate on problems and goals that we could positively influence and used the resulting mind-map as a guideline for following field observations and interviews.

4 CONTEXTUAL INQUIRIES

In order to inform our designs by, for example identifying common problems and possibilities to improve the wellbeing of commuters, we explored how commuters feel, act, and interact during and around commuting.

To this end, we chose to use the contextual inquiry method. In a contextual inquiry the interviewer accompanies the interviewee directly within the investigated tasks [3]. These interviews give a more realistic insight into their habitual and unconscious actions and motivations as opposed to letting the interviewees recall their day-to-day actions in a traditional interview.

Interview Design. Contextual interviews are set to be relatively open. Instead of going through a fixed questionnaire, the interviewees talk about their tasks. The interviewer is responsible for guiding the interview to keep a focus on things relevant for the project. To achieve that, we prepared a set of questions targeting the 14 different principles of *Positive Computing*. Here, the problems and goals from the ideation process were used to find questions that could trigger recent memories. For *Gratitude*, we asked the interviewees to describe the last situation in which they felt grateful. We also let them describe what they would usually do while commuting to see how engaged they were in commuting. Overall, the questions were not meant to be used as a questionnaire but more as a tool to support the interviewer. Not every question was asked in every interview. To get a general idea of the interviewee, we also gathered some general information about the commuters, for example their age, gender and how often and how long they commute.

Interviewee Selection. In our interviews we targeted a diverse group of commuters. We interviewed six people. Four used public transportation, one usually traveled alone by car and one was a member of a carpool. They had different reasons for commuting. While four of them commuted to university, one had to get to work. One commuter also drove to see his family every weekend. All commuters made the conscious decision to commute because they preferred to stay closer to family members and friends, or because they simply could not find a better place to live. The time they spent commuting daily ranged from about 30 minutes to over two hours. By interviewing this heterogeneous group, we hoped to gain insights on the advantages and problems of commuting without limitation to a certain mean of transport.

Consolidation of Observations. We gathered several similarities between commuters through our interviews. The commuters we interviewed often did not complain about stress, instead they seemed to be relatively relaxed when being confronted with delays or disturbances. Thus, most of them already planned for the common, regularly occurring delays, because they were aware that they could not change them. Only significant delays, caused by accidents or similar severe and unforeseen events, were named as bad experiences. In these cases, the commuters had no possibility to improve their situation. They could not switch to any other form of transport and did not know how long they would have to wait. This complete loss of control was perceived as very negative.

We observed them having become accustomed to their regular commuting schedules and rarely reflecting on or changing long optimized decisions like departure time or route choice. Many of the interviewees told us that they had little interest in interaction with their fellow commuters. A student explained that he would just sit down and not pay attention to any of the other passengers. One commuter even strongly opposed more contact with others and stated that people who started talking to him on public transport were often really intrusive. However, when asked about helping other commuters in the context of compassion, some remembered moments where they were delighted by the chance to help unacquainted commuters. One was happy to lift suitcases or assist with finding the right train ticket within a bulk of emails, because he could improve the day of his fellow travelers. Overall, the commuters did not mind short interactions with others, if they could spend the majority of their commute by themselves. The train commuters told us that they often used their daily commute as a resting place to wind down from university or work.

To communicate these findings within the team we created personas, descriptions of typical commuters that match the impressions we obtained from the contextual inquiries. To keep our broad view on the commuters we created a persona for each mode of transport: car, bus, and train. We utilized the personas to derive our prototype and to ensure our design matched the needs of our target audience.

5 PROTOTYPE

In sum, the contextual inquiries identified "support for relaxation" as a key desire of commuters. Therefore, we decided to physically and digitally assist commuters in creating a quiet space.

The neck cushion supports the head and neck of the commuter (see Figure 2). A removable hood can be used for shielding against outside sounds or cold breezes, which might be caused by air conditioning in some vehicles. If a commuter wants to take a nap, they can put on a sleep mask which can be attached to the back of the hood. *Pen-Pen* also features inear headphones, which can be used to cancel out or dampen surrounding sounds or to play music.

The app that belongs to *Pen-Pen* has two main features, the first being a location based alarm clock, where users can select their destination on a map. By default, the alarm will go off one minute before the expected arrival. If a user wants to be woken up earlier, they can configure the app accordingly. The wake-up time is calculated by accumulating the vehicle's speed during the last minute and extrapolating an expected arrival time from that.

The second feature is a relaxing sound game designed to increase mindfulness. Salehzadeh Niksirat et al. [14] showed that repetitive, slow motions with corresponding feedback stimulates awareness and increases mindfulness. Within the sound game in our app a user has to slowly move their finger across the screen. The position of the finger directly translates to the 3D-position of the relaxing music the user hears. To ensure slow finger movement, the phone vibrates and warns if movements are too fast. In addition, the volume will decrease if the user does not make a constant slow movement. To avoid contradicting the commuter's natural feeling of the vehicle accelerating and decelerating, the music also adapts to the current velocity of the surrounding, in this case the commuter's vehicle. This causes the pitch of the music to change whenever the vehicle's speed is increasing or decreasing. The described feedback loop is intended to improve the relaxing effect the app has on the commuter while improving their mindfulness.

6 IMPLEMENTATION

The *Pen-Pen* app is a native Android app which was built with *Android Studio*. We use Google's PlacePicker of the *Places SDK for Android* to select the target of our location based alarm clock. To retrieve the current position and speed of the user we use Android's *LocationManager*. The speed is cumulated over time so that sudden changes do not unintentionally

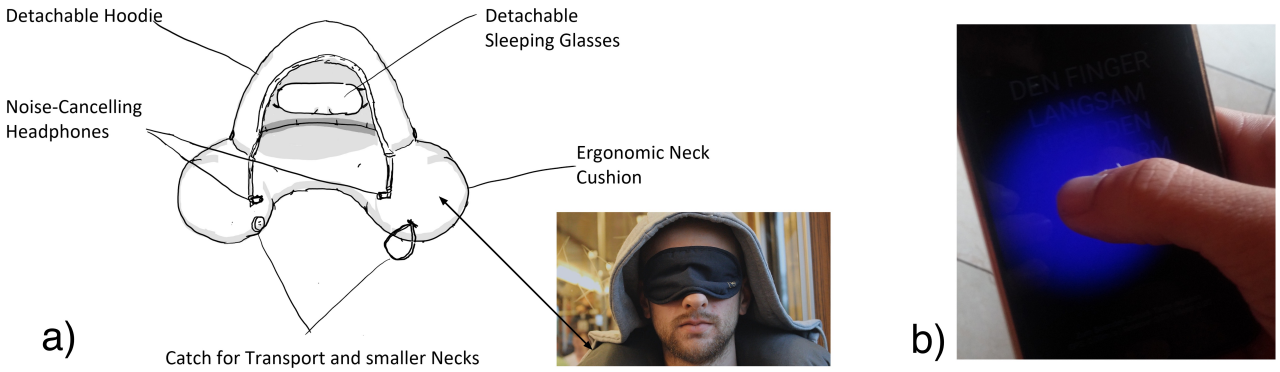

Figure 2: a) The parts of the *Pen-Pen* neck cushion and b) Mindfulness training with the Pen-Pen App

trigger the alarm. The *LocationManager* is wrapped in a foreground service, which sends a GPS update via Android's *LocalBroadcastManager* to the Activity. This is necessary to prevent the app from being stopped if the user puts the app in the background. On every GPS update, the Activity recalculates the distance and the approximate time needed to reach the target with the cumulative speed. We trigger the alarm if the following formula becomes true:

$$distance \leq cumulativeSpeed \cdot wakeupTime$$

The relaxing sound game uses *Resonance Audio for Android Studio* which is developed by Google and available for many other platforms. The central part is the *GvrAudioEngine* which creates a virtual audio room by rendering all sounds over 16 virtual loudspeakers arranged around the listener's head. We play two audio files at a time with different volume levels. One file has half the frequency of the other file, meaning it is one octave lower. We set the volumes of the higher and lower audio files by retrieving the current speed with GPS and cumulating it. A higher speed means that the higher audio file will be louder. With the touch event of the activity we set the positions of our sound objects in our virtual room, left vs. right and front vs. back, by getting the position of the finger on the screen. Additionally, we calculate the average moving speed of the finger to set the main volume. In case this speed is too high we start the vibration with the *VibrationManager*. For all touch and GPS data we store the last n values in an array and calculate the mean to have a smooth experience.

7 EVALUATION

In order to evaluate *Pen-Pen*, considering the *Positive Computing* factors autonomy, mindfulness, and the effect of the two wellbeing determinants on the motivation to use *Pen-Pen* we conducted an online survey and a field study.

Online Survey

This study was focused on commuters aged 18 or older who use cars or public transportation regularly. We mostly wanted to address passengers because they were our primary target group for *Pen-Pen*.

Study Design. The online questionnaire contained four sets of questions. The first set was used to gather general information about the interviewees, like age and time spent commuting. Sets two and three contained questionnaires to measure autonomy and mindfulness of participants. To guarantee the significance of this evaluation, we used established and validated methods: The Index of Autonomous Functioning by Weinstein et al. [16] and the Mindful Attention Awareness Scale (MAAS) by Brown et al. [4]. Using these questionnaires made it possible for us to check whether there was any correlation between the mindfulness and autonomy of commuters and their attitude towards *Pen-Pen*.

Before answering our last set of questions, the interviewees watched a short video introducing *Pen-Pen* and its features. The last set of questions was focused on the concept of our prototype. The interviewees could state whether the concept seemed useful to them, if they could see themselves using any part of *Pen-Pen* and how they thought it would affect them. We also asked for possible extensions and other use cases in a free form field.

Study Results. Our online study had 68 participants, with an equal distribution of men and women. 70% of the them were between 18 and 25 years old, 21% between 25 and 35 years old and the other ones older than 35. 42% of participants claimed that their biggest problem with commuting was the time consumption. 20% would use *Pen-Pen* themselves, but 60% were rather averse. Figure 3 shows our results for the autonomy and mindfulness scales of our participants. The means and standard deviations of all three autonomy

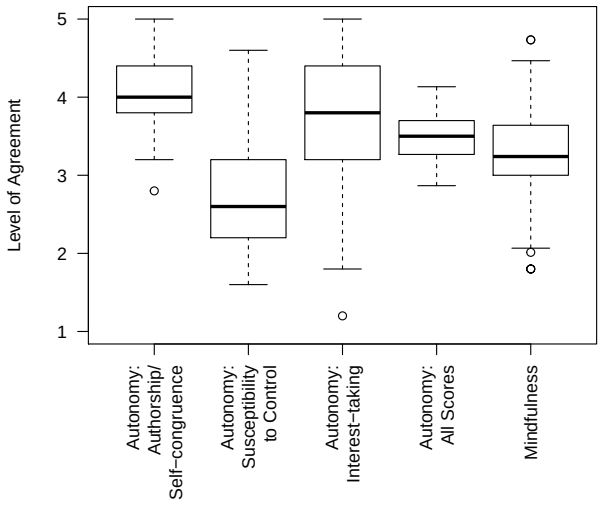

Figure 3: Autonomy and Mindfulness scores of our participants. Error bars denote standard deviation.

categories and mindfulness correspond to the values reported in the two papers that presented the questionnaires [4, 16].

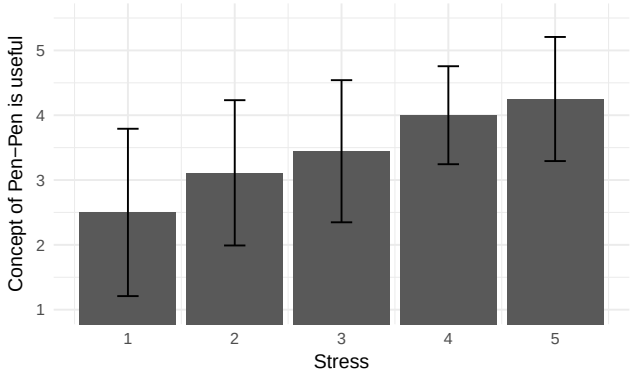

Figure 4: Correlation between how much commuters are stressed and the usefulness of *Pen-Pen*

How strongly people feel stressed correlates with the motivation/willingness to use *Pen-Pen* (see Figure 4). The people who would like to use *Pen-Pen* would recommend it to friends who are stressed while commuting. In addition, the same applies to those who think that their wellbeing would be enhanced by using it or that they have more control over rest and relax times.

Figure 5 specifies the correlation between mindfulness and *Pen-Pen* in detail. Participants expected that *Pen-Pen* would help them to relax regardless of their mindfulness level. However, participants with lower mindfulness were more motivated/willing to use *Pen-Pen* and were more convinced

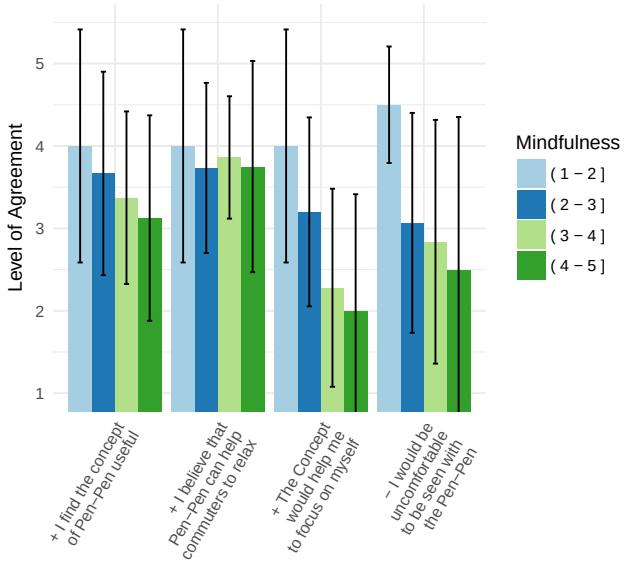

Figure 5: Influence of Mindfulness shown on exemplary questions. Error bars denote standard deviation.

that it would help them to focus on themselves. However, less mindful participants reported that they would feel more uncomfortable when being seen with *Pen-Pen* and they would not use it if they have to carry it to work. Considering these issues, a few participants mentioned that they would prefer an overall better-looking design, such as a design that would fits the style of a business suit/dress.

Overview of correlations between autonomy, mindfulness, and *Pen-Pen*-related questions and stress are illustrated in Figure 6. It seems that Autonomy has only a minor impact on negative aspects of *Pen-Pen* and no ascertainable impact on positive ones. Mindfulness seems to correlate stronger with answers to questions related to *Pen-Pen*. Furthermore, participants who are more stressed while commuting seem to feel more positive about *Pen-Pen*.

Field Study

To find out whether using *Pen-Pen* improves autonomy and mindfulness we performed an additional field study, where five commuters tested *Pen-Pen* while commuting.

Participants. Five commuters aged 21 to 23 participated in the evaluation. Three were male and two female. They were commuting 30 to 60 minutes per way and had been commuting for at least 9 months to up to over ten years. Four of them were commuting as passengers in a carpool. One usually drove by car but was a passenger during our study. In addition to the carpool, two commuters also used different modes of transportation, like tram, train or bicycle.

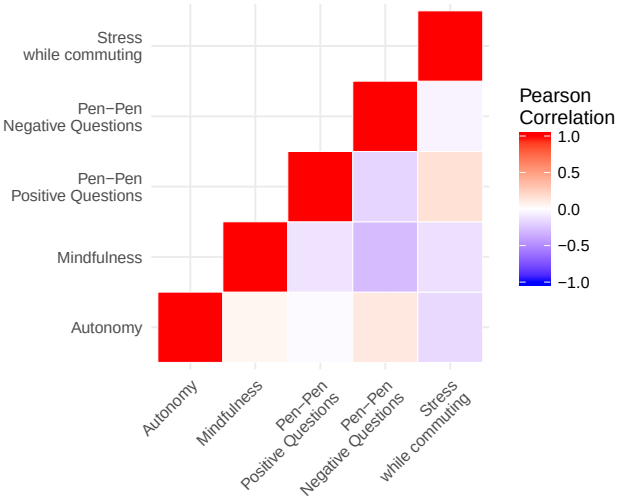

Figure 6: Correlations in our online study

Procedure. The evaluation was performed in the morning while our participants commuted to university. During a first interview, we asked general questions about the commuter and their attitude towards commuting. For example, we asked commuters to describe their usual commute. The commuters also filled out the surveys on autonomy and mindfulness that were also used in the online study. Afterwards, we explained features of *Pen-Pen* to them. At first, they used the app by itself and described their experiences to us. After this first feedback, they used both app and neck cushion. Right after their commute ended, we did an interview where we asked them to talk about their trip and describe how they felt about using *Pen-Pen*. The participants were also asked to fill out the surveys about autonomy and mindfulness again in respect to what they would expect if they used *Pen-Pen* regularly. To evaluate longer-term effects of *Pen-Pen*, we conducted a third interview with the commuters in the evening to find out how they felt hours after using *Pen-Pen*, if they noticed any differences in their day and if they now thought differently about the concept.

Results. Participants stated that they would talk to other members of their carpool, rest, listen to music or do small things on their phones during the commute. Talking to other members of their carpools and relaxing were the most popular activities. All participants said that they would prefer to work during their commute or do something similar to make them feel like they weren't wasting time. Another problem named by three commuters was physical discomfort.

Two participants reported to feel fully immersed when using the app. However, one participant complained that the feedback loop which required constant finger movement resulted in feeling stress. The others felt more relaxed after using the app. All five commuters said that they enjoyed using the neck cushion in addition to the app. The combination of cushion and app was preferred over using the app by itself. A participant of the field study said he felt he could concentrate better on the mindfulness training when being isolated from his surroundings through the cushion, as he was not as easily distracted. Another participant stated that the cushion relieved his neck muscles and thus aided his relaxation. *Pen-Pen*'s modular structure allowed the participants to adapt the cushion to their needs and preferences. All participants could see themselves using *Pen-Pen*. However, the commuter who didn't enjoy the feedback loop was only interested in using the neck cushion and the location-based alarm clock. The commuters who liked the game expected small increases in their mindfulness and autonomy over time because *Pen-Pen* would make it easier for them to relax and fully focus on themselves during a commute. The expected increase can be seen in Figure 7. In the evening all of our participants still had the same opinion about *Pen-Pen* and three out of the five reported that they had felt more relaxed and happy during the day. The other two had felt no difference about their day compared to a normal one. They suggested that *Pen-Pen* would be even more useful for a longer journey and wished for a mechanism to attach it to their bag, so that it would be easier to carry. One participant recommended to add a massage functionality to make our prototype even more relaxing.

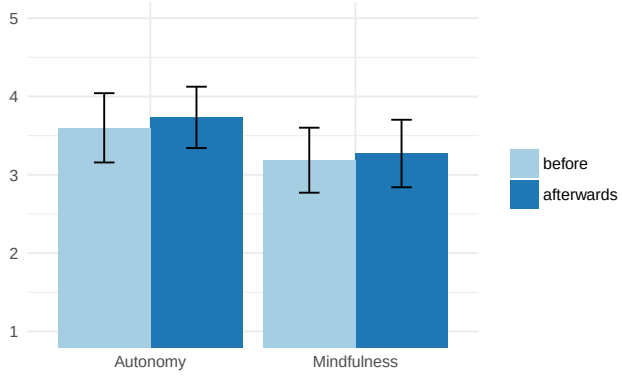

Figure 7: Change of Autonomy and Mindfulness

Discussion

During our studies, participants who scored lower with respect to the MAAS questionnaire, meaning them being comparatively less mindful, showed a higher interest in *Pen-Pen* while also being more likely to use it themselves. A possible explanation might be that these participants can see themselves benefit from a mindfulness training application, while

participants who were already quite mindful see less reason to use such a design.

We found a weak correlation between participants' mindfulness scores and their tendency to feel stressed while commuting. Participants with a strong tendency to feel stressed were more likely to find the concept of *Pen-Pen* useful.

While it is challenging to measure a long-term improvement of wellbeing, four out of five of the participants in our field study expected an increase in mindfulness and autonomy if they were to continue to use our application. We assume increasing mindfulness and autonomy would subsequently lead to an increase in their wellbeing in the context of commuting. This hints towards our design having the potential to benefit commuters in their everyday lives.

In our online survey we deducted that only few people, yet especially the participants with higher autonomy, stated that they would feel embarrassed when using *Pen-Pen* in public. We assume that more autonomous people like to solve their problems on their own, and thus don't want to be seen using an aid. Another explanation for that result could be that more autonomous people might not like being dependent on an app on their smartphone for waking them up.

About 20% of our online survey participants stated that they would actually use *Pen-Pen* themselves, with a high mindfulness value negatively influencing the willingness to use it. Still, most of the participants unwilling to use it suggested additional aspects where *Pen-Pen* could be used. Many could see it being used while traveling by plane, or while waiting in a waiting room or waiting hall.

Implications and Future Work

While around 20% of the participants in the online survey, who only got to see a video explaining *Pen-Pen*, stated that they would use the device, 100% of the participants in our field study, who came in contact and directly used it, said that they would continue using it. We think this disparity origins from the online survey participants not actually seeing and using *Pen-Pen*. Apparently our video does not convey the experience that using *Pen-Pen* does.

As already stated we found hints towards our target group being too narrow, as many of our interviewees and survey participants saw many more use cases for our concept. The scenario, which was used for the surveys, was based on our initial focus on improving commuting. Yet, multiple participants suggested they would possibly use *Pen-Pen* during flights and waiting rooms. We think *Pen-Pen* could also be integrated in mobile and multimodal apps that aim to help tourist while exploring foreign cities [2]. Expanding the target group of *Pen-Pen* and evaluating the effects on, and interests of, non-commuters could serve as a starting point for future work. We found the modularity of *Pen-Pen* to be a positive aspect, as it aided different users by providing the possibility for various usage patterns. Thus, we consider it as an aspect worth keeping for possible future iterations of our concept.

Especially less mindful people found our concept to be useful and had a bigger interest in using it themselves. As further research it would be interesting to evaluate whether a mindfulness training similar to the one with *Pen-Pen* has a greater impact on such people. As mentioned above, reevaluating the device within a broader environment, not limited to only commuting, and testing *Pen-Pen* in different scenarios might also be interesting future work.

Limitations

Wellbeing as well as the wellbeing determinants influencing it are long-term effects, which are hard to measure in such a limited time frame. Therefore our results are based on subjective estimates of the participants on how these factors might change if they consistently used *Pen-Pen*. Also, we told the participants prior to our study that our prototype was designed to improve autonomy and mindfulness, which might have influenced their assessments. To measure the autonomy and mindfulness of our participants, we used two questionnaires that were originally developed and evaluated in English. However, our surveys were conducted in German. We tried to translate the questions as closely as possible.

Furthermore, we only evaluated a small sample of commuters that was limited to students commuting to university by car. Consequently, it is hard to generalize insights to the broader public. Nevertheless we hope that these points did not overly distort our findings.

8 CONCLUSION

We reported on the design process and evaluation of *Pen-Pen*, which is a design that resulted from a "*Positive Computing*" approach, aiming to improve the wellbeing of commuters by improving feelings of autonomy or control and mindfulness. *Pen-Pen* consists of an augmented neck cushion, a location- or time-based alarm clock and a mindfulness training application. Conducting both an online survey and a field study we found that there is an interest in using *Pen-Pen*. Most of the participants of our field study expected their mindfulness and autonomy to increase when using it regularly. It has to be further evaluated whether our concept has an actual long-term impact on commuters and whether it could be applied to other areas.

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REFERENCES

[1] Ilhan Aslan, Hadrian Burkhardt, Julian Kraus, and Elisabeth André. 2016. Hold My Heart and Breathe with Me: Tangible Somaesthetic Designs. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NordiCHI '16)*. ACM, New York, NY, USA, Article 92, 6 pages. https://doi.org/10.1145/2971485.2996727

[2] Ilhan Aslan, Feiyu Xu, Hans Uszkoreit, Antonio Krüger, and Jörg Steffen. 2005. COMPASS2008: Multimodal, Multilingual and Crosslingual Interaction for Mobile Tourist Guide Applications. In *Intelligent Technologies for Interactive Entertainment*, Mark Maybury, Oliviero Stock, and Wolfgang Wahlster (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 3–12.

[3] Hugh Beyer and Karen Holtzblatt. 1997. *Contextual design: defining customer-centered systems*. Elsevier.

[4] Kirk Warren Brown and Richard M Ryan. 2003. The benefits of being present: mindfulness and its role in psychological well-being. *Journal of personality and social psychology* 84, 4 (2003), 822.

[5] Rafael A Calvo and Dorian Peters. 2014. *Positive computing: technology for wellbeing and human potential*. MIT Press.

[6] Kiron Chatterjee, Ben Clark, Adrian Davis, Deirdre Toher, and Adam Martin. 2017. The Commuting and Wellbeing Study: Understanding the Impact of Commuting on People's Lives.

[7] Giovanni Costal, Laurie Pickup, and Vittorio Di Martino. 1988. Commuting - a further stress factor for working people: evidence from the European Community. *International archives of occupational and environmental health* 60, 5 (1988), 377–385.

[8] Dick Ettema, Margareta Friman, Tommy Gärling, Lars E Olsson, and Satoshi Fujii. 2012. How in-vehicle activities affect work commuters' satisfaction with public transport. *Journal of Transport Geography* 24 (2012), 215–222.

[9] Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). 2017. Immer mehr Menschen pendeln zur Arbeit. https://de.statista.com/infografik/8781/deutsche-grossstaedte-nach-anzahl-der-pendelnden-beschaeftigten/. Accessed: 2018-07-05.

[10] Jérémy Frey, May Grabli, Ronit Slyper, and Jessica R. Cauchard. 2018. Breeze: Sharing Biofeedback Through Wearable Technologies. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18)*. ACM, New York, NY, USA, Article 645, 12 pages. https://doi.org/10.1145/3173574.3174219

[11] Benjamin Gardner and Charles Abraham. 2007. What drives car use? A grounded theory analysis of commuters' reasons for driving. *Transportation Research Part F: Traffic Psychology and Behaviour* 10, 3 (2007), 187–200.

[12] Jon Kabat-Zinn. 2003. Mindfulness-based stress reduction (MBSR). *Constructivism in the Human Sciences* 8, 2 (2003), 73.

[13] Sarah Martindale, Ben Bedwell, Robert Phillips, and Micaella Pedros. 2017. Proof in the Pudding: Designing IoT Plants to Promote Wellbeing. In *Proceedings of the 2017 Conference on Designing Interactive Systems*. ACM, 529–540.

[14] Kavous Salehzadeh Niksirat, Chaklam Silpasuwanchai, Mahmoud Mohamed Hussien Ahmed, Peng Cheng, and Xiangshi Ren. 2017. A Framework for Interactive Mindfulness Meditation Using Attention-Regulation Process. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 2672–2684.

[15] Alois Stutzer and Bruno S. Frey. 2008. Stress that Doesn't Pay: The Commuting Paradox*. *Scandinavian Journal of Economics* 110, 2 (June 2008), 339–366. https://doi.org/10.1111/j.1467-9442.2008.00542.x

[16] Netta Weinstein, Andrew K Przybylski, and Richard M Ryan. 2012. The index of autonomous functioning: Development of a scale of human autonomy. *Journal of Research in Personality* 46, 4 (2012), 397–413.